Revised Syllabus of M.Sc (Mathematics) as per NEP
Department of Mathematics, School of Basic Sciences, CSJMU, Kanpur, UP
(w.e.f Session -2023-2024)

	First Year				Second Year			
	Ist Semester		2nd semester		3rd semester		4th Semester	
S. N	Course Name	Credit/ Total marks	Course Name	Credit/ Total marks	Course Name	Credit/ Total marks	Course Name	Credit/ Total marks
1	Abstract Algebra **Core**	5/100	Complex analysis **Core**	5/100	Measure Theory andI ntegration **Core**	4/100		
2	Real Analysis **Core**	5/100	Partial Differential Equations **Core**	5/100	Probability and stat. **Core**	4/100		
3	Ordinary differential equation **Core**	5/100	Topology **Core**	5/100	Functional Anl. **Core**	4/100	**Elective-3** 1 Numerical analysis 2 Mathematical statics 3 Theory of bounded operators 4 Special th. Of relativity	4/100
4	Linear Algebra **Core**	5/100	**Eective1** 1 Mechanics 2 Integral Eq. and COV 3. Financial Mathematics 4 Number th.	5/100	Fluid dynamics **Core**	4/100	**Elective-4** 1 History and development of Indian mathematics 2. Discrete Mathematics 3 Cryptography	4/100

							4Mathematical Modelling 5. Operations research	
5					Elective-2 1Vadic Ganita 2 Special functions 3. graph theory 4. wavelet analysis	4/100	Numerical analysis Lab	4/100
6	Research project	-	Research project	8/100	Research project (review article)	4/100	Research project	12/200
7	Total credits:	20/400		28/500		24/600		24/500
	Total credits annually	First year 48			Second year 48 (Total 96 credit)			

Department of Mathematics float one minor elective course for other disciplines in Ist Semester

Course Name	Credit/ Total marks	
Integral Transform	4/100	

Course Name and Code of M.Sc. Mathematics Program w.e.f. Session 2023-24

Semester-I, Total Marks: 400, Credit: 20

Sl.No.	Course Code	Name of Paper	Maximum mark	Credit
1	B03U0701T	Abstract Algebra **Core**	100	5
2	B03U0702T	Real Analysis **Core**	100	5
3	B03U0703T	Ordinary Differential Equations **Core**	100	5
4	B03U0704T	Linear Algebra **Core**	100	5
5	B03U0807R	Research Project	-	-

Semester-II, Total Marks: 500, Credit: 28

Sl. No.	Course Code	Name of Paper	Maximum mark	Credit
6	B03U0801T	Complex Analysis **Core**	100	5
7	B03U0802T	Partial Differential Equations **Core**	100	5
8	B03U0803T	Topology **Core**	100	5
9	1. B03U0804T 2. B03U0805T 3. B03U0806T 4. B03U0807T	Elective-1 1 Mechanics 2 Integral equations and Calculus of Variations 3 Financial Mathematics 4 Number Theory	100	5
10	B03U0807R	Research Project	100	8

Semester-III, Total Marks: 600, Credit: 24

Sl. No.	Course Code	Name of Paper	Maximum mark	Credit
11	B03U0901T	Measure Theory and Integration **Core**	100	4
12	B03U0902T	Probability and Statistics **Core**	100	4
13	B03U0903T	Functional Analysis **Core**	100	4
14	B03U0904T	Fluid Dynamics **Core**	100	4
15	**1. B03U0805T** **2. B03U0806T** **3. B03U0807T** **4. B03U0808T**	Elective-2 1. Vedic Ganita 2. Special Functions 3. Graph Theory 4. Wavelet Analysis	100	4
16	B03U0807R	Research Project(Review article)	100	4

Semester-IV, Total Marks: 500, Credit: 24

Sl. No.	Course Code	Name of Paper	Maximum mark	Credit

17	 B03U1001T B03U1002T B03U1003T B03U1004T	Elective-3 1. Numerical Analysis 2 Mathematical Statistics 3 Theory of Bounded Operators 4 Special Theory of Relativity	100	4
18	 B03U1005T B03U1006T B03U1007T B03U1008T B03U1009T	Elective-4 1. History and Development of Indian Mathematics 2. Discrete Mathematics 3. Cryptography 4. Mathematical Modeling **5.** Operation Research	100	4
19	B03U1010P	Numerical Analysis (Lab) **Practical**	100	4
20	B03U1011R	Research Project	200	12

Program: M.Sc. Mathematics
Detailed Syllabus

Semester I

1. **Course Name: Abstract Algebra** **Credit: 05**
   Course Code: B03U0701T **L-4, T-1, P-0**

Upon successful completion of the course, students will be able to:

CO1 .	Learn about Contributions of ancient Indian mathematicians and to perform computations involving the concepts of Vedic maths and Number Theory.
CO2.	Identify ring-theoretic and group-theoretic properties and identify these properties in familiar rings and groups.
CO3.	Provide proofs to simple assertions of ring- and group-theoretic principles.
CO4.	Get a better understanding of later course In algebra and number theory and thus should give students a better platform to study more advanced topics in algebra.
CO5.	Apply the basic concepts of field theory, including field extensions and finite fields.

Syllabus

Unit I (8 Lectures)
Contributions of ancient Indian mathematicians, Contribution of Ramanujan in number theory, Basic concepts of Vedic mathematics, Fundamental theorem of arithmetic, arithmetical functions, Mobious inversion, Congruences, Chinese remainder theorem,

Unit II (8 Lectures)
An overview of Groups, Conjugacy Relation, Class equation, Cauchy's Theorem, Sylow' s theorems and their applications, Normal and Subnormal Series, Composition Series, Jordan – Holder Theorem, Solvable Groups, Nilpotent Groups.

Unit III (8 Lectures)
An overview of Rings and Fields, Prime and Maximal ideals, Quotient rings, unique factorization domain, principal ideal domain, Euclidean domain, Polynomial rings, Gaussian Rings, Irreducible Polynomials.

Unit IV (12 Lectures)
Field extensions, Algebraically Closed Fields, Splitting Fields, Algebraic and Transcendental Extensions, Seperable and inseperable extensions, Normal Extensions, Automorphism of Extensions, Galois Extension.

Unit V (12 Lectures)
Fundamental Theorem of Galois Theory, Construction and representation of finite fields using polynomials over Zp, Modules, Noetherian modules, Hilbert basis theorem.
Recommended Books:

Recommended Books:

1. Serge Lang, Algebra, Addison Wesley, Springer 2005.
2. V. Sahai &V.Bist, Algebra, Second edition, Narosa, CRC Press, 2002
3. I.N. Herstain, Topicin Algebra, Wiley Eastern limited, New Delhi 1975.
4. B.B.Dattaand A.N.Singh, History of Hindu Mathematics, 2Volumes. Bharatiya Kala Prakashan, Delhi, 200l.
5. C. N. Srinivasiengar, The history of Ancient Indian mathematics, World Press, 1988.

2. **Course: Real Analysis**
   Course Code: B03U0702T **L-4, T-1, P-0**

Upon successful completion of the course, students will be able to:

CO1.	Describe the fundamental properties of the real numbers that underpin the formal development of real analysis.
CO2.	Demonstrate an understanding of the theory of sequences and series, continuity, differentiation and integration.
CO3.	Demonstrate skills in constructing rigorous mathematical arguments.
CO4.	Apply the theory in the course to solve a variety of problems at an appropriate level of difficulty.
CO5.	Demonstrate skills in communicating mathematics.

Syllabus

Unit I (7 Lectures)
Elementary set theory, Countable and Uncountable sets, Real number system and its order completeness, Archimedean property, Supremum and Infimum.

Unit II (8 Lectures)

Definition and existence of Riemann-Stieltjes integral, Properties of the integral integration and differentiation, Fundamental theorem of integral calculus, Riemann- Stieljes integration, integration of vector valued functions, Rectifiable curves.

Unit III (9 Lectures)
Uniform convergence of sequences and series of functions, Pointwise and uniform convergence of sequences of functions, Cauchy's criterion for uniform convergence, Weierstrass M-test, Mn-test for uniform convergence, Abel's test and Dirichlet's test for uniform convergence, Bernstein Polynomial, Weierstrass approximation theorem, Power Series, Radius of convergence and Interval of convergence.

Unit IV (8 Lectures)
Functions of several variables, Euclidian spaces, Inner product in R^n space, Norm function in R^n space, Properties of norm function, Schwartz inequality, concept of functional of several variables, Linear transformations and its properties, Derivative as a linear transformation, Projection transformation, Open subset of R^n, Limit, continuous functions, Derivatives in an open subset of R^n.

Unit V (8 Lectures)
Directional derivative, Derivatives of higher order, Chain rule for differentiation, Partial derivatives, Hessian Matrix, Inverse function theorem, Implicit Function theorem and its illustrations with examples.

Recommended Books:

1. GF Simmons, Introduction toTopology and Modern Analysis, McGrawHill,1963.
2. JLKelly, Topology, Von Nostrand Reinhold Co. NewYork, 1995.
3. Walter Rudin, Principles of Mathematical Analysis, McGraw Hill Education, 2017.
4. G.de Barra , Measure Theory and Integration,wood head publishing ltd. 2003.
5. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International Publishers.

3. **Course: Ordinary Differential Equation** **Credit: 05**
Course Code: B03U0703T **L-4, T-1, P-0**

Upon successful completion of the course, students will be able to:

CO1.	Recognize differential equations that can be solved by each of the three methods – direct integration, separation of variables and integrating factor method – and use the appropriate method to solve them.
CO2.	Use an initial condition to find a particular solution of a differential equation, given a

	general solution.
CO3.	Check a solution of a differential equation in explicit or implicit form, by substituting it into the differential equation.
CO4.	Understand the various terms used in of population models and radioactivity.
CO5.	Solve a homogeneous linear system by the Eigen value method.

Syllabus

Unit I (8 Lectures)
Linear ordinary differential equations of higher order with constant coefficients, homogenous and non-homogeneous linear ordinary differential equations, Wronskian, variation of parameters method, reduction of order of equations.

Unit II (8 Lectures)
Power series method of ODE, introduction to initial value problem, existence and uniqueness of solution to initial value problem.

Unit III (8 Lectures)
Picard's and Peano's existence theorems, continuation of solutions and maximum interval of existence, continuous dependence.

Unit IV (8 Lectures)
Boundary value problems for second order equations, Green's function, Strum comparison theorems and oscillations, eigen value problems.

Unit V (8 Lectures)
Two dimensional autonomous systems and phase space analysis, critical points, proper and improper nodes, spiral point and saddle points, asymptotic behavior, stability.

RecommendedBooks:

1. E. A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, McGraw Hill,1955.
2. S.L.Ross, Differential Equations,John Wileysons,NewYork.
3. Shair Ahmad and M.R.MRao, Theory of ordinary differential equations. Affiliated East-WestPressPrivateLtd.NewDelhi, 1999.
4. G.F. Simmons, Differential Equations, McGraw Hill, 1991.
5. E.D. Renville and P.E.Bedient, Elementary Differential Equations, McGraw Hill, 1969.
6. Earl Coddington, An Introduction to Ordinary Differential Equations,Dover Publications Inc. 1989.

4. **Course: Linear Algebra** **Credit: 05**
   Course Code: B03U0801T **L-4, T-1, P-0**

Upon successful completion of the course, students will be able to:

CO1.	Find rank, nullity of linear transformation and its row space and column space.
CO2.	Understand notion of dual space and dual of dual space.
CO3.	Understand concepts of bilinear forms, adjoint operators and spectral theorem.
CO4.	Find geometric and algebraic multiplicity of Eigen values and its relation with diagonalization of matrix.
CO5.	Apply the above concepts to other disciplines.

Syllabus

UnitI
Review of matrices and system of equations, Vector spaces, subspaces, linear dependence, basis, dimension, , dual space, quotient space.
UnitII
Algebra of linear Transformation , representation of linear transformations by matrices, eigen values and eigen vectors, invariant subspaces, annihilating polynomials, triangulation and diagonalization.
UnitIII
Primary decomposition theorem, rational and Jordan form, inner product spaces, orthonormal bases, Gram-Schmidt orthogonalization process.
UnitIV
Linear functionals, adjoint, self adjoint, normal and unitary operators, spectral theorem for normal operators.
Unit V
Bilinear forms, positive forms, quadratic forms.

Recommended Books:
1. K. Hoffman and R. Kunze, Linear Algebra, PHI, 1996.
2. S. Axler, Linear Algebra Done Right, UTM, Springer 1997.
1. G.C. Cullen, Linear Algebra with Applications, Addison Wesley 1997.
2. P. R. Halmos, Finite dimensional vector spaces, Springer Verlag, New York, 1987.

5.Research Project (B03U0807R)

Semester II

1.Course: Complex Analysis **Credit: 05**

Course Code: B03U0704T **L-4, T-1, P-0**

Upon successful completion of the course, students will be able to:

CO1.	Apply the concept and consequences of analyticity and the Cauchy-Riemann equations and of results on Harmonic and entire functions including the fundamental theorem of algebra, Analyze sequences and series of analytic functions and types of convergence.
CO2.	Evaluate complex contour integrals directly and by the fundamental theorem, apply the Cauchy integral.
CO3.	Theorem in its various versions, and the Cauchy integral formula, and represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues.
CO4.	Evaluate complex integrals using the residue theorem.
CO5.	Understand range of analytic functions and concerned results.

Syllabus

Unit I (8 Lectures)
Analytic Function, Cauchy- Riemann Equation, harmonic conjugates, Construction of analytic function, Power series, Radius of Convergence of Power series, Power series representation of an analytic function, Cauchy Hadamard'stheorem.

Unit II (8 Lectures)
Elementary function: Branch Point, Branch cut, branch of multivalued function, Analyticity of branches of Logz, z^a, Mobius transformation, Conformal mapping, Cauchy's theorem, Cauchy integral formula, Morera's theorem, Open mapping theorem, Cauchy's inequality, Liouville's theorem and applications, Taylor's and Laurent's series, Maximum modulus principle and Schwarz's Lemma.

Unit III (8 Lectures)
Singularity: zeroes of an analytic function, Singular point, different types of singularities, limiting point of zeroes and poles, Weierstrass theorem.

Unit IV (8 Lectures)
Calculus of Residue's: Residue at pole, Residue at infinity, Cauchy's residue theorem, Jordan's lemma, Evaluation of real definite integral, evaluation of improper integral.

Unit V (8 Lectures)

Meromorphic function: Number of poles and zeros of a Meromorphic function, Principal of argument and Rouche's theorem, Analytic continuation, Complete analytic function, Uniqueness of analytic continuation, Analytic continuation by means of power series, Scwarz's reflection principle.

Recommended Books:

1. J.B.Conway, Functional of one complex variable, Narosa,1987.
2. L.V.Ahlfors, Complex analysis, McGraw Hil,1986.
3. Churchill, J.W. and Brown,R.V., Complex Analysis,McGrawHill.2009.
4. S.Ponnusamy, Herb Silverman, Complex Variables with Applications, Birkhäuser Boston, MA,2006.

5. **Course: Partial Differential Equation** **Credit : 05**
   Course Code: B03U0802T **L-4, T-1, P-0**

Upon successful completion of the course, students will be able to:

CO1.	Use knowledge of partial differential equations (PDEs), modeling, the general structure of solutions, and analytic and numerical methods for solutions.
CO2.	Formulate physical problems as PDEs using conservation laws.
CO3.	Understand analogies between mathematical descriptions of different (wave) phenomena in physics and engineering.
CO4.	Solve practical PDE problems with finite difference methods, implemented in code, and analyze the consistency, stability and convergence properties of such numerical methods.
CO5.	Interpret solutions in a physical context, such as identifying travelling waves, standing waves, and shock waves.

Syllabus

Unit I (8 Lectures)
Origin of first order partial differential equations, classification, Lagrange's method for solving of first order quasi-linear equations partial differential equations of the form Pp + Qq = R, integral surfaces passing through a given curve, surfaces orthogonal to a given system of surfaces, Cauchy's method for first order partial differential equations

Unit II (8 Lectures)
Non-linear partial differential equations, compatible system of first order equations, Charpit's and Jacobi's methods, Cauchy's method of characteristics, and general solution of higher order linear homogenous and non-homogenous partial differential equations with constant coefficients.

Unit III (8 Lectures)
Genesis of second order partial differential equations, classification, reduction to canonical forms and characteristics.

Unit IV (8 Lectures)
Solutions of boundary value problems by the method of separation of variables, method of separation of variable for wave equation, D'Alembert's solution, vibration of infinite string, vibration of a semi-infinite string, vibration of finite string.

Unit V (8 Lectures)
Hyperbolic Equations: quasi linear equations and the methods of charecterisatics conservation laws and shock waves, kinematic waves and specific Real-world nonlinear problems, introduction, kinematic waves, traffic flow problems, Flood waves in long rivers, Riemanns problem.

Recommended Books:

1. L.C.Evans, Partial Differential Equations, Graduate Studies in Mathematics,Vol.19, AMS,1999.
2. Jurgen Jost, Partial Differential Equations: Graduate Textin Mathematics, Springer Verlag Heidelberg, 1998.
3. Robert C Mcowen, Partial Differential Equations: Methods and Applications, Pearson Education Inc.2003.
4. FritzJohn, Partial Differential Equations, Springer-Verlag,1986.
5. I.N.Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1988.

3 Course: Topology **L-4, T-1, P-0**

Course Code: B03U0803T

Upon successful completion of the course, students will be able to:

CO1.	Understand concepts of complete metric space , continuity, Uniform continuity, Isometry , homeomorphism and related some important theorems.
CO2.	Understand axioms of choice , Zorn's lemma,Well ordering theorem and Cardinal number and its arithmetic.
CO3.	Understand the concepts of topological spaces, concepts of Bases and sub bases and the basic definitions of open sets, neighbourhood, interior, exterior, closure and their axioms for defining topological space.
CO4.	Understand the Characterization of topology in terms of Kuratowski closures perator, continuity, homomorphism, Separation axioms , regular and normal spaces and some important theorems in these spaces.
CO5.	Apply theoretical concepts in topology to understand real world applications

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Syllabus

Unit I (8 Lectures)
Topological Spaces: Definition through open set axioms, Examples including usual topology, Ray, Lower limit and upper limit topologies on R, Co-finite and co-countable topologies, Weak and strong topologies, Algebra of Topologies, Equivalent metrics, Metrizable spaces, Open Set, Neighbourhood, Limit Points, Derived Set, Closed Sets, Closure of a Set, Separated Set, Interior points and the Interior of a Set, Exterior of a Set, Boundary Points, Denseness, Perfect sets.

Unit II (8 Lectures)
Characterization of topologies in terms of closed sets, neighbourhoods and Kuratowski's closure axioms , Base for a topology, Sub-bases, Local base, First Countable Space, Second Countable Space, Relative topology and Subspaces, Hereditary property, Separable Space, Lindeloff theorem. Continuous Function, Open Mapping, Sequential Continuity, Homeomorphism, Topological properties.

Unit III (8 Lectures)
Separation axioms – T_0, T_1, T_2, T_3, $T_{3/2}$, regular space, normal space,completely regular space, completely normal space, T_4 and T_5, their characterizations and basic properties, Urysohn's lemma and Teitze Extension Theorem, Urysohn's Metrization Theorem.

Unit IV (8 Lectures)
Compact Space, Locally Compact Space, Finite Intersection Property, Bolzano Weierstrass Property, Sequentially Compact, Uniformly Continuous, Lebesgue Covering Lemma.

Unit V (8 Lectures)
Connected Set, Disconnected Set, Connectedness on the Real Line, components, Maximal Connected Set, Locally Connected Space and Totally Disconnected Set.

Recommended Books:

1. James R Munkres, Topology, A first course, Prentice Hall, New Delhi, 2000.
2. G. F.Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 1963.
3. J. L. Kelley, Topology, Van Nostr and Reinhold Co. NewYork,1995.
4. K.D. Joshi, Introduction of General Topology, Wiley Eastern Ltd., 1983
5. S. Willard, General Topology, Addison-Wesley Reading, 1970

6. Course: Elective 1 (One of the following E1 is to be chosen)

E1(a) Course Name: Mechanics **L-4, T-1, P-0**

Course Code: B03U0804T

Upon successful completion of the course, students will be able to:

CO1.	Newton’s laws of motion and conservation principles.
CO2.	Introduction to analytical mechanics as a systematic tool for problem solving.
CO3.	Relative motion. Inertial and non-inertial reference frames.
CO4.	Introduction to analytical mechanics as a systematic tool for problem solving.
CO5.	Parameters defining the motion of mechanical systems and their degrees of freedom

Syllabus

Unit I (10 Lectures)
Lagrangian Formulation: Mechanics of a particle, mechanics of a system of particles, constraints, generalized coordinates, generalized velocity, generalized force and potential. D’Alembert’s principle and Lagranges equations, some applications of Lagrangian formulation.

Unit II (10 Lectures)
Hamilton's principle, derivation of Lagrange's equations from Hamilton's principle, extension of Hamilton's principle to non-holonomic systems.

Unit III (10 Lectures)
Hamiltonian formulation: Legendre transformations and the Hamilton equations of motion,cyclic coordinates and conservation theorems, derivation of Hamilton's equations from avariationalprinciple,theprincipleofleastaction,theequationofcanonicaltransformation.

Unit IV (10 Lectures)
Poisson and Lagrange brackets and their invariance under canonical transformation. Jacobi's identity; Poisson's Theorem. Equations of motion infinitesimal canonical transformation inthePoissonbracket.HamiltonJacobiEquationsforHamilton'sprincipalfunction,the harmonic oscillator problem as an example of the Hamilton-Jacobi method.

Recommended Books:

1. H.Goldstein, Classical mechanics, 2ndedition, Narosa Publishing House.
2. W. Rindler, Relevant topics from Special relativity, Oliver & Boyd,1960.

E1(b) Course Name: Integral Equations and Calculus of Variation

Course Code: B03U0805T **L-4, T-1, P-0**

Upon successful completion of the course, students will be able to:

CO1.	Understand what functional are, and have some appreciation of their applications apply the formula that determines stationary paths of a functional to deduce the differential

	equations for stationary paths in simple cases.
CO2.	Use the Euler-Lagrange equation or its first integral to find differential equations for stationary paths.
CO3.	Solve differential equations for stationary paths, subject to boundary conditions, in straightforward cases.
CO4.	Conversion of Volterra Equation to ODE, IVP and BVP to Integral Equation.
CO5.	The concept of Fredholm's first, second and third theorem, Integral Equations with symmetric kernel, Eigen function expansion, Hilbert-Schmidt theorem

.

Syllabus

Unit I (8 Lectures)
Integral equation: Basic concept, solution of an integral equation, conversion of differential equations to integral equations, Intial value problem and boundary value problem, solution of Homogeneous Fredlholm's integral equation of the second kind with Seperable (or Degenerate) Kernel, Fredholm Integral equation with seperable Kernel

Unit II I (8 Lectures)
Complex Hilbert Space,Orthonormal system of functions,Gram-Schmidt Orthonormalization process , Riesz – Fischer Theorem, Symmetric Kernel, Hilbert –Schmidt Theorem , Schmidt's Solution of the Non –Homogeneous Fredholm Integral Equation of second kind

Unit III I (8 Lectures)
SolutionofFredhlomintegralequationofsecondkindbysuccessivesubstitutionandsuccessive approximation, Solution of Voltera integral equation of second kind by successive substitution and successive approximation, Reduction of Voltera integral equation into differential equation, reduction of Voltera integral equation of first kind to a Voltera integral equation of second kind, classical Fredhlom theory.

Unit IV I (8 Lectures)
Variational problems with fixed boundary: Eulear's equation, the Brachistochorn problem, functional, Euler's poission eqution, Extension of the variational case, Isoperimetric problem, variational problem with moving boundaries-: transversality condition, orthogonality conditions, variational problem with moving boundary with implicitfrom, onesided variation.

Unit V I (8 Lectures)
Sufficientconditionforanextremum:Jacobicondition,legendrecondition,,Principle of least action, Lagrenges equation from hamilton's principle, direct method invariational problem: Ritzmethod, Galerkin'smethod, Collocation method and least square method.

Recommended Books:

1. Gupta A.S.,Calculas of Variations with Applications, Prentice hall of India.
2. Elsgolts L., Differential equations and calculus of variations, MIR publisher,1980.

E1(c) Course: Financial Mathematics **L-4, T-1, P-0**
Course Code: B03U0806T

Upon successful completion of the course, students will be able to:

CO1.	To learn the principles of Market model.
CO2.	To analyze different types of Market Models
CO3.	To understand the capital asset pricing model.
CO4.	To apply different Mathematical techniques to solve the problem.

Syllabus

Unit I (10 Lectures)
Introduction- a simple market model: basic notions and assumptions, no– arbitrage principle. Risk-free assets: time value of money, future and present values of a single amount, future and present values of anannuity, Intra-year compounding and discounting, continuous compounding.

Unit II(10 Lectures)
Valuation of bonds and stocks: bond valuation, bond yields, equity valuation by dividend discount model and the P/E ratio approach. Risky assets: risk of a single asset, dynamics of stock prices, binomial tree model, other models, geometrical interpretations of these models, martingale property.

Unit III (10 Lectures)
Portfolio management: risk of a portfolio with two securities and several securities, capital asset pricing model, minimum variance portfolio, some results on minimum variance portfolio. Options: call and put option, put-call parity, European options, American options, bounds on options, variables determining option prices, time value of options.

Unit IV (10 Lectures)
Option valuation: binomial model (European option, American option), Black-Scholes model (Analysis, Black-Scholes equation, Boundary and final conditions, Black-Scholes formulae etc).

Recommended Books:

1. Capinski M. and Zastawniak T., Mathematics for Finance- An introduction to financialengineering, Springer 2003.
2. Teall J. L. and Hasan I., Quantitative methods for finance and investments, Blackwell publishing2002.
3. HullJ.C.,Options, futures and other derivatives, Pearsoneducation2005.
4. Chandra P., Financial Management–Theory and Practice, Tata McGraw Hill 2004.
5. Wilmott P., Howison S. and Dewynne J., The mathematics of financial derivatives- A student introduction, Cambridge university press 1999.

E1(d) Course: Number Theory **L-4, T-1, P-0**
Course Code: B03U0807T

Upon successful completion of the course, students will be able to:

CO1.	Utilize the congruence's, indices, residue classes, Linear congruence's Complete & reduced residue systems and the Euler – Fermate Theorem and Learn Chinese remainder theorem & its application and introduction of Cryptography.
CO2.	Learn more about prime numbers, primality test and analyze Fermat's little Theorem, Wilson theorem, Fermat-Kraitchik factorization method and solve various related problems.
CO3.	Understand order of an integer modulo n, primitive roots of primes and composite numbers, theory of indices and implement of these concepts to cryptography.
CO4.	Understand the concepts of quadratic residues, Legendre's symbol & Jacobi symbol, reciprocity law and implement the concepts to Diophantine equations for Solving different types of problems.
CO5.	Work effectively as part of a group to solve challenging problems in Number Theory.

Syllabus

Unit 1 (10 Lectures)
Introduction to Modular forms: Congruences Residue classes and complete residue system. Linear congruence's. Reduced residue system and the Euler-Fermat theorem. Polynomials congruence's modulo p, Lagrange's theorem. Simultaneous linear congruence's, The Chinese remainder theorem,

Unit II (10 Lectures)
Prime numbers, primality test, Polynomial congruences with prime power modulli, pseudoprime, Carmichael numbers, Wilson's theorem, Fermat-Kraitchik factorization method, Euler's generalization of Fermat's little theorem, modular exponentiation by repeated squaring method.

Unit III (10 Lectures)
Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, theory of indices, application of primitive roots to cryptography.

Unit IV (10 Lectures)
Quadratic residues, Euler's criterion, Legendre's Symbol and its properties Gauss Law, the quadratic reciprocity law, Applications of reciprocity law. The Jacobi symbol and reciprocity law for Jacobi symbols. Applications of reciprocity law to Diophantine equations.

Recommended Books:

1. A course in number theory and cryptography, Neal Koblitz, Springer-Verlag, 1994.
2. An introduction to the theory of number, Ivan Niven, Zuckerman, Montgomery, willy

India edition, 1991.
3. David M.Burton , Elementary number theory, Tata McGraw Hill Edition, 2002.
4. Johannes A. Buchmann , Introduction to cryptography, Springer, 2001.

6. Research Project B03U0807R (8 Credit)

Semester III

1. **Course: Measure Theory and Integration** **L-3, T-1, P-0**

Course Code: B03U0901T

Upon successful completion of the course, students will be able to:

CO1.	Students taking this course will develop an appreciation of the basic concepts of measure theory.
CO2.	These methods will be useful for further study in a range of other fields, e.g. Stochastic calculus, Quantum Theory and Harmonic analysis.
CO3.	The above outcomes are related to the development of the Science Faculty Graduate Attributes, in particular: 1.Research, inquiry and analytical thinking abilities, 4. Communication, 6. Information literacy.
CO4.	Integration and contribute to this classical field of knowledge by solving various problems.
CO5.	Study the properties of Lebesgue integral and compare it with Riemann integral.

Syllabus

Unit I (8 Lectures)
Lebesgue outer measure, Measurable sets, Regularity, Measurable functions, Boreland Lebesgue measurability, Non-measurable sets. Riemann integral, Lebesgue Integration of nonnegative functions, General integral, Comparison of Riemann integral and Lebesgue integrals.

Unit II (8 Lectures)
Dini's four derivatives, Functions of bounded variation, Differentiation of an integral, absolute continuity.

Unit III (8 Lectures)
Measures and outer measures, Measure spaces, Integration with respect to a measure. L p -spaces, Holder and Minkowski inequalities, Completeness of L p -spaces.

Unit IV (8 Lectures)
Convergence in measure, almost uniform convergence, Egorov's theorem, Product measure, Fubini Theorem, Tonelli Theorem.

Unit V (8 Lectures)
Signed measures, HahnandJordan decomposition theorems, Mutually singular measures, Radon-Nikodym theorem, Lebesgue decomposition.

Recommended Books:

1. G.deBarra, Measure Theory and Integration, New Age International(P) Ltd., New Delhi,2014.
2. H.L.Roydenand P.M. Fitzpatrick, Real Analysis, Fourth Edition, Pearson, 2015.

3. **Course: Probability and Statistics** **L-3, T-1, P-0**

   Course Code: B03U0902T

Upon successful completion of the course, students will be able to:

CO1.	Organize, manage and present data. Analyze statistical data using measures of central tendency, dispersion and location.
CO2.	Translate real-world problems into probability models.
CO3.	Derive the probability density function of transformation of random variables.
CO4.	Calculate probabilities, and derive the marginal and conditional distributions of bivariate random variables.
CO5.	Understand critically the problems that are faced in testing of a hypothesis with reference to the errors in decision making.

Syllabus

Unit I (8 Lectures)
Probability: Axiomatic and statistical definition, Properties, addition and multiplications theorem of probability, Conditional probability, Bayes theorem and independence of events, Random variables, Distribution function, Probability mass and density functions, Discrete distribution function, Mathematical Expectation, Moments, Moment generating function and cumulant.

Unit II (8 Lectures)
Probability distributions: Binomial, Geometric, Negative -Binomial, Poisson, Uniform, Exponential, Gamma, Normal distributions, characteristic function, Covariance, Correlation.

Unit III (8 Lectures)
Statistics: Origin of the theory of sampling, Objects of sampling, Population, Sample, Parameters, test of significance, critical region, standard error, Fiducial limit.

Unit IV (8 Lectures)
Test of Hypotheses: z-test and t-test for means, variance, two sample problems and for proportions, Chi-square goodness of fit tests, Contingency tables.

Unit V (8 Lectures)
Estimation Theory: Types of estimation, Unbiasedness, Method of moment, Confidence interval, Relation between confidence intervals and tests of hypotheses, estimation for mean, difference of means, variance and proportions.

Recommended Books:

1. S.C.GuptaandV.K.Kapoor, Fundament also Mathematical Statistics, Sultan Chand & Sons New Delhi.
2. V.K.RohatgiandA.K.Md.EhsanesSaleh,An Introduction to Probability and Statistics", John Wiley and Sons, 2nd edition 2000.
3. R.V.Hogg andA.Craig, Introduction to Mathematical Statistics, Pearson Education, 6th Edition, 2005.

4. **Course: Functional Analysis** **L-3, T-1, P-0**

Course Code: B03U0903T

Upon successful completion of the course, students will be able to:

CO1.	Central concepts from functional analysis, including the Hahn-Banach theorem, the open mapping and closed graph theorems.
CO2.	Banach-Steinhaus theorem, dual spaces, weak convergence, the Banach Analogue theorem, and the spectral theorem for compact self-adjoint operators.
CO3.	The student is able to apply his or her knowledge of functional analysis to solve mathematical problems.
CO4.	Appreciate the role of Inner product space. Understand and apply ideas from the theory of Hilbert spaces to other areas.
CO5.	Understand the fundamentals of spectral theory, and appreciate some of its power.

Syllabus

Unit I (8 Lectures)
Baires Category theorem: Complete Metric space, Category, Baires Category Theorem, Fixed pointtheorem: Contraction Mapping, Banach Fixed Point Theorem.

Unit II (8 Lectures)
Normed Linear Spaces: Linear Metric Space, Normed Linear Space, Basic Normed Linear Spaces.

Unit III (8 Lectures)
Banach Space, Hahn Banach theorem,Open mapping and Closed graph theorems, Uniform boundedness principle.

Unit IV (8 Lectures)
Operator Theory: Linear Operator, Self Adjoint Operators, Compact Operator, Normal and unitary operators.

Unit V (8 Lectures)
Hilbert Spaces: Inner Product Spaces, Orthonormal Sets, Riesz Representation Theorem, Bounded Linear Operator on Hilbert Spaces. Banach Algebras: Normed Algebra, Spectrum, Selfadjoint, normal and unitary operators; Commutative Banach Algebra.

Recommended Books:

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

4.Course: Fluid Dynamics **L-3, T-1, P-0**

Course Code: B03U0904T

Upon successful completion of the course, students will be able to:

CO1.	Describe the physical properties of a fluid.
CO2.	Calculate the pressure distribution for incompressible fluids.
CO3.	Describe the principles of motion for fluids.
CO4.	Identify derivation of basic equations of fluid mechanics.
CO5.	Identify how to derive basic equations and know the related assumptions.

Syllabus

UnitI (8 Lectures)
Introduction to fluid dynamics, Normal and Shearing stress, Different types of flows, Lagrangian and Eulerian method, local and individual time rate of change, velocity potential, vortricity vector, Beltranic flow, stream line and path line, vortricity equation, equation of continuity by Euler'smethod, equation of continuity in orthogonal curvilinear coordinates, cartisian coordinat cylindrical coordinates & spherical polar coordinates.

Unit II (8 Lectures)
Euler's equation of motion, Lamb's hydrodynamical equation ,Conservative field of force, Pressure Equation, Bernoulli's equation for steady motion .

Unit III (8 Lectures)
Viscous flow: Definition of viscosity, general theory of stress and rate of strain in fluid flow,stress analysis in fluid motion, nature of strain, relation between stress and rate of strain,NavierStokesequation,dissipationofenergy,Reynold's.number,studyflowbetweenparallelpla tes ,Laminar flow between parallel plates.

Unit IV (8 Lectures)
Gas dynamics: speed of sound, equation of motion, subsonic, sonic and supersonic flow,isentropic gas flow, Reservoir discharge through a channel of varying cross-section, Shockwaves,formationofshockwaves,elementaryanalysisofnormalshockwaves.

UnitV (8 Lectures)
Magneto Hydrodynamics: nature of magneto hydro dynamics, Maxwell electromagnetic fieldequation, equation of motion of conducting fluid, rate of flow of charge, magnetic Reynold's umber, Alfven's theorem, Ferraro's law of isorotation.

Recommended Books:

1. Hermann Schilichting, Klaus Gersten, Krause E.,Jr.OertelH., MayesC,"Boundary–Layertheory",8th edition springer2004.
2. Kundu, PijushK.,and CohenIraM., fluid mechanics.3rd ed.Burlington, MA:Elsevier,2004.
3. Bachelor G.K, An introduction to fluid dynamics, Publisher, Cambridge University Press,2000.

5.Course: Elective 2 (Any of the following E2 can be chosen) L-3, T-1, P-0

E2(a) Course Name: Vedic Ganita
Course Code: B03U0805T

Upon successful completion of the course, students will be able to:

CO1.	To understand about history of Vedic Ganit.

CO2.	To learn different vedic ganit sutra for fast multiplication.
CO3.	To learn the vedic ganit sutra for squaring the numbers.
CO4.	To apply vedic ganit sutras for fast calculation of division.

Syllabus

Unit I (10 Lectures)
History of Vedic Ganita, Why Vedic Ganita, Silent features of Vedic Ganita, Vedic Ganita formulas, 16 sutras, 13 sub sutras, Terms and operations, High speed addition by using the concept of computing the whole and from left to right, Super fast subtraction by Nikhilam sutram from basis 100,1,000,10,000.

Unit II (10 Lectures)
Multiplication by Urdhav trighbhyam sutram, Multiplication by vinculum sutram. Multiplication by Nikhilam sutram, Fast multiplication by 11, Multiplication of numbers consisting of all 9s, Multiplication of numbers nearest to the base 10 and multiplication of numbers with subbase 50,500,5000.

Unit III (10 Lectures)
Meaning of Ekadhiken sutram and its. applications in finding squaring or numbers ending in5, squares by Anurupeyana sutram, Square by Yavdunam thava dunikritya vargamcha yojyjetsutram, Squaring by Dwandvayoga sutram, Squaring numbers nearest SO, Square roots of perfect square, General method of square roots, Cubesby Anurnpeyana sutram.

Unit IV (10 Lectures)
Decimal and fractions. Division by Nikhilam Sutram, Division of 1/19.1/29 by Ekadhikenpurven sutram, Division by Paravartya sutram, Division by Anurupeyana sutra111.Division of polynomial. Factors of general second-degree equation by Lopsthapanabhyamsutram.

Recommended book.

1. Vedic Mathematics .published by Motilal Oannrasi Dns1965.ISBN81-2 08-0163-6.
2. Vedic Ganita,Vihangam Drishti-1.ShikshaSanskritiUtthanNyasa.NewDelhi.

E2 (b) Special Functions **L-3, T-1, P-0**
Course Code: B03U0806T

Upon successful completion of the course, students will be able to:

CO1.	Explain and Usefulness of this function
CO2.	Classify and explain the functions of different types of differential equations

CO3.	To determine types of PDE this may be solved by applications of Special functions.
CO4.	To analyse properties of Special functions by their integral representation and symmetries.
CO5.	Identified the application of some basic mathematical methods via all these special functions.

Syllabus

Unit I (10 Lectures)
Infinite products: Definition of infinite product, necessary condition for convergence, the associated series of logarithms, absolute convergence, uniform convergence. The gamma function, The beta function, Legendre's duplication formula, Gauss multiplication formula summation formula due to Euler, behavior of log gamma z for log mod z. Asymptotic series,Watson'slemma.

Unit II (10 Lectures)
Hypergeometric function, integral representation, contiguous function relation, hypergeometirc differential equation, logarithmic solution of the hypergeometric function, elementary series manipulation, simple transformation, generalized hypergeometric function, confluent hypergeometric function.

Unit III (10 Lectures)
Bessel function: Definition of Bessel function, Bessel differential equation, recurrence relation, generating function, Bessel integral, modified Bessel functions, Neumann polynomial, Neumannseries. Legendre Polynomial, Hermite polynomial Jacobi Polynomial:Generating function, differential equation, recurrence relation, Rodrigues formula, Hypergeometric form of Legendre polynomial, special properties, orthogonality, an expansion theorem, expansion o fx^{n}.

Unit IV (10 Lectures)
Elliptic function: Doubly periodic function, Elliptic function, elementary properties, order ofan Elliptic function, The Weierstrass function P(z), other Elliptic function, A differential equation for P(z), connection with Ellipticintegral. Theta function: Definition, Elementary properties, the basic properties table. Jacobain Elliptic Function: A differential equation, involving The tafunction, The function sn(u), The function cn(u)and dn(u), relation involving square and derivatives.

Recommended Books:

1. E.D. Rainville, Special function,Mac MillanCo.,1971.
2. L.C.Andrews, Special function of Mathematics for Engineering, SPIEPublications,1997.
3. GeorgeE. Andrews, Richard Askey, Ranjan Roy-Special Functions, Cambridge University Press,1999.

E2(c) Graph Theory **L-3, T-1, P-0**

Course Code: B03U0807T

Upon successful completion of the course, students will be able to:

CO1.	Students will achieve command of the fundamental definitions and concepts of graph theory.
CO2.	Students will understand and apply the core theorems and algorithms, generating examples as needed, and asking the next natural question.
CO3.	Students will achieve proficiency in writing proofs, including those using basic graph theory proof techniques such as bijections, minimal counterexamples, and loaded induction.
CO4.	Students will work on clearly expressing mathematical arguments, in discussions and in their writing
CO5.	Students will become familiar with the major viewpoints and goals of graph theory: classification, extremality, optimization and sharpness, algorithms, and duality

Syllabus

Unit I(10 Lectures)
Graph and its terminology, Directed and undirected graph, Multi graph,Simple graph, Complete graph,Weighted graph, Planarandnon planargraph, Regulargraph, Graph isomorphism and homeomorphism, Euler's formula, Statement and applications of Kuratowski's theorem, Path factorization of a graph, representing graphs in computer system, Coloring of graph.

Unit II(10 Lectures)
Graphconnectivity, Konigsberg bridge problem, Euleriapathand Eleriancircuit, Hamiltonian path and Hamiltonian circuit, Shortest path, Dijkstra's algorithm, Paths betweenthe vertices, Path matrix, Warshall's algorithm, Cut point, bridge, cut sets and connectivity, Menger's theorem.

Unit III (10 Lectures)
Tree and related terminology, spanning tree, Finding minimum spanning tree by Kruskal's algorithm and Prim's algorithm, in order, preorder, and post order tree traversals, Binary tree, Expression tree sand reverse polish notation(RPN), RPN evaluation by stack.

Unit IV(10 Lectures)
Flow network, Feasible flows, Multiple sources and multiple sinks, Cutsets in flow network, Relation between flows and cuts, Max flow problem, Max flow min-cut theorem, Matching,Covering,ApplicationofnetworksinOperationsResearch–CPM/PERT.

Recommended Books:

1. Graph Theory, Harary,Addison- Wesley1969.
2. Introduction to Graph Theory, D. B. West, Prentice Hall1996.
3. Graph Theory and Its Applications, Jonathan Grossand JayYellan,CRC1998.

E2 (d) Wavelet Analysis **L-3, T-1, P-0**

Course Code: B03U0808T

Upon successful completion of the course, students will be able to:

CO1.	To learn about Fourier and Wavelet Transforms.
CO2.	Able to Construct Harr wavelet.
CO3.	To analyze the different types of wavelets.
CO4.	To apply the wavelet transform in signals.

Syllabus

Unit I (10 Lectures)

Review of Fourier Analysis, Wavelet Transform and Time Frequency Analysis: The Gabortrans form, Short time Fourier transforms and the uncertainty principle. The integral wavelet transform–Diadic Wavelets and inversions–Frames.

Unit II (10 Lectures)

Multi Resolution Analysis and Wavelets**:** The Haar wavelet construction – Multi resolution analysis–Riesz basis to orthonormal basis–Sealing function and scaling identity–Construction of wavelet basis.

Unit III (10 Lectures)

Compactly Supported Wavelets: Vanishing moment's property–Meyer's wavelets–Construction of a compactly supported wavelet–Smooth wavelets.

Unit IV (10 Lectures)

Applications: Digital Filters – Discrete wavelet transforms and Multi resolution analysis –Filters for perfect reconstruction – Para unitary filters and orthonormal wavelets – Filter design for orthonormal wavelets–Biorthogonalfilters.

Recommended Books:

1. C.K.Chui, An introduction to Wavelets", Academic Press,SanDiego,CA,1992.
2. P.Wojtaszczyk, A mathematical introduction to Wavelets", London Mathematical Society Student Texts 37, Cambridge UniversityPress,1997.
3. Y.T.Chan, Wavelet Basics, Kluwer Academic Publishers,1995.

Research Project (Review article) B03U0807R **(4 Credit)**

Semester IV

1. **Course: Elective 3 (Any of the following E3 can be chosen)** **L-3, T-1, P-0**

E3 (a) Numerical Analysis

Course Code: B03U1001T

Upon successful completion of the course, students will be able to:

CO1.	To solve the algebraic and transcendental Equation.
CO2.	To solve the linear system of equation using different numerical methods.
CO3.	To understand the interpolation techniques.
CO4.	To able to integrate the functions using Numerical Methods.
CO5.	To solve the various differential equations using Numerical Methods.

Unit I (8 Lectures)

Roots of transcendental equations and polynomial equations, Bisection method, Iteration based on first degree equations, Regula-Falsi methods, Rate of convergence, Generalized Newton-Raphson method.

Unit II (8 Lectures)

System of linear equation: Direct method-: Gauss Elimination method, Triangularization method, Iterative methods-: Jacobi's method, Gauss-Seidel method, SOR method, Givens power method for Eigen value and Eigenvectors.

Unit III (8 Lectures)

Interpolation and Approximation Lagrange's and Newton's divided difference, Finite difference operators, Hermite interpolation, piecewise & cubic spline interpolation, Least square approximation, Min-Max polynomial approximation method, Chebyshev polynomial, Lanczos economization.

Unit IV (8 Lectures)

Newton cotes methods, Method based on undetermined coefficients, Gauss Legendre integration method

Unit V (8 Lectures)

Numerical Methods for ODE: Single step method-Euler's method, Taylor series method,Runge-Kutta method of 2^{nd}and4^{th}order, Numerical methods for BVP, Multi stepmethod-predictor-corrector method, Adams Bash forth method, Adams Moulton method, Milne method, convergence and stability.

Recommended Books:

1. Gerald,C.Fand Wheatly, P.O, Applied Numerical Analysis ",6^{th}edition,Wesley,2002.
2. Jain, M.K, Iyengar, S.R.K and Jain, R.K, "Numerical methods for Scientific and Engineering computation, New Age Pvt. Pub, New-Delhi, 2000.
3. S.S Sastry, Introduction to Numerical Analysis, Prentice Hall, Flied, 2012.
4. Krishnamurthy,E.V&Sen,S.K, Applied Numerical analysis, East West Publication,2001.

E3(b) Mathematical Statistics **L-3, T-1, P-0**

Course Code: B03U1002T

Upon successful completion of the course, students will be able to:

CO1.	Organize, manage and present data. Analyze statistical data using measures of central tendency, dispersion and location.
CO2.	Use the basic probability rules, including additive and multiplicative laws, using the terms, independent and mutually exclusive events.
CO3.	Translate real-world problems into probability models.
CO4.	Derive the probability density function of transformation of random variables and calculate probabilities, and derive the marginal and conditional distributions of variate random variables.
CO5.	Determine properties of point estimators (efficiency, consistency, sufficiency); find minimum variance unbiased estimators; find method of moments and maximum likelihood estimators.

Syllabus

Unit I (8 Lectures)
CORRELATION AND REGRESSION: Method of Least Squares- Linear Regression -Normal Regression Analysis Normal Correlation Analysis Partial and Multiple Correlation -Multiple Linear Regression.

Unit II (8 Lectures)
TESTING OF HYPOTHESIS: Type I and Type II errors Tests based on Normal, t, Chi-squareand F distributions for testing of mean,variance and proportions-Testsfor Independence of attributes and Goodness off it.

Unit III (8 Lectures)
SAMPLINGDISTRIBUTIONSANDESTIMATIONTHEORY: Sampling distributions Characteristics of good estimators Method of Moments, Maximum Likelihood Estimation Interval estimates for mean variance and proportions.

UnitI V (8 Lectures)
DESIGNOFEXPERIMENTS: Analysis of Variance-One-way and two-way Classifications - Completely Randomized Design - Randomized Block Design-Latin Square Design.

UnitV (8 Lectures)
MULTIVARIATE ANALYSIS: Covariance matrix – Correlation Matrix - Normal density function-Principal components-Sample variation by principal components-Principal components by graphing.

Recommended Books:

1. J.E.Freund: Mathematical Statistica, Prentice Hallf India, 5thEdition,2001.
2. R.A.Johnsonand, D.W.Wichern, Applied Multivariate Statistical Analysis, Pearson Education Asia, 5thEdition,2002.
3. S.C.Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 11th Edition, 2003.

E3(c) Theory of Bounded Operators **L-3, T-1, P-0**

Course Code: B03U1003T

Upon successful completion of the course, students will be able to:

CO1.	To understand the theory of Bounded operators.
CO2.	To apply the Banach algebra concepts.
CO3.	To understand the concepts Abelian C*-algebras and functional calculus.
CO4.	To learn Spectral theory for Hilbert space Operators.
CO5.	To Learn Spectral theorem for unbounded normal operators.

Syllabus

Unit I (8 Lectures)
Review of Results on Operators: Basic definitions and results on bounded operators on a Banach space, Dual space, Adjoint of bounded operators on a Hilbert space, Statements of Hahn-Banach theorem, closed graph theorem, and uniform bounded ness principle.

Unit II (8 Lectures)
Banach Algebras and Spectral Theory for Operators on A Banach Space: Properties and examples of Banach algebras, ideals and quotients, Spectrum and Riesz functional calculus on Banach algebras, Spectrum of bounded operators on a Banachspace, Spectral theory of compact operators.

Unit III (8 Lectures)
C*-Algebras: Properties and examples, Abelian C*-algebras and functional calculus, Positive elements in C*-algebra.

Unit IV (8 Lectures)
Spectral theory for Hilbert space Operators Spectral measures and representations of abelian C*-algebras, Spectral theorem for normal operators, some applications of the spectral theorem, Topologies on the space of bounded operators, Commuting operators.

Unit V (8 Lectures)
Unbounded Operators on A Hilbert Spaceand Spectral Theory Closed and closable operators, adjoint and their properties, Symmetric and self adjoint operators, Cayley transform, Spectral theorem for unbounded normal operators.

Recommended books:

1. J.B. Conway, A Course in Functional Analysis. 2 nd Edition, Springer, (Relevant topics from Chapters VII-X), 1997.
2. G.BachmannandL. Naricii, Functional Analysis. Academic Press, 1966.B.V.
3. Limaye,"Functional Analysis. 2ndEdition, New AgeInternational,1996.
4. M.Thamban Nair,(2001/2020).Functional Analysis: A First Course. Prentice Hall of India, PHI-Learning, 2nd Edition,2020

E3 (d) Special Theory of Relativity **L-3, T-1, P-0**

Course Code: B03U1004T

Upon successful completion of the course, students will be able to:

CO1.	To understand the historical account of the theory of relativity.
CO2.	To learn about the space time concepts.
CO3.	To learn about the relativistic correlation of mass and energy.
CO4.	To understand the principle of equivalence in terms of relativity.

Syllabus

Unit I (10 Lectures)
Historical back ground and postulates of special relativity, Relativity of simultaneity. Lorentz.: transformation and its consequences. Relativistic addition of velocities.

Unit II (10 Lectures)
Doppler effect, Space-time diagrams. Time order and Space-time separation of event s. Nullcone, Thetwin-paradox.

Unit III (10 Lectures)
Relativistic mass and momentum, The equivalence of mass and energy, The relativistic force law and dynamics or a single particle, Energy momentum tensor of incoherent matter.

Unit IV (10 Lectures)
Principle of equivalence. Principle of general covariance. Criteria for gravitational field equations. Einstein field equations, Gravityasa geometric Phenomenon. The energy momentum tensor, Inclusion of forcesinthe field equations and their classical limits.

Recommended books:

1. Rindler W.,Special Relativity,1966.
2. Resnick, R.,Introduction to specialrelativity,Wiley-Eastern,1990.
3. Ajoy Ghatak, Special Theory of Relativity, Anshan Publishers-2009.

Course: Elective 4 (Any of the following E4 can be chosen) L-3, T-1, P-0

E4 (a) History and Development of Indian Mathematics

Course Code: B03U1005T

Upon successful completion of the course, students will be able to:

CO1.	To understand the contribution of decimal system and place value.
CO2.	To learn about the contribution of different great Mathematicians.
CO3.	To learn about the work in number system of different great Mathematicians.
CO4.	To learn about the Srinivasa Ramanujan.

Syllabus

Unit I (10 Lectures)
Indian contributions to decimal system and place value, The mathematical sophistication of the Harappan culture, The Vedic period and the sulva geometry.

Unit II (10 Lectures)
Contribution of the Jainas, Chandas Sutras of Pingala and binaryarithmetic, The Baksali Manuscript, Aryabhata I,Varahamihir, Brahmagupta, Bhaskara I.

Unit III (10 Lectures)
Contributions of Sridharacharya, Mahaveeracharya, Shripati, AryabhataII, Bhaskaracharya11, Contributions of Kerala Schoolas Madhava, Nilkantha.

Unit IV (10 Lectures)
Contributions of Srinivasa Ramanujan, Swami Bharati Krishna Tirthaji, Prasanta Chandra Mahalanobis. Prof. Harishchandra.

Recommended books:

1. B.B.Dattaand A.N.Singh, History of Hindu Mathematics, 2Volumes. Bharatiya Kala Prakashan,Delhi,200l.
2. C. N. Srinivasiengar, The history of Ancient Indian mathematics, World Press, 1988.

E4 (b) Discrete Mathematics L-3, T-1, P-0

Course Code: B03U1006T

Upon successful completion of the course, students will be able to:

CO1.	Have the knowledge of Fibonacci sequence, linear recurrence relations with constant coefficients.

CO2.	Construct generating function and study its application to counting and in solving recurrence relations.
CO3.	Simplify logic and Boolean circuits using K-maps.
CO4.	Find principle disjunctive & conjunctive normal forms and application of inference theory.
CO5.	Grasp the concepts of relations.

Syllabus

Unit I (8 Lectures)
Logic: Introduction to logic, Rules of Inference, Validity of arguments, Normal forms, Direct and Indirect proofs, Proof by contradiction.

Unit II (8 Lectures)
Recurrence relations with examples of Fibonacci numbers, the tower of Hanoi problem, Difference equation, Generating function, solution of recurrence relation using generating functions.

Unit III (8 Lectures)
Definition and types of relations, representing relations using digraphs and matrices, closureof relations, paths in diagraph, Transitive closure using Warshall's algorithm, Posets, Hassediagram,Lattices.

Unit IV (8 Lectures)
Boolean algebra and Boolean functions, different representations of Boolean function, application to synthesis of circuits, circuitminimization and simplification, Karnaughmap.

Unit V (8 Lectures)
Automata theory,Finite state automaton, Types of automaton, Deterministicfinite stateautomaton,Non-deterministicfinitestateautomaton,Non-deterministic finite state automaton with ϵ , Equivalence of NFA and DFA, Equivalence of NFA and NFA-ϵ , Equivalence ofNFA-ϵand DFA, Finite state machines :Moore and Mealy machine and their conversion, Turning machine.

Recommended Books:

1. C.LLiu, Elements of Discrete Mathematics,TataMcGraw- Hill,2000.
2. Kenneth Rosen, WCBMcGraw-Hill, 6thedition,2004.
3. J.PTremblayandR.PManohar, Discrete Mathematical structures with Application to Computerscience,McGraw-Hill(1975).

E4 (c) Cryptography **L-3, T-1, P-0**

Course Code: B03U1007T

Upon successful completion of the course, students will be able to

CO1.	Understand fundamental concepts of cryptography.
CO2.	Describe the difference among symmetric, asymmetric and public key Cryptography.
CO3.	Define basic requirements of cryptography.
CO4.	Apply concepts of Encryption & Decryption.
CO5.	Describe the process for implementing cryptographic systems

Syllabus

Unit I (8 Lectures)
Introduction to cryptology : Monoalphabatic and Polyalphabatic cipher, The Shift Cipher, The Substitution Cipher, The Affine Cipher, The Vigenere Cipher, The Hill Cipher, Cryptanalysis, Some Cryptanalytic Attacks, Stream & Block ciphers, Mode of operations in block cipher.

Unit II (8 Lectures)
Shannon's Theory of Perfect Secrecy: Perfect Secrecy, Random Numbers, Pseudorandom Numbers. DES & AES: The Data Encryption Standard (DES), Feistel Ciphers, Description of DES, Security analysis of DES, Differential & Linear Cryptanalysis of DES, The Advanced Encryption Standard(AES), Description of AES, analysis of AES, Prime Number Generation: Trial Division, Fermat Test, Carmichael Numbers, Miller Rabin Test

Unit III (10 Lectures)
Public Key Cryptography: Principle of Public Key Cryptography, *RSA Cryptosystem*, Factoring problem, Cryptanalysis of RSA, Quadratic Residue Problem, Diffie-Hellman (DH) Key Exchange Protocol, Discrete Logarithm Problem (DLP), *ElGamal Cryptosystem*, ElGamal & DH, Algorithms for DLP. Elliptic Curve, Elliptic Curve Cryptosystem (ECC), Elliptic Curve Discrete Logarithm Problem (ECDLP).

Unit IV (6 Lectures)
Cryptographic Hash Functions: Hash and Compression Functions, Security of Hash Functions, Message Authentication Codes.

Unit V (8 Lectures)
Digital Signatures: Security Requirements for Signature Schemes, Signature and Hash Functions, RSA Signature, ElGamal Signature, Digital Signature Algorithm (DSA), ECDSA

Recommended Books:
1. Wenbo Mao, Modern Cryptography: Theory and Practice. Pearsion Education, 2004
2. W Starling, Cryptography and Network security, Pearson Education, 2004.
3. J Buchmann, Introduction to Cryptography, Springer (India) 2004
4. D R Stinson, Cryptography: Theory and Practice. CRC Press, 2000.
5. Bruce Schenier, Applied cryptography, John Wiley & Sons, 1996.
6. B Forouzan, Cryptography and Network security, Tata McGraw Hill, 2011

E 4 (d) Mathematical Modeling

Course Code: B03U1008T

Upon successful completion of the course, students will be able to:

CO1.	To Understand the theory of mathematical modeling.
CO2.	To make the mathematical model of real life problems.
CO3.	To solve mathematical model using various techniques.
CO4.	To apply basic Theory of linear difference equations with constant coefficients.
CO5.	To apply Mathematical Modeling through partial differential equations.

Syllabus

Unit I (10 Lectures)
Introduction to mathematical modeling: need, classification, modeling process, Elementary Mathematical models; Role of mathematics in problem solving. Single species population model: The exponential model and the logistic model, Harvesting model and its critical value.

Unit II (10 Lectures)
Modeling with ordinary differential equations: Overview of basic concepts in ODE and stability of solutions: steady state and their local and global stability, Linear and non-linear growth and··decay models. Compartment models. Mathematical modeling of geometrical problems , reaction kinetics. Some applications in economics, ecology, Modeling in epidemiology (SIS, SIR, SIRS models) and basic reproduction number.

Unit III (10 Lectures)
Mathematical models through difference equations, Some simple models, Basic Theory of linear difference equations with constant coefficients, Mathematical modeling through difference equations in economics and finance, Mathematical modeling through difference equation in population dynamics.

Unit IV (10 Lectures)
Mathematical Modeling through partial differential equations, Situations giving rise to ofpartialdifferentialequationmodels.Theone-dimensionalheatequation: derivation and solution. Wave equation: Derivation and Solution.

Recommended Books:

1. 1J.N.Kapur, Mathematical Modelling, New AgeIntern. Pub.
2. J.N.Kapur, Mathematical Models in Biology and Medicine,East-WestPress.
3. Fred Brauerand CarlosCastillo-Chavez, Mathematical Modelsin Population Biologyand Epidemiology, Springer.
4. WalterJ.Meyer,Concept of Mathematical Modelling, McGraw-Hill.
5. Zafar Ahsan, Differential Equations and Their Applications, PHI learning Private Limited, New Delhi.

E4 (e) Operations Research

Course Code: B03U1009T

Upon successful completion of the course, students will be able to:

CO1.	Formulate and solve the LPP including those that lead to cycling and degeneracy.
CO2.	Apply integer programming to the LPP's where integer solution is sought.
CO3.	Solve transportation and assignment problems and their importance.
CO4.	Apply the above concepts to real life problems.
CO5.	Simulate different real life probabilistic situations using Monte Carlo simulation technique.

Syllabus

Unit I (8 Lectures)
Origin of OR and its definition, Phases of OR problem approach, Formulation of Linear Programming problems, Graphical solution of LPP.

Unit II (8 Lectures)
Solution of LPP by Simplex method, Two phase method, Big-Mmethod, Methods to solve degeneracy in LPP, Revised Simplex Methods and applications.

Unit III (8 Lectures)
Concept of duality in LPP, Comparison of solutions of Dual and Primal, Dual Simplex method, Sensitivity Analysis, Integer Programming.

Unit IV (8 Lectures)
Mathematical formulation Of Transportation problem, Tabular representation, Methods to find initial basic feasible solution, Optimality test, Method of finding Optimal solution, Degeneracy in Transportation problem, Unbalanced Transportation problem, MathematicalformulationofAssignmentproblem,HungarianAssignmentmethod.

Unit V (8 Lectures)
Theory of Games: Introduction, Two-Person Zero-Sum Games, Saddle point, Maximin-Minimax Criteria for Optimal Strategy, Minimax Theorem, Principle of Dominance, Graphical Method, Arithmetic Method, Game without Saddle Points- Mixed Strategies, Solution of Games by LPP.

Recommended Books:

1. Rao,S.S,Optimization theory and applications, 2ndedition,WilleyEasternLtd.,New-Delhi.
2. Hiller,F.S and Liberman, Introduction to Operations Research, 6th Ed. McGraw-Hill,InternationalEdition,IndustrialEngg.Series,1995.
3. Taha,H.A,Operations Research, An Introduction,8thEd,PrenticeHallPublishers.
4. Gupta,P.K,Hira,D.S, Operations Research, S.Chand&CompanyPvt.Ltd.
5. Sharma,S.D,Operations Research ,Kedar Nath Ram Nathand Co.Meerut,2002.

4. **Numerical Analysis (Lab)** **L-0, T-0, P-4**

Lab Code: B03U1010P

Upon successful completion of the course, students will be able to:

CO1.	Write computer programs to solve engineering problems with MATLAB/maple and/or C Language
CO2.	Implement numerical methods in MATLAB/ maple / C Language.
CO3.	Analyze the stability of algorithm.
CO4.	Analyze and evaluate the accuracy of common numerical methods.
CO5.	Ability to use approximation algorithm in real world problem

Syllabus

Unit 1
Bisection method, fixed point iteration scheme, Newton-Raphson method, secant method
Unit II
Gaussian elimination, Jacobi, Gauss Seidel methods, LU Decomposition.
Unit III
Lagrange's interpolation formula, Newton's divided difference formula.
Unit IV
Trapezoidal rule, Simpson's 1/3,3/8-rules.
Unit V
Euler's method modified Euler's method, Runge-Kutta method, Milne's method, Adams-predictor-corrector method.

Recommended Books:

1. W. H. Press, B. P. Flannery, S. A. Teukolsky, W. T. Vetterling, "Numerical Recipes in C", Cambridge University Press, 1st edition,1988.
2. M. Pal, Numerical Analysis for Scientists and Engineers: Theory and C Programs, Narosa, 2008.

Research Project (12 Credit) B03U1011R

Department of Mathematics float one minor elective course for other disciplines in Ist Semester

Integral Transform (Minor) **L-3, T-1, P-0**
Course Code: B03U0705T

CO1.	Solve differential equations with initial conditions using Laplace transform.
CO2.	Evaluate the Fourier transform of a continuous function.
CO3.	Axisymmetric problems in cylindrical polar coordinates are solved with Hankel transform.
CO4.	Analyzing the behavior of many functions with Mellin Tansform.
CO5.	Students will gain a range of techniques employing the Laplace and Fourier Transforms in the solution of ordinary and partial differential equations. They will also have an appreciation of generalized functions, their calculus and applications.

Syllabus

Unit I (8 Lectures)

Laplace Transform: Existence of Laplace Transform, Function of exponential order, a function of Class A, Laplace Transform of some elementary function, First and Second translation, change of scale property, Laplace transform of the derivative, Laplace transform of Integral, Multiplication, Division, Periodic function.

Unit II (8 Lectures)

Inverse Laplace Transform: Null Function, Lerch's Theorem, first and second Translation, Change of scale, Derivatives, Integrals, Multiplication, Division, Convolution Theorem, Heviside's expansion, The complex inversion formula.
Applications: Solution of Ordinary Differential equations. Solution of Simultaneous Ordinary differential equations, Solution of Partial differential equation, Application to Electric circuits, Mechanics. Integral equations, Initial and Boundary value problem.

Unit III (8 Lectures)

Fourier Integral theorem, Fourier Transform, Convolution, Relation between Fourier and Laplace Transform, Parseval's Indentity for Fourier Transform, Relationship between Fourier and Laplace Transforms, Fourier Transform of derivative of function, Finite Fourier Transform, Application of Fourier transform in Initial and Boundary value problems.

Unit IV (8 Lectures)

Hankel Transfrom, Inversion formula for the Hankel Transform, Some important results for Bessel function, Hankel Transform of derivative of Function, Parsevals Theorem, Finite Hankel Transform, Application of Hankel Transform in initial and Boundary value Problems.

Unit V (8 Lectures)

Mellin Transform, The Mellin inversion Theorem, Linear property, some elementary properties, Mellin transform of derivative, Mellin transform of Integral, convolution Theorem Z-transform.

Recommended Books:

1. Ian N Senddon,The Use of Integral Transform,McGraw Hill,1972.
2. L. Dobanth and D. Bhatta, Integral Transforms and Their Applications, 2nd edition, Taylor and Francis Group, 2003.
3. E.Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2011.