VIVEKANANDA GLOBAL UNIVERSITY

Syllabus of

Master of Science Mathematics

Programme structure and detailed syllabus

Programme Structure

M.Sc. MATHEMATICS SCHEME EFFECTIVE FROM 2023-24				
SEMESTER I				
Course Code	University Course Type	Course Name	Teaching	
			Internal	External
PGMAT101	Discipline Specific Core (Theory)	Advanced Abstract Algebra	30	70
PGMAT102	Discipline Specific Core (Theory)	Topology	30	70
PGMAT103	Discipline Specific Core (Theory)	Integral Transforms	30	70
PGMAT105	Discipline Specific Core (Theory)	Special Functions	30	70
PGMAT106	Discipline Specific Core (Practical)	MATLAB	30	70
PGMAT104	Department Specific Elective 1 (Choose Any One)	Differential Geometry	30	70
UGCSE101/ UGCSE111		Object Oriented Programming with C++ with Theory and Lab	30	70

M.Sc. MATHEMATICS SCHEME EFFECTIVE FROM 2023-24				
SEMESTER II				
Course Code	University Course Type	Course Name	Teaching	
			Internal	External
PGMAT111	Discipline Specific Core (Theory)	Mathematical Programming	30	70
PGMAT112	Discipline Specific Core (Theory)	Advanced Numerical Analysis	30	70
PGMAT113	Discipline Specific Core (Theory)	Integral Equations and Calculus of Variations	30	70
PGMAT114	Discipline Specific Core (Theory)	Discrete Mathematical Structures	30	70

PGMAT115	Discipline Specific Core (Practical)	Numerical Analysis Lab – I	30	70
PGMAT116	Department Specific Elective 2 (Choose Any One)	Functional Analysis	30	70
UGCSE214		Computer System Organization	30	70

M.Sc. MATHEMATICS SCHEME EFFECTIVE FROM 2023-24				
SEMESTER III				
Course Code	University Course Type	Course Name	Teaching	
			Internal	**External**
	Core Theory	Advanced Linear Algebra	30	70
	Core Theory	Operations Research	30	70
	Core Theory	Tensor Analysis	30	70
	Department Specific Elective 3	Choose any one from list of DSE Courses	30	70
	Department Specific Elective 4	Choose any one from list of DSE Courses	30	70
	Core Practical	Numerical Analysis Lab – II	30	70
Total Credits				

M.Sc. MATHEMATICS SCHEME EFFECTIVE FROM 2023-24				
SEMESTER IV				
Course Code	University Course Type	Course Name	Teaching Scheme	
			Internal	External
	Core Practical	Project	30	70
	Core Practical	Seminar	30	70

	Core Practical	LaTeX Lab	30	70
	Department Specific Elective 5	Choose any one from list of DSE Courses	30	70
	Department Specific Elective 6	Choose any one from list of DSE Courses	30	70
	Department Specific Elective 7	Choose any one from list of DSE Courses	30	70

LIST OF DEPARTMENT SPECIFIC ELECTIVE COURSES

S. No.	Department Specific Elective
1.	Fluid Mechanics
2.	Mathematics in Multimedia
3.	Mathematical Modeling
4.	Wavelet Analysis
5.	Fuzzy Sets and Applications
6.	Cryptography
7.	Mathematical Statistics
8.	Differential Equation and Finite Element Analysis

Syllabi of Courses in Semester I

M.Sc. MATHEMATICS SCHEME EFFECTIVE FROM 2023-24				
SEMESTER I				
Course Code	University Course Type	Course Name	Teaching	
			Internal	External
PGMAT101	Discipline Specific Core (Theory)	Advanced Abstract Algebra	30	70
PGMAT102	Discipline Specific Core (Theory)	Topology	30	70
PGMAT103	Discipline Specific Core (Theory)	Integral Transforms	30	70
PGMAT105	Discipline Specific Core (Theory)	Special Functions	30	70
PGMAT106	Discipline Specific Core (Practical)	MATLAB	30	70
PGMAT104	Department Specific Elective 1 (Choose Any One)	Differential Geometry	30	70
UGCSE101/ UGCSE111		Programming for Problem Solving	30	70

Course: Mathematics		
Prerequisite: Solid understanding of basic algebraic structures (groups, rings, and fields), familiarity with proof techniques, and knowledge of linear algebra and mathematical logic.		
Semester: I	**Core:** DSC	**Program/Class:** M.Sc. (Mathematics)
Course Code: PGMAT101	**Course Title:** Advanced Abstract Algebra	

Course Outcomes:

After studying this course, the student will be able to

CO1: Develop a thorough understanding of quotient groups and their properties.
CO2: Analyze the concept of solvable groups and identify their fundamental properties and apply the Jordan-Holder theorem to decompose finite groups and understand the uniqueness of composition series.
CO3: Apply factorization theory to analyze the unique factorization of elements in integral domains.
CO4: Understand ring homomorphism, quotient modules, and completely reducible modules.
CO5: Investigate field extensions and their algebraic properties, including finite and infinite extensions.
CO6: Apply the Fundamental Theorem of Ring Isomorphism, allowing them to establish isomorphisms between rings and simplify algebraic expressions effectively.

Topics
Unit I: Quotient groups- Fundamental theorem of homomorphism.
Unit II: Structure theory of groups- free abelian groups, finitely generated abelian groups.
Unit III: Group actions on a set, Sylow's Theorem.
Unit IV: Solvable groups, Jordan-Holder Theorem.
Unit V: Normal series, Quotient rings, Maximal and prime ideal.
Unit VI: Polynomial rings, Factorization theory of Integral domains, Prime fields.
Unit VII: Extension of fields.
Unit VIII: Ring homomorphism and Quotient modules.

Unit IX: Completely reducible modules, Free modules over polynomial rings.

Unit X: Unit Over a Ring and Properties of Unit

Unit XI: Fundamental Theorem of ring isomorphism.

Unit XII: Field of Quotients and embedding of rings.

Suggested Books:

1. Joseph A. Gallian, (1999), Contemporary Abstract Algebra, Narosa Publishing House, New Delhi.
2. Artin M., (2011), Algebra, Prentice Hall India, New Delhi.
3. Ramanathan K.G., (1954), Lectures in Abstract Algebra, TIFR.
4. Jacobson N., (1964), Lectures in Abstract Algebra, Vol. III, Van Nostrand, Princeton.
5. Dummit D.S. and Foote R.M., (2008), Abstract Algebra, Wiley India Pvt. Ltd.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	1	1	1	2	2	2	3	2	2	3	2	1	1
CO2	3	3	2	1	1	1	2	2	2	3	2	2	3	3	2	1
CO3	3	3	2	1	1	1	2	2	2	3	2	2	3	2	1	1
CO4	3	3	2	1	1	1	2	2	2	3	2	2	3	3	2	1
CO5	3	3	2	1	1	1	2	2	2	3	2	2	3	3	2	1
CO6	3	3	2	1	1	1	2	2	2	3	2	2	3	3	2	1

Course: Mathematics		
Prerequisite: Solid understanding of calculus, including limits, continuity, and basic set theory, as well as familiarity with proof techniques and basic concepts in analysis and algebra**.**		
Semester: I	**Core:** DSC	**Program/Class:** M.Sc. (Mathematics)
Course Code: PGMAT102	**Course Title:** Topology	

Course Outcomes:

After studying this course, the student will be able to

CO1: Define and explain the concept of topological spaces and understand the notions of neighborhoods, interior, exterior, and boundary of sets in a topological space.
CO2: Understand fundamental concepts in topology, including bases and sub-bases, subspaces and relative topology, neighborhood systems, continuous mapping and homeomorphism, as well as nets and filters.
CO3: Apply separation axioms $\boldsymbol{T_0, T_1, T_2, T_3, T_4}$, analyze and classify different topological spaces based on their levels of separation.
CO4: Identify and analyze compact spaces using different techniques, such as sequential compactness and Baire's Category Theorem.
CO5: Apply compactness principles and locally compact properties in problem-solving and advanced mathematical research.
CO6: Understand the product spaces and their basic properties, including the construction of product topologies and the product of connected spaces.

Topics

Unit I: Definition and examples of topological spaces.
Unit II: Interior, exterior, and boundary, accumulation points, open sets.
Unit III: Closed sets, derived sets, closure and related sets.
Unit IV: Bases and sub-bases, Subspaces and relative topology, neighborhood systems.
Unit V: Continuous mapping and homeomorphism.
Unit VI: Nets and Filters.
Unit VII: The separation axioms T_0, T_1, T_2, and their characterizations, basic properties.
Unit VIII: The separation axioms T_3, T_4, and their characterizations, basic properties, Urysohn Metrization theorem, Tietze extension theorem

Unit IX: Compactness-Basic properties of compactness, Compactness and finite intersection property, Sequential, Compact space, and B-W compactness.

Unit X: Locally compactness and Locally Compact Space.

Unit XI: Product space, Connected spaces and their basic properties.

Unit XII: Locally connectedness and locally connected spaces.

Suggested Books:

1. Kelley J.L., (1995), General Topology, Van Nostrand.
2. Munkers, J.R., (2015), Topology- A First Course, Pearson Education India.
3. Bredon G.E., (2014), Topology and Geometry, Springer.
4. Joshi, K.D., (2017), Introduction to General Topology, New Age International Private Limited.
5. Davis S.W., (2006), Topology, Tata McGraw Hill.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	1	1	1	2	2	2	3	2	2	3	2	2	1
CO2	3	3	2	1	1	1	2	2	2	3	2	2	3	3	2	1
CO3	3	3	2	1	1	1	2	2	2	3	2	2	3	3	2	1
CO4	3	3	2	2	1	1	2	2	2	3	2	2	3	3	2	1
CO5	3	3	2	2	1	1	2	2	2	3	2	2	3	2	1	1
CO6	3	3	2	1	1	1	2	2	2	3	2	2	3	2	1	1

Course: Mathematics		
Prerequisite: Strong foundation in calculus, complex analysis, linear algebra, differential equations, and familiarity with elementary transforms.		
Semester: I	**Core:** DSC	**Program/Class:** M.Sc. (Mathematics)
Course Code: PGMAT103	**Course Title:** Integral Transforms	

Course Outcomes:

Students will be able to-

CO1: Know the use of Laplace transform in system modeling, digital signal processing, process control, solving Boundary Value Problems.
CO2: Understand the Fourier transform and its properties, including the Fourier sine, cosine, and complex transforms.
CO3: Apply Laplace and Fourier transforms to solve ordinary and partial differential equations, demonstrating proficiency in their practical applications.
CO4: Apply the Laplace transform method to obtain solutions for linear and time-invariant ODEs, and use the Fourier Transform to analyze signals and functions in the frequency domain**.**
CO5: Understand the Mellin transform, including its definition and elementary properties and apply the Mellin transform to various functions and analyze its behavior in different contexts.
CO6: Understand the Hankel transform, including its definition and elementary properties and apply the Hankel transform to various functions and analyze its behavior in different contexts.

Topics	
Unit I: Laplace transform– Definition and its properties, Rules of manipulation.	
Unit II: Laplace transform of derivatives and integrals.	
Unit III: Properties of inverse Laplace transform, Convolution theorem.	
Unit IV: Fourier transform – Definition and properties of Fourier sine, cosine and complex transforms.	
Unit V: Convolution theorem, Inversion theorems.	
Unit VI: Fourier transforms of derivatives.	
Unit VII: Applications of Laplace transform for Solution of ordinary and partial differential equations.	
Unit VIII: Applications of Fourier Transform for Solution of ordinary and partial differential equations.	

Unit IX: Mellin Transform: Definition and elementary properties.	
Unit X: Mellin transforms of derivatives and Integrals, Inversion theorem, Convolution theorem.	
Unit XI: Hankel transform– Definition and elementary properties.	
Unit XII: Hankel transform of derivatives, Inversion theorem, Parseval Theorem.	

Suggested Books:

1. Murrey R.S., (1965), Laplace Transforms (SCHAUM Outline Series), McGraw Hill.
2. Lokenath D., Bhatta, D., (2014), Integral Transforms and Their Applications, Taylor and Francis.
3. John M.W., (2011), Integral Transforms in Applied Mathematics, Cambridge University Press.
4. Davies B., (2012)., Integral Transforms and Their Applications, Springer New York, NY.
5. Hildebrand F.B., (1992), Methods of Applied Mathematics, Dover Publications.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	3	2	1	2	3	2	3	2	2	3	3	2	3
CO2	3	2	2	1	1	1	2	3	1	3	2	2	3	3	2	3
CO3	3	3	3	3	2	1	2	3	3	3	3	2	2	3	2	3
CO4	3	2	2	2	1	1	2	3	2	3	3	2	2	2	2	3
CO5	3	2	2	2	1	1	2	3	1	3	2	2	2	2	1	2
CO6	3	2	2	2	1	1	2	3	1	3	2	2	2	2	1	2

Course: Mathematics

Prerequisite: Strong foundation in calculus, algebra, and familiarity with functions, including exponential, logarithmic, trigonometric, and hyperbolic functions.

Semester: I	**Core:** DSC	**Program/Class:** M.Sc. (Mathematics)
Course Code: PGMAT105	**Course Title:** Special Functions	

Course Outcomes:

After studying this course, the student will be able to

CO1: Understand the Gamma and Beta functions, including their definitions, elementary properties, and applications in various mathematical fields.
CO2: Understand the Hypergeometric Function, including its definition, integral representation, transformations, and elementary properties.
CO3: Understand the confluent hypergeometric function and familiar with its definition and elementary results, including recurrence relations, which help simplify and transform the function in various mathematical contexts.
CO4: Understand the Legendre functions and their properties.
CO5: Understand the Bessel functions and their properties.
CO6: Understand the Hermite polynomials, Laguerre polynomials, and Associated Laguerre polynomials, including their definitions, recurrence relations, generating functions, and integral representations.

Topics	
Unit I: The Gamma and Beta Function: Preliminaries, Euler's integral for Gamma (Z), Gamma and Beta functions and its elementary properties, Factorial function, Legendre's duplication formula, Gauss Multiplication formula, Incomplete gamma function.	
Unit II: Incomplete beta function. Riemann Zeta function and simple properties.	
Unit III: The Hypergeometric Function: Definition, Integral representation of hypergeometric function, Transformations, Gauss's hypergeometric functions and its elementary properties.	
Unit IV: Gauss's hypergeometric differential equation and its solution, Evaluation of hypergeometric function.	
Unit V: Relations of contiguity, Generalized Hypergeometric series, the function of ${}_uF_v$, Bilateral hypergeometric series.	
Unit VI: Kummer's function (The Confluent hypergeometric function): Definitions and some elementary results, Recurrence relations, The differential equation, Kummer's first and second	

formula, Addition and multiplication theorems, Integral representations, Basic properties of $_1F_1$, Special cases and its relation to other functions, Products of Kummer's functions.

Unit VII: Basic properties of $_1F_1$, Special cases and its relation to other functions, Products of Kummer's functions.

Unit VIII: Legendre functions: Legendre's differential equation and its solution, Relations between Legendre functions, the function P(x) and Q(x), Multiplications of two Legendre functions, Rodrigue's formula, Integral representations.

Unit IX: Integrals involving Legendre functions, Associated Legendre functions.

Unit X: Bessel functions: Bessel differential equation and its solution, Bessel's functions $J_u(x)$, recurrence relation, generating functions, integral representation, and orthogonality of Bessel functions, modified Bessel function and its properties.

Unit XI: Hermite polynomials and Properties.

Unit XII: Laguerre polynomials, Associated Laguerre polynomials.

Suggested Books:

1. Sharma J.N. and Gupta R.K., (2020), Differential equations with Special Functions, Krish**.** na Publications.
2. Bansal J.L. and Dhami H.S., (2004), Differential Equations, Voll-II, Jaipur Publishing House.
3. Rainville E.D., (1960), Special Function, The Macmillan Company, New York.
4. Andrews G.E., Askey R. and Roy R., (1999), Special Function, Cambridge University Press.
5. Wang Z.X. and Guo D.R., (2010), Special Function, World Scientific.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	1	1	1	2	3	2	3	2	2	3	3	2	1
CO2	3	3	2	1	1	1	2	3	1	3	2	2	3	3	2	1
CO3	3	3	3	1	1	1	2	3	1	3	2	2	3	3	2	1
CO4	2	2	2	1	1	2	2	3	1	2	2	2	2	2	2	**1**
CO5	2	2	2	1	1	1	2	3	1	2	2	2	2	2	**2**	**1**
CO6	2	2	2	1	1	1	2	3	1	2	2	2	2	2	**2**	**1**

Course: Mathematics		
Prerequisite: Having a good understanding of mathematics (especially linear algebra, calculus, and numerical methods) is essential for working with MATLAB.		
Semester: I	**Core:** DSC(Practical)	**Program/Class:** **M.Sc. (Mathematics)**
Course Code: PGMAT106	**Course Title:** MATLAB	

Course Outcomes:

At the end of the course, students will be able to-

CO1: Creating, saving and executing the script file and function file.

CO2: Solve the linear equation and the system of linear equations.

CO3: Fit a polynomial curve, linear curves and nonlinear curves.

CO4. Sketch curves in a plane using its mathematical properties in the different coordinate systems of reference.

Topics

MATLAB Programming: Input output of data from MATLAB command. File types. Creating, saving and executing the script file. Creating and executing functions file. Working with files and directories. Matrix manipulation. Creating vectors. Arithmetic operations. Relational operations. Logical operations. Matrix functions. Determinant of matrix. Eigen values and Eigen vectors.

Programming in MATLAB: Function files, sub functions, global variations, loops, branches and control flow. Interactive input. Recursion. Publishing a report. Controlling command windows. Command line editing.

Linear Algebra and Interpolation: Solving the linear equation. Gaussian elimination, matrix factorization, curve fitting, polynomial curve fitting, least squares curve fitting. General nonlinear fits. Interpolation.

Differential Equations and Graphics: First order and second order ODE. Double integration. Roots of polynomial. Two- and three-dimensional plots. MATLAB plotting tools. Mesh and surface plots.

Suggested Books:

1. Getting Started with MATLAB 7: Rudra Pratap; Oxford Press.
2. Applied numerical Methods using MATLAB: Won Young Yang, Tae-Sang-Chung, John Morris: John Wiley and Sons.
3. Solving ODE's with MATLAB: L.F. Shampine, I Gladwell, S. Thompson; Cambridge University Press.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	1	2	3	1	1	2	3	1	3	3	2	2	3	1	3
CO2	3	3	3	3	2	2	2	3	2	3	3	3	2	3	2	2
CO3	2	2	2	2	1	1	1	2	1	2	2	1	3	3	2	1
CO4	2	1	2	1	1	1	2	2	1	1	1	1	2	2	1	1

Course: Mathematics		
Prerequisite: Strong foundation in calculus, Two- and three-dimensional geometry, multivariable calculus, as well as familiarity with curves, surfaces, and basic concepts in differential equations and vector calculus.		
Semester: I	**Core:** DSE 1	**Program/Class:** M.Sc. (Mathematics)
Course Code: PGMAT104	**Course Title:** Differential Geometry	

Course Outcomes:

After studying this course, the student will be able to

CO1: Understand the concepts of graphs, level sets as solutions of smooth real valued functions, vector fields and tangent space.
CO2: Know line integrals, be able to deal with differential forms and calculate arc length and curvature of surfaces.
CO3: Learn about linear self-adjoint Weingarten maps and curvature of a plane curve with applications in geometry and physics.
CO4: Study surfaces with boundaries and be able to solve various problems and the Gauss- Bonnet theorem.
CO5: Learn to apply Clairaut's theorem, which relates the geodesic curvature and the normal curvature of a curve on a surface.
CO6: Learn to apply the concepts of geodesic equations, curvature, and torsion in analyzing and solving problems in differential geometry.

Topics	
Unit I: Space curves, Tangent, Contact of curve and surface, Osculating plane, Principal normal and Binormal, Curvature, Torsion	
Unit II: Serret-Frenet's formulae, Osculating circle and Osculating sphere.	
Unit III: Existence and Uniqueness theorem for space curves, Bertrand curves, Involute and Evolutes.	
Unit IV: Conoids, Inflexional tangents, Singular points, Indicatrix, Ruled surface, Developable surface,	
Unit V: Tangent plane to a ruled surface, Necessary and sufficient condition that a surface should represent a developable surface	
Unit VI: Metric of a surface, first fundamental form.	
Unit VII: second fundamental form, Fundamental magnitudes of some important surfaces, orthogonal trajectories.	

Unit VIII: Normal curvature, Principal directions and Principal curvatures, first curvature, Mean curvature, Gaussian curvature,	
Unit IX: Radius of curvature of a given section through any point on a surface	
Unit X: Third Fundamental Form, Relation between fundamental forms.	
Unit XI: Canonical geodesic equations, nature of geodesics on a surface of revolution.	
Unit XII: Clairaut's theorem, Normal property of geodesics, Torsion of a Geodesic, Geodesic curvature. Gauss-Bonnet theorem.	

Suggested Books:

1. Somasundaram D., (2010), Differential Geometry: A First Course, Narosa Pub. House.
2. Thorpe J.A., (1979), Elementary Topics in Differential Geometry, Springer Verlag.
3. Tu W.L., (2010), An Introduction to Manifolds (2nd Ed.), Springer-Verlag, New York.
4. Willmore T.J., (1965), An Introduction to Differential Geometry, Oxford University Press.
5. O'Neill B., (1966), Elementary Differential Geometry, Academic Press, New York.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	1	1	1	2	2	2	3	2	2	3	3	2	2
CO2	3	3	3	2	1	1	2	3	1	3	2	2	2	3	2	2
CO3	3	3	2	2	1	2	2	3	1	3	2	2	3	3	2	2
CO4	3	3	3	2	1	1	2	3	1	3	2	2	3	2	2	2
CO5	3	3	2	1	1	2	2	3	1	3	2	2	3	3	2	2
CO6	3	3	3	2	1	1	2	3	1	3	3	2	3	3	2	2

Course: Mathematics		
Prerequisite: Strong foundation in calculus, Two- and three-dimensional geometry, multivariable calculus, as well as familiarity with curves, surfaces, and basic concepts in differential equations and vector calculus.		
Semester: I	**Core:** DSE 1	**Program/Class:** M.Sc. (Mathematics)
Course Code: UGCSE101/ UGCSE111	**Course Title:** **Object Oriented Programming with C++**	

Course Outcomes:

- Identify importance of object oriented programming and difference between structured oriented and object oriented programming features.
- Able to make use of objects and classes for developing programs.
- Able to use various object oriented concepts to solve different problems.

Topics
Unit I: Different paradigms for problem solving, need for OOP, differences between OOP and Procedure oriented programming, Abstraction, Overview of OOP principles, Encapsulation, Inheritance and Polymorphism.
Unit II: C++ BASICS: Structure of a C++ program, Data types, Declaration of variables, Expressions, Operators, Operator Precedence
Unit III: Evaluation of expressions, Type conversions, Pointers, Arrays, Strings, Structures, Flow control statement- if, switch, while, for, do, break, continue, goto statements.
Unit IV: Structure and Union: Introduction, types of storage classes, Introduction to structures, Advantages of structures, accessing elements of a structure, nested structures, array of structures, functions and structures, Unions, bit- fields, enumerated data types.
Unit V: Functions-Scope of variables, Parameter passing, Default arguments, inline functions, Recursive functions, Pointers to functions.
Unit V: C++ Classes And Data Abstraction: Class definition, Class structure, Class objects, Class scope, this pointer, Friends to a class, Static class members, Constant member functions, Constructors and Destructors, Dynamic creation and destruction of objects

Unit VI: Data abstraction, Function overloading, Operator overloading, Inheritance: Defining a class hierarchy, Different forms of inheritance, Defining the Base and Derived classes

Text/Reference Books:

1. Problem solving with C++, The OOP, 4th Edition, Walter Savitch, Pearson Education.
2. C++, The Complete Reference, 4th Edition, Herbert Schildt, TMH.
3. C++ Primer, 3rd Edition, S.B.Lippman and J.Lajoie, Pearson Education.
4. The C++ Programming Language, 3rd Edition, B.Stroutstrup, Pearson Education.
5. Object Oriented Programming in C++, 3rd Edition, R.Lafore, Galgotia Publications pvt ltd.

OBJECT ORIENTED PROGRAMMING LAB WITH C++

Learning Outcomes

- The working of OOPS programming approach.
- The knowledge of object oriented programming style.
- The basic concepts involved in computer programming.
- Important programming aspects i.e object, class, inheritance and polymorphism.
- Knowledge with respect to the software development phase of OOPS.

1. Create a user defined function (any) and use it inside the program.
2. Implement "call by value" & "call by reference " function call techniques by using any user defined functions.
3. Implement the working of classes and objects by using any real world object.
4. Create any user defined class using the concept of static data and member functions.
5. Create a Class or program implementing the concept of passing and returning object to/from member functions.
6. WAP to implement polymorphism through function overloading (Area of different shapes).
7. Create a user defined type Complex and do all the Complex number arithmetic. And also make use of operator overloading.
8. Implement single level inheritance by using Student and Marks class.
9. Implement multilevel inheritance by using the Stack class.
10. Implement the concept of Abstract classes and virtual functions by using Shape, Rectangle and Triangle class.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1	0	0	1	1	1	1	0	1	1	1	1	1	1	2
CO2	1	1	1	0	0	0	1	1	1	2	1	0	0	1	1	2
CO3	2	2	2	1	0	0	1	1	1	2	1	0	0	1	1	1
CO4	2	1	0	1	1	0	1	1	1	1	1	0	0	1	0	2
CO5	1	1	0	0	0	0	1	1	1	1	1	0	0	1	0	2

Syllabi of Courses in Semester II

M.Sc. MATHEMATICS SCHEME EFFECTIVE FROM 2023-24				
SEMESTER II				
Course Code	University Course Type	Course Name	Teaching	
			Internal	External
PGMAT111	Discipline Specific Core (Theory)	Mathematical Programming	30	70
PGMAT112	Discipline Specific Core (Theory)	Advanced Numerical Analysis	30	70
PGMAT113	Discipline Specific Core (Theory)	Integral Equations and Calculus of Variations	30	70
PGMAT114	Discipline Specific Core (Theory)	Discrete Mathematical Structures	30	70
PGMAT115	Discipline Specific Core (Practical)	Numerical Analysis Lab – I	30	70
PGMAT116	Department Specific Elective 2 (Choose Any One)	Functional Analysis	30	70
UGCSE216		Computer System Organization	30	70
Total Credits				

Course: Mathematics		
Prerequisite: Strong foundation in calculus, algebra, and familiarity with Simplex method, duality and other problem in LPP.		
Semester: II	**Core:** DSC	**Program/Class:** M.Sc. (Mathematics)
Course Code: PGMAT111	**Course Title:** Mathematical Programming	

Course Outcomes:

After studying this course, the student will be able to

CO1. Formulate the LPP, Conceptualize the feasible region, solve the LPP using different methods & understand the importance of LPP in daily life.

CO2. Proficient in formulating and solving pure and mixed integer programming problems for efficient optimization in real-world scenarios.

CO3. Gain a comprehensive understanding of the mathematical foundations of quadratic forms, constrained optimization, saddle points, and Kuhn-Tucker theory.

CO4. Gain a strong foundation in quadratic programming, enabling them to apply specialized methods.

CO5. Know about dynamic programming and its application to solve optimization problems with a finite number of stages, including linear programming problems.

CO6. Be equipped with the skills to analyze and design dynamic programming algorithms, making them well-prepared to address real-world decision-making challenges and optimize various processes efficiently.

Topics	
Unit I: Introduction- Separating plane, supporting hyperplane and related theorems.	
Unit II: Convex function, local and global maxima and minima, theorem based on convexity and concavity of quadratic forms.	
Unit III: Simplex method and revised simplex method for solving L.P.P, bounded variable problems.	
Unit IV: Integer programming- Pure and mixed integer programming problems, Gomory's-cutting plane method, Branch and bound algorithm.	
Unit V: Branch and bound algorithm for solving Integer Programming Problem	
Unit VI: Quadratic forms and Lagrangian function, Saddle Points-Necessary and sufficient conditions for saddle points.	
Unit VII: Classical optimization –Nonlinear programming problem.	
Unit VIII: Kuhn-Tucker Theory and Kuhn-Tucker necessary and sufficient condition for NLPP.	

Unit IX: Quadratic programming problem Wolfe's method for solving quadratic programming problems.	
Unit X: Beale's method for solving quadratic programming problems.	
Unit XI: Dynamic programming-Introduction Bellman's principle of optimality, solution of problem with finite number of stages.	
Unit XII: Solution of LLP by Dynamic Programming.	

Suggested Books:

1. Hiller F.S. and G. J. Leiberman G.J., (1995), Introduction to Operations Research (6th Edition), McGraw-Hill International Edition.
2. Hadley G., (1964), Nonlinear and Dynamic Programming, Addison Wesley.
3. Taha H.A., (2012), Operations Research –An Introduction, Macmillan.
4. Swarup K., Gupta P.K. and Mohan M., (2008), Operations Research, Sultan Chand & Sons, New Delhi.
5. Rao S.S., (1979), Optimization Theory and Applications, Wiley Eastern.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	3	3	3	3	3	3	2	2	3	2	2	2	2
CO2	3	3	2	3	3	3	2	3	3	2	2	3	3	3	2	3
CO3	3	3	3	2	2	2	3	2	3	2	2	3	3	3	2	2
CO4	2	2	2	3	2	2	2	2	2	1	2	2	2	2	1	2
CO5	3	2	2	2	3	3	2	2	2	2	2	2	2	2	1	2
CO6	3	2	2	3	3	3	2	2	2	2	2	3	2	2	1	2

Course: Mathematics		
Prerequisite: Strong foundation in calculus, algebra, and basic knowledge of interpolation, numerical integrations, ODE and System of linear and nonlinear equations.		
Semester: II	**Core:** DSC	**Program/Class:** M.Sc. (Mathematics)
Course Code: PGMAT112	**Course Title:** Advanced Numerical Analysis	

Course Outcomes:

After completing this course, the student will able to -

CO1: Use the iterative methods with algorithms to implement several numerical methods.

CO2: develop a strong understanding of polynomial equations and various root finding methods.

CO3: gain practical skills in solving real and complex roots of polynomials and be capable of applying these techniques to a wide range of real-world problems.

CO4: Apply various methods to solve System of simultaneous linear equations.

CO5: be equipped with practical skills to analyze data, select appropriate models, and apply regression and interpolation methods effectively by using curve fitting and function approximation techniques.

CO6: Apply various methods to find Numerical Solution of ordinary differential equations.

Topics	
Unit I: Iterative methods- Theory of iteration method, acceleration of the convergence, Chebyshev method.	
Unit II: Muler's method, Methods of multiple and complex roots.	
Unit III: Newton Raphson's method for simultaneous equations, Convergence of iteration process in the case of several unknowns.	
Unit IV: Solution of polynomial equations- Polynomial equation, Real and complex roots, Synthetic Division, Birge- Vieta method.	
Unit V: Bairstow and Graeffe's root square method for solution of polynomial equations.	
Unit VI: System of simultaneous linear equations- Direct Method, Method of determinant, Gauss Jordan methods.	
Unit VII: Lui –Factorization- Dolittle's, Crout's and Cholesky's Partion method.	
Unit VIII: Method of successive Approximation- Conjugate gradient and relaxation methods.	
Unit IX: Curve fitting and function Approximation- Least square error criteria, linear regression, polynomial fitting and other curve fittings.	

Unit X: Approximation of functions by Taylor series and Chebyshev polynomials.

Unit XI: Numerical Solution of ordinary differential equations- Taylor's series method, Runge-Kutta method of fourth order.

Unit XII: Multistep method, Predictor-Corrector strategies, Stability Analysis- single and multistep methods. BVP's of ordinary differential equations- shooting methods, finite difference methods.

Suggested Books:

1. Shastry, S.S., (2005), Introductory Methods of Numerical Analysis, PHI Learning Pvt. Ltd.
2. Xavier, C.C, (2007), Language and Numerical Methods, New Age Int. Ltd.
3. Gerald, C.F. and Wheatley, P.O., (2003), Applied Numerical Analysis, 7th Edition, Pearson Education Asia.
4. Bradie, B., (2007), A friendly introduction to Numerical Analysis. Delhi: Pearson Education.
5. Conte S.D., Boor C., (1980), Elementary Numerical Analysis, McGraw-Hill.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	1	1	1	1	2	2	2	2	3	3	2	1	3
CO2	2	2	1	1	1	1	1	2	2	1	2	2	2	3	2	2
CO3	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2
CO4	2	2	2	3	2	2	2	2	2	2	2	2	2	2	1	3
CO5	2	2	2	2	2	2	1	2	2	1	2	2	2	3	2	2
CO6	2	2	1	1	1	1	1	2	2	2	2	2	2	2	1	2

Course: Mathematics		
Prerequisite: Strong foundation in calculus, differential equations, and familiarity with integral calculus and basic properties of functions.		
Semester: II	**Core:** DSC	**Program/Class:** M.Sc. (Mathematics)
Course Code: PGMAT113	**Course Title:** Integral Equations and Calculus of Variations	

Course Outcomes:

After studying this course, the student will be able to

CO1: Formulate and solve initial and boundary value problems for the heat and wave equations in spherical and cylindrical coordinates.

CO2: Solve linear Volterra and Fredholm integral equations using appropriate methods.

CO3: Understand the relationship between integral and differential equations and transform one type into another.

CO4. Determine the solutions system of Volterra integral equations and integra-differential equation.

CO 5. Understand the Concept of Variation of functional and its property.

CO 6. Understand the Concept of Functional dependent on several unknown functions and their first order derivatives.

Topics	
Unit I: Linear integral equations– Definition and classification. Conversion of initial and boundary value problems to an integral equation.	
Unit II: Eigen values and Eigen functions. Solution of homogeneous and general Fredholm integral equations of First kind with separable kernels.	
Unit III: Solution of Fredholm and Volterra integral equations of second kind by methods of successive substitutions and successive approximations.	
Unit IV: Resolvent kernel and its results. Conditions of uniform convergence and uniqueness of series solution. Integral equations with symmetric kernels– Orthogonal system of functions.	
Unit V: Fundamental properties of eigen values and eigen functions for symmetric kernels. Expansion in eigen functions and bilinear form.	
Unit VI: Hilbert-Schmidt theorem. Solution of Fredholm integral equations of second kind by using Hilbert-Schmidt theorem.	
Unit VII: Solution of Volterra integral equations of second kind with convolution type kernels by Laplace transform. Solution of singular integral equations by Fourier transforms.	
Unit VIII: Classical Fredholm theory– Fredholm theorems. Solution of Fredholm integral equation of second kind by using Fredholm first theorem.	

Unit IX: Series solution: Radius of Convergence, Method of Differentiation, Cauchy- Euler Equation.

Unit X: Solution near a regular Singular point (Method of Forbenius) for different cases, Particular Integral at point of infinity**.**

Unit XI: Calculus of variation-Functional, Variation of functional and its property, Variation problems with fixed boundaries.

Unit XII: Euler's Equation, Functional dependent on several unknown functions and their first order derivatives.

Suggested Books:

1. M.D. Raisinghania M.D., (2010), Integral Equations and Boundary Value Problems, S. Chand.
2. Shanti Swarup S., (2010), Integral Equations, Krishna Publications, Meerut.
3. Ross S. L., (2004), Differential Equations, New Delhi: John Wiley and Sons (2004).
4. Kanwal R.P., (1997), Linear Integral Equations, Birkhäuser Boston.
5. Bradie B., (2005), A friendly introduction to Numerical Analysis, Delhi: Pearson.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	1	1	1	1	2	2	2	2	2	2	2	1	2
CO2	2	2	2	1	1	1	1	2	2	2	2	2	2	2	1	2
CO3	2	3	2	1	1	1	1	2	2	2	2	2	2	2	1	2
CO4	2	2	2	2	1	1	1	2	2	2	2	2	2	2	1	2
CO5	2	2	2	1	1	1	1	2	2	2	2	2	2	3	2	2
CO6	2	2	1	1	1	1	1	2	2	2	2	2	2	2	1	2

Course: Mathematics		
Prerequisite: The prerequisite for discrete mathematics is to have understanding of algebra, geometry, and pre-calculus.		
Semester: II	**Core:** DSC	**Program/Class:** M.Sc. (Mathematics)
Course Code: PGMAT114	**Course Title:** Discrete Mathematical Structures	

Course Outcomes:

After studying this course, the student will be able to

CO1: Understand the fundamental concepts, principles, and applications of combinatorics, including permutation and combination, binomial theorem, and multimodal coefficients.

CO2: Understand discrete numeric functions and generating functions**.** Define linear recurrence relations with constant coefficients.

CO3: Understand the fundamental concepts of propositional logic, including propositions, logical connectives, truth tables, tautologies, and contradictions, and apply this knowledge to analyze and evaluate logical expressions.

CO4: Identify and analyze equivalence relations and partial ordering relations in various contexts.

CO5: Develop a comprehensive understanding of graph theory fundamentals and apply them to analyze and study various types of graphs, including their properties, connectivity, and planarity.

CO 6: Analyze and describe the properties of trees, identify and construct spanning trees in graphs, understand the concept of minimal spanning trees and algorithms for their determination.

or

CO 6: Understand the groups, including their definitions, properties, and various types such as Abelian groups and permutation groups.

Topics	
Unit I: Combinatorics: Introduction, Permutation and combination, Binomial Theorem, Multimodal Coefficients.	
Unit II: Recurrence Relation and Generating Function: Introduction to Recurrence Relation and Recursive algorithms, linear recurrence relations with constant coefficients, Homogeneous solutions, Particular solutions, Total solutions.	
Unit III: Generating functions, Solution by method of generating functions. The Pigeonhole and Generalized Pigeonhole Principles.	
Unit IV: Propositional Logic: Proposition, First order logic, Basic logical operation, truth tables, tautologies, Contradictions.	
Unit V: Algebra of Proposition, logical implications, logical equivalence, predicates, Normal Forms, Universal and existential quantifiers. 2-way predicate logic.	

Unit VI: Posets Hasse Diagram and Lattices: Equivalence relation, Partial ordering relation, Job-Scheduling problem. Introduction of partially ordered set.

Unit VII: Hasse diagram of partially ordered set, isomorphic ordered set, well ordered set, properties of Lattices, bounded and complemented lattices.

Unit VIII: Graph Theory: Introduction and basic terminology of graphs, Planar graphs, Multigraphs and weighted graphs, Isomorphic graphs, shortest path in weighted graph.

Unit IX: Paths, Cycles, connectivity, Hamiltonian paths and circuits

Unit X: Graph coloring, chromatic number, Isomorphism and Homomorphism of graphs, matching, vertex/edge covering.

Unit XI: Trees- Properties, Binary and Rooted Tree, Planar graph, region, homeomorphic graph and Dual graphs

Unit XII: Spanning Tree, Minimal Spanning Tree, Matrix representation of graphs.

Suggested Books:

1. Edgar G. Goodaire and Michael M. Parmenter, (2005), Discrete Mathematics with Graph Theory, Third Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint.
2. Rosen, Kenneth H., (2012), Discrete mathematics and its applications, Seventh Edition, McGraw Hill Education.
3. Mott J.L., Kendel A. and Baker T.P., (2008), Discrete mathematics for Computer Scientists and Mathematicians, Prentice Hall of India Pvt Ltd.
4. Liu C.L. and Mohapatra D.P., (2008), Elements of discrete mathematics, Tata McGraw Hill.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	1	1	1	1	2	2	2	2	2	3	3	2	1
CO2	2	2	1	1	1	1	1	2	2	2	2	2	2	3	1	2
CO3	2	2	3	1	1	1	1	2	2	2	2	2	2	3	2	1
CO4	2	2	2	2	1	1	1	2	2	2	2	2	2	2	1	2
CO5	2	2	2	1	1	1	1	2	2	2	2	2	3	3	2	2
CO6	3	2	1	1	1	2	1	2	2	2	2	2	2	2	1	2

Course: Mathematics

Prerequisite: Strong foundation in calculus, differential equations, and basic knowledge of Sci-Lab and MATLAB

Semester: II	**Core:** DSC (Practical)	**Program/Class:** M.Sc. (Mathematics)
Course Code: PGMAT115	**Course Title:** Numerical Analysis Lab – I	

Course Outcomes:

After studying this course, the student will be able to

CO1.understand the key ideas, concepts and definitions of the computational algorithms, origins of errors, convergence theorems.

CO2.decide the best numerical method to apply to solve a given differential equation and quantify the error in the numerical (approximate) solution.

CO3.analyze an algorithm's accuracy, efficiency and convergence properties.

CO4: Typeset mathematical formulas, use nested list, tabular & array environments.

Topics

List of Practicals (Any eight using any software)

1. Solution of quadratic equation.
2. Solution of algebraic and transcendental equations.
3. Solve the system of equations by Gauss-Seidel method.
4. Solve the system of equations by Matrix inversion method.
5. Solution of the system of equations by Gaussian elimination method.
6. Solve the 1st order ordinary differential equation by Euler's method.
7. Solve the 1st order ordinary differential equation by Euler's modified method.
8. Solution of 1st order ordinary differential equation by Runge-Kutta methods.
9. Solution of numerical integration by Trapezoidal method.
10. Solution of numerical integration by Simpson's 1/3 method.
11. Solution of numerical integration by Simpson's 3/8 method.
12. Introduction to LaTeX and typesetting a simple document.
13. Adding basic information to a document, Environments by LaTeX.

Suggested Books:

1. Shastri S.S., (1994), Introductory Methods of Numerical Methods, PHI, Second Edition.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	3	1	1	1	1	2	1	1	2	2	3	3	2	2
CO2	3	3	3	2	1	1	1	2	1	3	2	2	2	3	1	3
CO3	2	3	3	2	1	1	1	2	1	2	2	2	2	3	1	3
CO4	1	1	1	1	1	1	1	2	1	1	2	1	1	2	2	2

Course: Mathematics		
Prerequisite: Basic tools of Functional Analysis involving normed spaces, Banach spaces and Hilbert spaces, their properties dependent on the dimension and the bounded linear operators from one space to another.		
Semester: II	**Core:** DSE	**Program/Class:** M.Sc. (Mathematics)
Course Code: PGMAT116	**Course Title:** **Functional Analysis**	

Course Outcomes:

After studying this course, the student will be able to

CO1. Understand normed linear spaces with their properties and familiar with the concept of norm in a linear space, enabling them to analyze the magnitude and convergence of vectors in such spaces.

CO2. Understand the basic properties of finite-dimensional normed linear spaces, compactness and able to analyze and compare norms on a given vector space.

CO3. Understand the continuous linear functionals in normed spaces and their importance in functional analysis.

CO4: Understand the orthogonality in Hilbert spaces and learn about orthonormal sets, Bessel's inequality, complete orthonormal sets, and Parseval's identity, which provide fundamental insights into the structure and completeness of Hilbert spaces.

CO5. Learn how to compute the adjoint of various operators and understand the properties of adjoint operators, such as self-adjointness and normality.

CO6. Understand the role of projections in functional analysis and their applications in various mathematical contexts.

Topics	
Unit I: Normed linear spaces, Quotient space of normed linear spaces and its completeness.	
Unit II: Banach spaces and examples, bounded linear transformations, Normed linear space of bounded linear transformations.	
Unit III: Equivalent norms, Basic properties of finite dimensional normed linear spaces and compactness.	
Unit IV: Reisz Lemma, Multilinear mapping, Open mapping theorem, Closed graph theorem, Uniform boundedness theorem.	
Unit V: Continuous linear functional, Hahn-Banach theorem and its consequences.	
Unit VI: Embedding and Reflexivity of normed spaces, Dual spaces with examples.	
Unit VII: Inner product spaces, Hilbert space and its properties.	
Unit VIII: Orthogonality and Functionals in Hilbert Spaces. Pythagorean theorem, Projection theorem.	

Unit IX: Orthonormal sets, Bessel's inequality, complete orthonormal sets, Parseval's identity.

Unit X: Structure of a Hilbert space, Riesz representation theorem, Reflexivity of Hilbert spaces.

Unit XI: Adjoint of an operator on a Hilbert space, Self-adjoint, Positive, Normal and Unitary operators and their properties.

Unit XII: Projection on a Hilbert space. Invariance, Reducibility, Orthogonal projections.

Suggested Books:

1. Taylor E., (1958), An Introduction to Functional Analysis, John Wiley.
2. Limaye B.V., (2014), Functional Analysis, Wiley Eastern.
3. Kreyszig, E., (2006), Introductory Functional Analysis with Applications, John Wiley and Sons (Asia) Pvt. Ltd.
4. Simmons, G. F., (2008), Introduction to Topology and Modern Analysis.
5. Bachman, G. and Narici, L., (2000), Functional Analysis, Dover.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1	1	1	1	2	2	2	2	2	3	2	2	1
CO2	2	3	1	1	1	1	1	2	2	2	2	2	3	2	2	1
CO3	2	2	3	1	1	1	1	2	2	2	2	2	3	2	2	1
CO4	2	2	1	3	1	1	1	2	2	2	2	2	3	2	2	1
CO5	2	2	1	1	2	1	1	2	2	2	2	2	2	2	1	2
CO6	2	2	1	1	1	2	1	2	2	2	2	2	2	2	1	2

Course: Mathematics		
Prerequisite: Basic tools of Functional Analysis involving normed spaces, Banach spaces and Hilbert spaces, their properties dependent on the dimension and the bounded linear operators from one space to another.		
Semester: II	**Core:** DSE	**Program/Class:** M.Sc. (Mathematics)
Course Code: UGCSE214	**Course Title:** Computer Systems Organization	

Course Outcomes:

After studying this course, the student will be able to

CO1. Understand the hardware components and concepts related to the control design

CO2. Familiarize with addressing modes, different types of instruction formats

CO3. Learn about various I/O devices and the I/O interface.

CO4. Gain the concepts related to the memory organization.

CO5. Understand the theoretical concept of parallel processing and multiprocessing.

Topics	
Unit I: Fundamental of Computer Design: Basic Structure of Computers, Computer Types; Functional **Unit**s; Bus structure; Performance- Processor Clock, Basic Performance Equation, Clock rate; Historical Perspective; Machine Instructions and Programs: Numbers, Arithmetic Operations and Characters; Memory Location and Addresses; Memory Operations; Instructions and Instruction Sequencing.	
Unit II: Instruction set, Assembly language and input/output Organization: Machine Instructions and Programs: Addressing Mode; Assembly Language; Basic input and Output Operations; Stacks and Queues; Subroutines; Encoding of Machine Instructions; Accessing I/O Devices; Interrupts- Interrupt Hardware; Enabling and Disabling Interrupts; Handling Multiple Devices; Controlling Device Requests; Exceptions; Direct Memory Access; Standard I/O Interfaces-PCI Bus, SCSI Bus, USB.	
Unit III: The Memory System: Basic Concepts: Semiconductor RAM Memories, read only memories, speed, size, and cost, cache memories- mapping functions, replacement algorithms; cache performance; cache optimization; Virtual memory; Protection: Virtual memory and virtual machines.	
Unit IV: Arithmetic for Computers: Addition and subtraction of signed numbers, design of fast adders, multiplication of positive numbers, signed operand multiplication, fast multiplication, integer division, floating-point numbers and operations.	
Unit V: Pipelining and Parallel Processing: Introduction to Pipelining; Implementation of pipeline; Instruction level parallelism concepts and challenges: Overcoming data hazards with dynamic scheduling; hardware-based speculation; Exploiting ILP using multiple issue and static scheduling; Introduction to multicore architecture.	

Suggested Books:

1. Hayes J. P., (2012), Computer Architecture and Organization, 3rd Edition, McGraw Hill.
2. Morris Mano M., (2017), Computer System Architecture, 3rd Ed, Pearson Education.
3. Hamacher C., and Zvonko V., (2011), Computer Organization, 5th Edition.
4. Hennessey J.L. and Patterson D.A., (2006), Computer Architecture, A Quantitative Approach, 4th Edition, Morgan Kaufmann.
5. Hwang K., (2010), Advanced Computer Architecture Parallelism, Scalability, Programmability, 2nd Edition, Tata Mc Graw Hill.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	1	0	0	1	1	1	2	1	0	1	1	1	2
CO2	2	1	1	1	0	0	1	1	1	2	1	0	0	1	0	1
CO3	1	1	1	1	0	0	1	1	1	2	1	0	0	1	0	1
CO4	2	1	1	1	0	0	1	1	1	2	1	0	1	1	0	1
CO5	2	1	1	1	0	0	1	1	1	2	1	0	2	1	1	0

ADVANCED LINEAR ALGEBRA

Course Objective: The primary objective of this course is to introduce the tools of Linear algebra. This course emphasizes the application of techniques using the vector spaces, basis and dimension, rank of

matrix, change of basis, linear transformations, dual space, inner product space (real and complex),

adjoint of a linear operator, bilinear forms and their properties.

Courses Outcomes: On completion of this course, the student will be able to:
CO1.Appreciate the significance of vector spaces, basis and dimension.
CO2.Compute with the characteristic polynomial, eigenvalues, eigenvectors, and eigenspaces, as well as the geometric and the algebraic multiplicities of an eigenvalue and apply the basic diagonalization result.
CO3.Compute inner products and determine orthogonality on vector spaces, including Gram-Schmidt orthogonalization to obtain orthonormal basis.

Unit-I Vector spaces and its Properties

Unit-II Basis and dimension, rank of matrix, change of basis.

Unit-III Linear transformations -Algebra of linear transformation,

Unit-IV linear functional, dual space, dual basis,

Unit-V linear transformation of direct sum.

Unit-VI Elementary canonical form introductive, Characteristic values ,

Unit-VII Annihilator polynomial. Invariant subspace, direct sum deco potion,

Unit-VIII invariant direct sum, primary decomposition theorem.

Unit-IX Inner product space- inner product(real and complex), adjoint operator hermition form,

Unit-V linear functional and adjoint unitary operator , normal operator .

Unit-XI Bilinear form : Bilinear form , symmetric bilinear form ,

Unit-XII Skew symmetric bilinear form, graphs preserving bilinear form.

Text Books:

1. K. Hoffman and Ray Kunje : Linear Algebra (Prentice - Hall of India private Ltd.)
2. J.S. Golan : Foundations of linear algebra (Kluwer Academic publisher (1995))

Reference Books:

1. M. Artin : Algebra (Prentice - Hall of India private Ltd.)
2. A.G. Hamilton : Linear Algebra (Cambridge University Press (1989))
3. N.S. Gopalkrishanan : University algebra (Wiley Eastern Ltd.)
4. J.S. Golan : Foundations of linear algebra (Kluwer Academic publisher (1995))
5. Henry Helson : Linear Algebra (Hindustan Book Agency (1994))
6. I.N. Herstein : Topics in Algebra, Second edition (Wiley Eastern Ltd.)

OPERATIONS RESEARCH

Course Objectives: One of the objectives of the course is to develop the conjugate duality theory and deal with some numerical techniques to solve a nonlinear problem. Further, the course aims to study
dynamic programming approach to solve different types of problems and to study optimal control problems.

Course Outcomes: After studying this course, the student will be able to

CO1. have studied notions of sub-gradients and directional derivative for nondifferentiable functions.

CO2. understand the use of conjugate functions to develop the theory of conjugate duality.

CO3. know numerical methods like gradient descent method, gradient projection method, Newton's method and conjugate gradient method.

CO4. deal with dynamic programming approach to solve some problems including stage coach problem, allocation problem and linear programming problem. CO5. know both classical and modern approaches in the study of optimal control problems.

Unit -I Nonlinear Programming, Quadratic Programming,

Unit -II Duality in Quadratic Programming Problems,Unconstrained Optimization,

Unit -III Direct search methods, Gradient Method,

Unit -IV Constrained Optimization, Separable Programming.

Unit -V Inventory Models-Deterministic and Probabilistic Models.

Unit -VI Queuing Theory-Characteristics of queuing systems,

Unit -VII Birth and death process, Steady state solutions,

Unit -VIII Single server model (finite and infinite capacities),

Unit -IX Single server model (with SIRO), Models with state dependent arrival and service rates, Waiting time distributions.

Unit -X Replacement Theory-Replacement of assets that deteriorate with time,

Unit -XI Replacement of items that deteriorate suddenly.

Unit -XII Project Scheduling by PERT, CPM.

Text Books:

1. F. S. Hiller and G. J. Leiberman, Introduction to Operations Research (6th Edition), McGraw-Hill International Edition, 1995.

2. G. Hadley, Nonlinear and Dynamic Programming, Addison Wesley.

Reference Books:

1. H. A. Taha, Operations Research –An Introduction, Macmillan.

2. KantiSwarup, P. K. Gupta and Man Mohan, Operations Research, Sultan Chand & Sons, New Delhi.

3. S. S. Rao, Optimization Theory and Applications, Wiley Eastern.

4. N. S. Kambo, Mathematical Programming Techniques, Affiliated East-West Press Pvt. Ltd., NewDelhi.

Fluid Mechanics

Course Objectives: Prepare a foundation to understand the motion of fluid and develop concept, models and techniques which enables to solve the problems of fluid flow and help in advanced studies and research in the broad area of fluid motion.

Course Outcomes: After studying this course the student will be able to

CO1. understand the concept of fluid and their classification, models and approaches to study the fluid flow. formulate mass and momentum conservation principle and obtain solution for no viscous flow.

CO2. Understand the concept of stress and strain in viscous flow and to derive Navier-Stokes equation of motion and solve some exactly solvable problems.

CO3. know Eulerian and Lagrangian methods.

CO4. Understand Conservation Laws, Equation of energy, Irrotational and Rotational Flows, Bernoulli's equation,

Unit I Introduction to Fluids: Concept of fluids, Continuum Hypothesis.

Unit II Fluid Properties: Density, Specific weight, Specific volume.

Unit III Fluid Kinematics: Kinematics of Fluids, Eulerian and Lagrangian methods of description of fluids, Equivalence of Eulerian and Lagrangian methods.

Unit IV Motion of Fluid Elements: General motion of fluid elements, Integrability and compatibility conditions, Strain rate tensor.

Unit V Flow Visualization: Streamlines, Path lines, Streak lines.

Unit VI Special Fluid Lines: Stream function, Vortex lines, Circulation.

Unit VII Stresses in Fluids: Stress tensor, Symmetry of stress tensor.

Unit VIII Stress Transformation: Transformation of stress components from one coordinate system to another, principal axes and principle values of stress tensor

Unit IX Conservation Laws: Equation of conservation of mass, Equation of conservation of momentum, Navier-Stokes equation.

Unit X Conservation of Moments and Energy: Equation of moments of momentum, Equation of energy.

Unit XI Coordinate Systems and Boundary Conditions: Basic equations in different coordinate systems, Boundary conditions.

Unit XII Irrotational and Rotational Flows: Bernoulli's equation, Bernoulli's equation for irrotational flows, Two-dimensional irrotational incompressible flows, Blasius theorem. Circle theorem, Sources, sinks, and doublets in two-dimensional flows.

Reference Books:

1. An Introduction to fluid dynamics, R.K. Rathy, Oxford and IBH Publishing Co.1976.
2. Theoretical Hydrodynamics, L. N. Milne Thomson, Macmillan and Co. Ltd.
3. Fluid Mechanics, L. D. Landau and E.N. Lipschitz, Pergamon Press, London.
4. S. W. Yuan, Foundations of Fluid Mechanics, Prentice-Hall.

Mathematics In Multimedia

Course Objectives: The objective of this course is to provide students with a basic understanding of multimedia systems. This course focuses on topics in multimedia information representation and relevant signal processing aspects, multimedia networking and communications, and multimedia standards especially on the audio, image and video compression. All of these topics are important in multimedia industries.

Course Outcomes: After studying this course the student will be able to

CO 1: Students are expected to achieve a basic understanding of multimedia systems.

CO 2: Students would be able to evaluate more advanced or future multimedia systems.

CO 3: This course will also arouse students' interest in the course and further motivate them towards developing their career in the area of multimedia and internet applications.

Unit I Multimedia: Introduction to Multimedia, Concepts.

Unit II Uses of multimedia.

Unit III Hypertext and hypermedia; Image, video and audio standards.

Unit IV Audio: digital audio, MIDI.

Unit V processing sound, sampling, compression.

Unit VI Video: MPEG compression standards.

Unit VII Compression through spatial.

Unit VIII Temporal redundancy, inter-frame and intra-frame compression.

Unit IX Animation: types, techniques.

Unit X Key frame animation, utility, morphing.

Unit XI Introduction to Virtual Reality (VR), Key concepts and principles of VR.

Unit XII VR applications and its role in multimedia.

Text Books:

1. Mukherjee, Fundamentals of Computer graphics & Multimedia, PHI.

2. Elsom Cook – "Principles of Interactive Multimedia" – McGraw Hill

Reference Books:

1. Sanhker, Multimedia –A Practical Approach, Jaico.

2. Buford J. K. – "Multimedia Systems" – Pearson Education.

MATHEMATICAL MODELING

Course Objectives: The objective of the course is to familiarize the students to understand the concepts to relate the differential equations with mathematical models in the manner of daily life problem, and geometrical and physical meaning of solutions of differential equations.

Course Outcomes: At the end of the course, students will be able to-

CO1.know about the concepts, uses and techniques of differentiation equations
CO2. Solve and use the differential equations in mathematical modeling,
CO3. Relate the biological, medicinal, physical, economic, environmental problems with mathematics and solve them by differential equation methods.

Unit-I Introduction to Mathematical Modeling using Differential Equations: Principles of Mathematical Modeling.

Unit II Compartment Model, Population Models, Framing of Population Model.

Unit III Growth and Decay, Drug absorption (Case of single cold pill, Case of a course of cold pills).

Unit-IV Applications of First Order Differential Equations: Reaction to Stimulus, Alcohol Absorption (Accident Risk), Artificial Kidney Machine,

Unit V The Spread of Technological Innovations, Rocket flight.

Unit-VI Applications of first Order Linear Differential Equations: Sales Response to Advertising, Art Forgeries, Electric Circuits.

Unit VII Pollution of the Great Lakes, Exploited Fish Populations, Neoclassical Economic Growth.

Unit-VIII Applications of Second Order Linear Differential Equations: Mechanical Oscillations, Consumer Buying Behavior.

Unit IX Electrical Networks and Testing for Diabetes.

Unit-X Applications of Systems of Differential Equations to Models: Spring-Mass System, The

Unit XI Dynamics of Arms Races, Epidemics.

Unit XII Interacting Species, Competing Species (The Struggle for Existence).

Text Books:

1. D. N. Burghes, Modelling with Difference Equations, Ellis Harwood and John Wiley.
2. J. N. Kapur, Mathematical Modelling, Willey Eastern Limited, Reprint, 2000.

Reference Books:

1. D. J. G. James and J. J. Macdonald, Case studies in Mathematical Modelling, Stanly Thames, Cheltonham.
2. . M. Crossand and A. O. Moscrcadini, The art of Mathematical Modelling, Ellis Harwood and John Wiley.
3. C. Dyson, Elvery, Principles of Mathematical Modelling, Academic Press, New York.

Wavelet Analysis

Course Objective: To expose the students to the basics of wavelet theory and to illustrate the use of wavelet processing. The student should reach good comprehension in the fields of Fourier series and the Fourier transform, theory of distributions Multi resolution analysis (MRA) Some commonly used wavelet systems.

Course Outcomes: Students are able to

CO1: understand about Fourier transform and difference between Fourier transform and wavelet transform.

CO2: understand wavelet basis and characterize continuous and discrete wavelet transforms

CO3: understand multi resolution analysis and identify various wavelets and evaluate th eir time- frequency resolution properties

CO4: implement discrete wavelet transforms with multidate digital filters

Unit I Fourier analysis: Fourier and inverse Fourier transforms, Convolution and delta function.

Unit II Fourier transform of Square integrable functions.

Unit III Fourier series, Basic Convergence Theory and Poisson's Summation formula.

Unit IV Wavelet Transforms and Time Frequency Analysis: The Gabor Transform. Short-time Fourier transforms and the uncertainty principle.

Unit V The integral wavelet transforms Dyadic wavelets and inversions. Frames.

Unit VI Wavelet Series. Scaling Functions and Wavelets: Multi resolution analysis, scaling functions with finite two scale relations.

Unit VII Direct sum decomposition of L2(R). Linear phase filtering.

Unit VIII Compactly supported wavelets, Wavelets and their duals.

Unit IX Orthogonal Wavelets and Wavelet packets, Example of orthogonal Wavelets.

Unit X Identification of orthogonal two-scale symbols.

Unit XI Construction of Compactly supported orthogonal wavelets.

Unit XII Orthogonal wavelet packets, orthogonal decomposition of wavelet series.

Textbooks

1. E. Hernandez & G. Weiss, A First Course on Wavelets, CRC Press, 1996.

2. L. Prasad & S. S. Iyengar, Wavelet Analysis with Applications to Image Processing, CRC Press, 1997.

Reference Books:

1. C. K. Chui, A First Course in Wavelets, Academic press NY 1996.

2. I. Daubechies, Ten Lectures in Wavelets, Society for Industrial and Applied Maths, 1992.

Fuzzy Sets and Applications

Course Objectives: The main objective of the course is to familiarize the students with the basic concepts of set theory and fuzzy set theory. The course will develop a depth understanding of fuzzy sets and its applications into real life problems. which in turn help in life-long self-learning.

Course Outcomes: At the end of the course, students will be able to-

CO1. Understand the role of membership and fuzzy sets in decision making problems.

CO2. apply knowledge of fuzzy sets to minimize uncertainty in real life scenario.

Unit I Fuzzy sets – Basic definitions, level sets, convex fuzzy sets.

Unit II Basic operations on fuzzy sets – Types of fuzzy sets – Cartesian products.

Unit III Algebraic products bounded sum and difference.

Unit IV Extension principle and application.

Unit V Zadeh extension principle, image and inverse image of fuzzy sets.

Unit VI Fuzzy numbers – Elements of fuzzy arithmetic.

Unit VII Fuzzy relations on fuzzy sets, The union and intersection of fuzzy relation.

Unit VIII Composition of fuzzy relations – Min-max composition and its properties**.** Fuzzy equivalence relation.

Unit IX Fuzzy Decision-Fuzzy linear programming problem. Symmetric fuzzy linear programming problem-

Unit X Fuzzy linear programming with crisp objective function-Fuzzy graph.

Unit XI Fuzzy logic: An overview of classic logic, its connectives – Tautologies – Contradiction fuzzy logic.

Unit XII Fuzzy quantities – Logical connectives for fuzzy logic Applications to control theory.

Text Books:

1. G. J. Klir& B. Yuan, “Fuzzy sets and Fuzzy logic; Theory and Applications”, Prentice Hall of India 1995.

2. K. H. Lee, First Course on Fuzzy theory and Applications”, Springer, 2004

Reference Books:

1. Didier Dubois, Henri M. Prade, “Fuzzy Sets and Systems: Theory and Applications”, Academic Press, 1994.

2. H. J. Zimmermann, Fuzzy set theory and its applications, Allied publishers Ltd., New Delhi, 2001.

Mathematical Statistics

Course objectives: The objective of this course is to provide an understanding for the graduate business student on statistical concepts to include measurements of location and dispersion, probability, probability distributions, sampling, estimation, hypothesis testing, regression, and correlation analysis, multiple regression

Learning Outcomes:

CO1: Demonstrate knowledge of, and properties of, statistical models in common use,

CO2:. Understand the basic principles underlying statistical inference (estimation and hypothesis testing).

CO3: Be able to construct tests and estimators, and derive their properties,

CO4: Demonstrate knowledge of applicable large sample theory of estimators and tests.

Unit 1 Random variables and distribution functions (univariate and multivariate); expectation and moments. Independent random variables,

Unit 2 Marginal and conditional distributions. Characteristic functions.

Unit 3 Uniform, Binomial, Poisson, Geometric and Negative Binomial distributions and their properties**.**

Unit 4 Continuous distributions: Uniform, Normal and Exponential distributions and their properties.

Unit 5 Types of Sampling, errors in sampling, Parameter and Statistic, Tests of Significance: Null Hypothesis,

Unit 6 Alternative Hypothesis, One-tailed, Two-tailed tests. Sampling Attributes:

Unit 7 Tests of Significance for single proportion and difference of proportions. Sampling of Variables.

Unit 8 Sampling Distributions: Chi-Square Distribution,

Unit 9 Moment generating function of Chi-Square and its applications.

Unit 10 Student's - ***t*** distribution. ***F*** and ***Z*** distributions.

Unit 11 Estimation Theory: Characteristics of Estimators, Efficient estimator, Most Efficient estimator,

Unit 12 Minimum variance unbiased estimators. Methods of estimation.

Text Books: S.C. Gupta, Huber, Ross, Stapleton, Durrett , Adams , Schinazi

Reference Books:

1. Gupta, S. C., and Kapoor, V. K. *Fundamentals of Mathematical Statistics*, New Delhi: Sultan Chand & Sons, 2002.
2. E.J. Dudewicz and S.N.Mishra , Modern Mathematical Statistics, John Wiley and Sons, New York, 1988.
3. V.K.Rohatgi An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern New Delhi, 1988(3rd Edn)
4. G.G.Roussas, A First Course in Mathematical Statistics, Addison Wesley Publishing Company, 1973
5. B.L.VanderWaerden, Mathematical Statistics, G.Allen&Unwin Ltd., London, 1968.
6. M. Fisz , Probability Theory and Mathematical Statistics, John Wiley and sons.
7. Baisnab, and Jas, M. *Element of Probability and Statistics*, New Delhi: Tata McGraw Hill, 2001.

Differential Equation and Finite Element Analysis

Course Objectives: This course provides methods to solve non-linear differential equations, Riccati's equation, Monge's method to solve special type of second order partial differential equations, solution of Strum Liouville boundary value problems and an introduction to finite elements method with a focus on one dimensional problem in structures, heat transfer, static and dynamics

Course Learning outcomes: Upon completion of this course student should be able to:

CO 1. Solve non-linear differential equations, partial differential equations of order two with variable coefficients by different methods.

CO2. Understand the solutions of linear homogeneous boundary value problems.

CO3. Acquire the concept and purpose of Finite element methods.

CO4. Apply suitable boundary conditions to a global equation for axis symmetric and dynamic problems and solve them displacements, stress and strains induced.

Unit 1: Non-Linear differential equations of particular form. Riccati's equation - General solution and the solution when one, two or three particular solutions are known.

Unit 2 Total differential equations – necessary and sufficient equations,

Unit 3 Method of solution, geometric meaning of total differential equations.

Unit 4 : Partial differential equations of second order with variable coefficients- Monge's method,

Unit 5 Classification of Second order Partial differential equations with variable coefficients,

Unit 6 Canonical forms, Cauchy's problem for first order partial differential equations,

Unit 7 Method of separation of variables, Laplace wave and diffusion equations.

Unit 8: linear homogeneous boundary value problems. Eigen values and eigen functions, Strum Liouville boundary value problems. Orthogonality of eigen functions, Reality of eigen values.

Unit 9: General theory of finite element methods, Difference between finite element and finite difference, Review of some integral formulae,

Unit 10 Concept of discretization, Convergence requirements,

Unit 11 Different coordinates, One dimensional finite element, shape functions, stiffness matrix,

Unit 12 Connectivity, boundary conditions, equilibrium equation, FEM procedure.

Text Books:

1. Ross S. L., *Differential Equations*, New Delhi: John Wiley and Sons (2004).

2. Raisinghania, M.D. *Advanced Differential Equations*, New Delhi: S.Chand& Company Ltd. 2001

Reference Books:

1. George, F Simmons, *Differential equations with applications and historical notes*, New Delhi: Tata McGraw Hill, 1974.).

2. Sneddon I. N., *Elements of Partial Differential Equations*, New Delhi: Tata McGraw Hill (1957).

3. Piaggio H. T. H., *Differential Equations*,New Delhi: CBS Publisher (2004).

4. Braess, D., Schumaker and Larry L. *Finite Elements: Theory, Fast Solvers, and Applications in Solid Mechanics*, New York: Cambridge University Press, 2001.

5. Desai C. S. *Introductory Finite Element Method*, Boca Raton: CRC Press, 2001.

6.Smith, G. D. *Numerical solution of Partial Differential Equations*, Oxford: Clarendon Press, 1986.

7.Bradie, B. *A friendly introduction to Numerical Analysis,* Delhi: Pearson, 2005.

8.Reddy, J. N. *An introduction to Finite Element Methods,* Delhi: McGraw-Hill Higher Education, 2005.

NUMERICAL ANALYSIS LAB- II

Course Objectives: The aim of this course is to enable students to design and analyze numerical methods to approximate solutions to differential equations and to acquaint students with the latest typesetting skills. This course is devoted to learning basic scientific computing for solving differential equations. The concept and techniques included in this course enable the student to construct and use elementary MATLAB, MATHEMATICA programs for differential equations.

Course Outcomes: After studying this course, the student will be able to

CO1.understand the key ideas, concepts and definitions of the computational algorithms, origins of errors, convergence theorems.

CO2.decide the best numerical method to apply to solve a given differential equation and quantify the error in the numerical (approximate) solution.

CO3.analyze an algorithm's accuracy, efficiency and convergence properties.

CO4: Typeset mathematical formulas, use nested list, tabular & array environments.

Solve (using any software):

1. Solution of Transportation problem by North-West Corner Method.
2. Solution of Transportation problem by Lowest cost entry method.
3. Solve Assignment problem
4. Solve Dual Simplex method
5. Solve mixed integer programming problem.
6. Solution of L.P.P. with one constraint.
7. Solution of L.P.P. with multiple constraints.
8. Local and Global optimization involving one variable.
9. Numerical non-linear local optimization of functions.
10. Numerical non-linear global optimization of functions.
11. Introduction of Footnotes, Sectioning and displayed material in LaTeX.
12. Accents and symbols, Mathematical Typesetting (Elementary and Advanced) in LaTeX.

Text Books:

1. Hamdy A. Taha, "Operations Research an Introduction", 8th Edition, Pearson Education, 2004.
2. F.S.Hillier& G.J. Lieberman, "Introduction to Mathematical programming",McGraw-Hill International Edition, 2010.

Reference Books:

1. S.S. Rao, "Optimization: Theory and Applications", 2nd Edition, Wiley EasternCompany, 2010.
2. Bazaara, Shetty and Sherali, "Non-linear Programming: Theory and Algorithms",Wiley Eastern Company, 2006.
3. Robert E. Larson and John L.Casti, "Principles of Dynamic Programming", reprint, 2011.

CRYPTOGRAPHY

Course Objectives: This course aims at familiarizing the students to cryptography. Classical ciphers and their cryptanalysis have been discussed. Linear feedback shift registers have been studied. RSA and Diffie Hellman key exchange have been described.

Course Outcomes: After studying this course, the student will

CO1. Have been introduced to the concept of secure communication and fundamentals of cryptography.

CO2. Know classical ciphers such as Vigenere Cipher and Hill Cipher.

CO3. Have insight into DES and AES.

CO4. Be familiar with secure random bit generator and linear feedback shift register sequences.

CO5. Know of RSA, attacks on RSA, Diffie-Hellman key exchange and ElGamal, public key cryptosystem.

Unit-I Time estimates for doing arithmetic - Divisibility

Unit-II the Euclidean algorithm –Congruences - Modular exponentiation - Some applications to factoring.

Unit-III Finite Fields - Multiplicative generators

Unit-IV Uniqueness of fields with prime power elements - Quadratic residues and reciprocity.

Unit-V Some simple crypto systems - Digraph transformations -

Unit-VI Enciphering Matrices – Affine enchipering transformations RSA -

Unit-VII Discrete Log - Diffie-Hellman key exchange –

Unit-VIII The Massey – Omura cryptosystem - Digital Signature standard - Computation of discrete log.

Unit-IX Pseudo primes - Strong pseudo primes - Solovay-Strassen Primality test –

Unit-X Miller - Rabin test - Rho method - Fermat factoring and factor bases - Quadratic sieve method.

Unit-XI Elliptic Curves - Elliptic curve primality test - Elliptic Curve factoring -

Unit-XII Pollard's p – 1 method -Elliptic curve reduction modulo n - Lenstras Method.

Text Books:

1. J.A. Buchmann, Introduction to Cryptography, Second Edition, Springer 2003.

Reference Books:

1. Neal Koblitz, "A course in Number Theory and Cryptography", 2nd Edition, Springer-Verlag, 2010.

2. Menezes A, Van Oorschot and Vanstone S.A, "Hand book of Applied Cryptography",Taylor& Francis, 1996.