Scheme & Syllabus

of

M. Sc. (Mathematics)

DEPARTMENT OF MATHEMATICS

Vision

The Department of Mathematics, SLIET, has always strived to be among the best Mathematics Departments in the country and has worked towards becoming a centre for advanced research in various areas of mathematics so that it can contribute to the development of the nation.

Mission

- To work towards transformation of young people to competent and motivated professionals with sound theoretical and practical knowledge.
- To make students aware of technology to explore mathematical concepts through activities and experimentation.
- To produce post-graduate students with strong foundation to join research or to serve in industry.
- To create an atmosphere conducive to high class research and to produce researchers with clear thinking and determination who can, in future, become experts in relevant areas of mathematics.
- To inculcate in students the ability to apply mathematical and computational skills to model, formulate and solve real life applications.
- To make the students capable of discharging professional, social and economic responsibilities ethically.

M.Sc. (MATHEMATICS) 2 YEAR PROGRAMME

(SEMESTER SYSTEM)

Mathematics is the backbone of science and engineering. Its utility in the emerging areas of science, engineering and technology is increasing day by day. Considering its importance, the Department of Mathematics feels encouraged to propose the scheme and syllabi of M.Sc. (Mathematics). After thorough deliberations and discussions and keeping syllabi of Indian universities in mind, the proposed syllabi contains various topics on pure, applied and computational mathematics. The course would be beneficial to student community for their academic growth and employment.

NUMBER OF SEATS: 25

ELEGIBILITY: B.A./B. Sc.with Mathematics as one of the subject.

PROGRAMME EDUCATIONAL OBJECTIVES:

- To provide students with knowledge and insight in mathematics so that they are able to work as mathematical professionals.
- To prepare them to pursue higher studies and conduct research.
- To train students to deal with the problems faced by industry through knowledge of mathematics and scientific computational techniques.
- To provide students with knowledge and capability in formulating and analysis of mathematical models in real life applications.
- To introduce the fundamentals of mathematics to students and strengthen the student's logical and analytical ability.
- To provide a holistic approach in learning through well designed courses involving fundamental concepts and state-of-the-art techniques in the respective fields.

PROGRAMME OUTCOMES:

The successful completion of this program will enable the students to:

1. Apply knowledge of mathematics to solve complex problems.
2. Identify the problems and formulate mathematical models.
3. Design the solutions for real life problems.
4. Analyse and interpret data to provide valid inferences.
5. Apply modern techniques to obtain solutions of mathematical problems.
6. Take the responsibility for mathematics practice.
7. Demonstrate the mathematics knowledge for sustainable development.
8. Apply ethical principles and commit to professional ethics.
9. Function effectively as an individual and as a member/leader in multidisciplinary groups.
10. Communicate mathematics effectively and make effective presentations.
11. Handle projects in mathematics independently or in multidisciplinary environments.
12. Recognise the need for society and engage in lifelong preparedness for technological advancement of the nation.

STUDY SCHEME:

M.Sc. (MATHEMATICS) (2 YEARS; 4 SEMESTERS)

SEMESTER-I AUG TO DEC (INCLUDING EXAMINATION)

SN	SUB CODE	SUBJECT TITLE	L	T	P	CREDITS
1	MA 8101	REAL ANALYSIS	4	1	0	5
2	MA 8102	NUMBER THEORY	4	1	0	5
3	MA 8103	ABSTRACT ALGEBRA	4	1	0	5
4	MA 8104	CLASSICAL MECHANICS	4	1	0	5
5	MA 8105	DIFFERENTIAL EQUATIONS	4	1	0	5
		TOTAL	20	5	0	25

SEMESTER-II JAN TO MAY (INCLUDING EXAMINATION)

SN	SUB CODE	SUBJECT TITLE	L	T	P	CREDITS
1	MA 8201	LEBESGUE MEASURE AND INTEGRATION	4	1	0	5
2	MA 8202	COMPLEX ANALYSIS	4	1	0	5
3	MA 8203	LINEAR ALGEBRA	4	1	0	5
4	MA 8204	OPERATIONS RESEARCH	4	1	0	5
5	MA 8205	C- PROGRAMMING	3	0	0	3
6	MA-8251	C- PROGRAMMING LAB	0	0	2	1
		TOTAL	19	4	2	24

SEMESTER-III AUG TO DEC (INCLUDING EXAMINATION)

SN	SUB CODE	SUBJECT TITLE	L	T	P	CREDITS
1	MA 9101	TOPOLOGY	4	1	0	5
2	MA 9102	MATHEMATICAL METHODS	4	1	0	5
3	MA 9103	MATHEMATICAL STATISTICS	4	1	0	5
4	MA 9104	NUMERICAL ANALYSIS	4	0	0	4
5	MA 9151	NUMERICAL ANALYSIS LAB	0	0	2	1
6	MA 910--	ELECTIVE-I*	4	1	0	5
		TOTAL	20	4	2	25

*Students have to opt any one subject from the list of electives for semester-III.

SEMESTER-IV JAN TO MAY (INCLUDING EXAMINATION)

SN	SUB CODE	SUBJECT TITLE	L	T	P	CREDITS
1	MA 9201	FUNCTIONAL ANALYSIS	4	1	0	5
2	MA 9202	ALGEBRAIC CODING THEORY	4	1	0	5
3	MA 9203	TENSORS AND DIFFERENTIAL GEOMETRY	4	1	0	5
4	MA 9251	SOFTWARE LAB USING MATHEMATICA, MATLAB AND LATEX	0	0	6	3
5	MA 920--	ELECTIVE-II**	4	1	0	5
6	MA 920--	ELECTIVE-III**	4	1	0	5
		TOTAL	20	5	6	28

**Students have to opt any two subjects from the list of electives for Semester-IV.

LIST OF ELECTIVE SUBJECTS FOR SEMESTER-III (Any one**)**

MA 9105 GENERAL RELATIVITY AND COSMOLOGY

MA 9106 FLUID DYNAMICS

MA 9107 DISCRETE MATHEMATICS

MA 9108 ADVANCED ABSTRACT ALGEBRA

LIST OF ELECTIVE SUBJECTS FOR SEMESTER-IV (Any two**)**

MA 9204 ADVANCED NUMERICAL ANALYSIS

MA 9205 ADVANCED OPERATIONS RESEARCH

MA 9206 MATHEMATICAL THEORY OF SEISMOLOGY

MA 9207 WAVELET ANALYSIS

MA 9208 THEORY OF LINEAR OPERATORS

MA 9209 ADVANCED COMPLEX ANALYSIS

NOTE: Elective courses shall be offered depending upon the availability of the faculty in the Department as well as sufficient number of students in one course.

ASSESSMENT

Assessment will be done as per institute rules.

SEMESTER- I

MA 8101 REAL ANALYSIS

L	T	P	C
4	1	0	5

Course Objectives: This course presents a rigorous treatment of fundamental concepts in analysis. To introduce students to the fundamentals of mathematical analysis and reading and writing mathematical proofs. The aim is to understand the axiomatic foundation of the real number system, in particular the notion of completeness and some of its consequences; understand the concepts of limits, continuity, differentiability, and integrability, rigorously defined; Students will attain a basic level of competency in developing their own mathematical arguments and communicating them to others in writing.

UNIT- I

Elementary set theory, finite, countable and uncountable sets. Metric spaces: definition and examples, open and closed sets, Compact sets, elementary properties of compact sets, k- cells, compactness of k-cells, compact subsets of Euclidean space R^k, Heine Borel theorem, Perfect sets, Cantor set, Separated sets, connected sets in a metric space, connected subsets of real line.

UNIT- II

Convergent sequences (in Metric spaces), Cauchy sequences, sub sequences, Complete metric space, Cantor's intersection theorem, category of a set and Baire's category theorem. Examples of complete metric space, Banach contraction principle.

UNIT- III

Limits of functions (in Metric spaces), Continuous functions, continuity and compactness, Continuity and connectedness, Discontinuities, Monotonic functions, Uniform continuity.

UNIT- IV

Riemann Stieltje's Integral: Definition and existence of Riemann Stieltjes Integral, Properties of integral, integration and differentiation, Fundamental theorem of Calculus, 1^{st} and 2^{nd} mean value theorems for Riemann Stieltje's integral, Integration of vector valued functions, Rectifiable curves.

Course Outcomes (CO):
Upon completion of this course, the student will be able to:

1) Understand basic properties of R, such as its characterization as a complete and ordered field, Archimedean Property, density of Q and R/Q and uncountability of each interval.
2) Classify and explain open and closed sets, limit points, convergent and Cauchy convergent sequences, complete spaces, compactness, connectedness, and uniform continuity etc. in a metric space.
3) Know how completeness, continuity and other notions are generalized from the real line to metric spaces.
4) Determine the Riemann-Stieltjes integrability of a bonded function and prove a selection of theorems concerning integration.

CO/PO Mapping												
(S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
Cos	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S	S	M		M	M		
CO2	S	S	S	S	S	S	M		M	M		
CO3	S	S	S	S	S	S	M		M	M		
CO4	S	S	S	S	S	S	M		M	M		

RECOMMENDED BOOKS

1. Walter Rudin, Principles of Mathematical Analysis, 3rd edition, McGraw-Hill (2013).
2. H.L. Royden, P.M. Fitzpatrick, Real Analysis, 4rd edition, Prentice Hall of India2010.
3. Tom M. Apostol, Mathematical Analysis, Pearson (1974).
4. G. F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw-Hill (2008).

MA 8102 NUMBER THEORY

L	T	P	C
4	1	0	5

Course Objectives : This course will introduce some of the fundamental theorems and results of number theory. Students will have a knowledge of congruences, solve equations involving congruences and will understand the development of basics of theory of numbers.

UNIT I

Divisibility, Greatest common divisor, Euclidean algorithm, Diophantine equation ax + by=c, Primes, fundamental theorem of arithmetic, basic properties of congruences, residue classes, linear congruences, Chinese remainder theorem, theorems of Euler, Fermat and Wilson.

UNIT II

Arithmetical functions, sum and number of divisors, Moebius inversion formula, greatest integer function, Euler's phi function, Euler's theorem, Some properties of phi function, congruences of higher degree, congruences of prime power moduli and prime modulus, power residue.

UNIT III

Order of an integer modulo n, primitive rootsfor primes, composite numbers having primitive roots, theory of indices, Quadratic residue, Euler's criterion, Legendre symbols, Gauss's lemma and reciprocity law. Jacobi symbol. Perfect numbers, Fermat numbers.

UNIT IV

Farey series, rational approximation, Hurwitz theorem, irrational numbers, irrationality of e and π. Representation of the real numbers by decimals. Finite continued fractions, infinite simple continued fractions, periodic continued fractions, approximation by convergence, best possible approximation.

Course Outcomes (CO):
Upon completion of this course, the student will be able to:

1) Understand the operations with congruences, and solve linear congruences, use Chinese Remainder Theorem.
2) Learn the properties of arithmetic functions and also solve congruences of higher degree.
3) Determine the solubility of quadratic congruence by computation of Legendre symbol.
4) Understand continued fractions and approximate real numbers by rational numbers.

CO/PO Mapping
(S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak

Cos	Programme Outcomes (Pos)										
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S	S	S	M	M	M		
CO2	S	S	S	S	S	S	S		M	M		
CO3	S	S	S	S	S	S	S	M	M	M		
CO4	S	S	S	S	S	S	S	M	M	M		

RecommendedBooks:

1. G.H. Hardy and E.M. Wright, Theory of Numbers, Oxford Science Publications(2003).
2. I. Niven and H.S. Zuckerman, Introduction to the Theory of Numbers, John Wiley &Sons (1960).
3. D.M. Burton, Elementary Number Theory, Tata McGraw-Hill (2006).
4. H. Davenport, Higher Arithmetic, Cambridge University Press (1999).

MA-8103 ABSTRACT ALGEBRA

L	T	P	C
4	1	0	5

Course Objectives: Study of algebra is a tool for understanding geometry rigorously. The objective of the course is to introduce basic structures of algebra like groups, rings and fields.Hence, the main pillar to tackle real life problems. The course gives the students a good mathematical maturity and enables to build mathematical thinking and skill.

UNIT- I

Review of basic concepts of groups with emphasis on exercises, order of group, subgroup, some counting principles, coset and Lagrange's theorem, cyclic groups, normal subgroups and quotient groups, homomorphisms, fundamental theorem of homomorphism and isomorphism. Group of automorphism.

UNIT- II

Review of permutation groups, Alternating group and simplicity of A_n ($n \geq 5$), Structure theory of groups, Direct products, fundamental theorem of finitely generated abelian groups, invariants of finite abelian groups, Sylow's theorems, groups of order p^2, pq.

UNIT- III

Rings, rings of fractions (Integral domains and their fields of fractions), division rings. Factorization in Integral domain, Euclidean and principle ideal domains, ring homomorphism,Ideals,algebra of ideals, sum and direct sum of ideals, maximal and prime ideals, nilpotent and nil ideals.

UNIT- IV

Basics of Fields and their examples, characteristic of a field, some basic field extensions, algebraic and transcendental elements.

Course Outcomes (CO):
Upon completion of this course, the student will be able to:

1)Explore the properties of groups, sub-groups, including symmetric groups, cyclic groups, normal sub-groups and quotient groups.
2) Apply class equation and Sylow's theorems to solve different problems.
3) Explore the properties of rings, sub-rings, ideals including integral domain, principle ideal domain, Euclidean ring and Euclidean domain.
4) Understand the concepts of homomorphism and isomorphism between groups and rings

CO/PO Mapping (S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
Cos	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M			W	S	S			W		
CO2	S	M	S		M	S	S			S		
CO3	S	M			W	S	S			M		
CO4	S	W	S		M	S	S			S		

RECOMMENDED BOOKS:

1. Surjeet Singh and Qazi Zameeruddin, Modern Algebra, Vikas Publishing House.
2. I.N. Herstein, Topics in Algebra, Wiley Eastern.
3. I.N.Herstein, Abstract Algebra, PHI.

4. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House.
5. Joseph A. Gallian, Contemporary Abstract Algebra, CENGAGE Learning.
6. I. S. Luthar, I. B. S. Passi, Algebra Volumes 1&2 ,Narosa Publishing House.

AM-8104 CLASSICAL MECHANICS

L	T	P	C
4	1	0	5

Course Objectives: The aim of this course is to understand the principle of classical mechanics influenced by legends as Langrage, Hamilton, Kepler, Euler and Legendre and to enable students to formulate mathematical models leading to solutions in physical world.

Unit-I

Motion Under Central Force: Conservation of energy. Differential equation for the orbit. Conditions for closed orbits. Elliptic orbits and planetary motion. Changes of orbit. Disturbed Orbits. Satellite orbits. Laplace-Runge-Nenz vector. Scattering in central force field.

Principle of Variations: Functional, variation, extremals. Principle of stationary action. Applications to shortest distance problem, maximum surface of revolution and brachistochrone. Geodesics on sphere, catenoid and helicoid.

Unit-II

Lagrangian Mechanics: Generalized coordinates. Degree of freedom. Holonomic and nonholonomic systems. Scleronomic and rhenomic systems. D'Alembert's principle. Lagrangian. Euler-Lagrange equation of motion.

Lagrange Mechanics on Manifolds: Holonomic constraints. Differentiable manifolds. Lagrange dynamical systems. Noether's theorem, D' Alembert principle.

Unit-III

Hamiltonian Mechanics: Cyclic coordinates, Routh's equations. Hamiltonian. Hamiltonian principle of least action. Hamiltonian canonical equation of motion, Hamilton principle of least action. Legendre transformation.

Phase Space Structure: Phase flow. Liouville theorem. Poincare-Birkoff theorem, Poincare recurrence theorem.

Unit-IV

Canonical Transformation: Hamiltonian canonical equation of motion. Hamilton-Jacobi equation. Jacobi's theorem. Condition for a transformation to be canonical. Poisson brackets. Poisson's identity. Jacobi-Poisson theorem.

Perturbation Theory: Action angle variables. Adiabatic invariants. Liouville theorem. Time dependent perturbation theory. Average of perturbation.

Course Outcomes (CO):
Upon completion of this course, the student will be able to:

1) To understand the importance of classical mechanics
2) To introduce the basic aspects of classical mechanics
3) To understand underlying principles
4) Applications in mathematical and physical domain

CO/PO Mapping												
COs	POs											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO09	PO10	PO11	PO12
CO1						M						M
CO2		M	S	S	M							
CO3	S	M	M	M	M					M		
CO4	M	M	S	M	M	M	S		S		M	

RECOMMENDED BOOKS

1.F. Chorlton, Text Book of Dynamics, CBS Publishers, Delhi, 1998.
2. John R. Taylor, Classical Mechanics, University Science Books, 2005.
3. V.I. Arnold, Mathematical Methods of Classical Mechanics, Springer, 1989.
4. Herbert Goldstein, Charles Poole and John Safko, Classical Mechanics, Addison-Wisely, 2000.

AM-8105 DIFFERENTIAL EQUATIONS

L	T	P	C
4	1	0	5

Course Objectives: The main aim of this course is to understand various analytical methods to find exact solution of ordinary and partial differential equations and their implementation to solve real life problems.

UNIT-I

Initial value problem, Existence of solutions of ordinary differential equations of first order, Existence and Uniqueness theorem, Picard-Lindelof theorem, Peano's existence theorem, Existence of independent solutions, Wronskian, Method of successive approximation, method of Variation of parameters.

UNIT-II

Regular and singular points, Power series solution of differential equation at regular and regular singular points, Bessel's and Legendre's equations and their solutions, Orthogonal properties, Generating functions, Recurrence relations.

UNIT-III

Linear systems, Autonomous systems, The phase plane and its phenomena, Existence and uniqueness of solution (statement only), Critical points and their nature, Stability analysis for linear systems.

UNIT-IV

Classification of PDE, First order PDE, Lagrange's linear PDE, Charpit's method. Well- posed and Ill-posed problems, Monge's method, Separation of variables method for parabolic, hyperbolic and elliptic equations.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:

1) Learn how to check the existence and uniqueness of the solution of initial value problems and various methods to solve them.
2) Obtain power series solutions of various important classes of ordinary differential equations including Bessel's and Legendre's differential equations.
3) Learn how the stability of linear autonomous systems is studied by using phase plane phenomena in the sense of nature of critical points.
4) Classify first and second order PDE, and learn to solve such equations by Lagrange's, Charpit's, Monge's and separation of variables methods.

CO/PO Mapping												
(S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S					S						
CO2	S					S						
CO3	S					S						
CO4	S					S						

RECOMMENDED BOOKS:

1. E.A. Coddington and N. Levinson, Theory of Differential Equations, McGraw-Hill (1955).
2. G.F. Simmons, Differential Equation with Applications and Historical Notes, Tata McGraw-Hill (2003).
3. S.G. Deo and V. Raghavendra, Ordinary Differential Equations and StabilityTheory, Tata McGraw-Hill (1997).
4. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill (1957).
5. S.L. Ross, Differential Equations, Wiley (2004).

SEMESTER – II

MA-8201 LEBESGUE MEASURE AND INTEGRATION

L	T	P	C
4	1	0	5

Course Objectives: This course provides the essential foundations of important aspect of mathematical analysis. Theory of Lebesgue Measure and integrationhas numerous applications in other branches of pure and applied mathematics, for example, in the theory of (partial) differential equations, functional analysis, Probability theory etc. The objective of this course is to give fundamental knowledge of various families of subsets of a nonempty set - algebra, sigma algebra, monotone classes, Borel sets etc. (with specific emphasis on subsets of real line), set function (measure) defined on sigma algebras of sets, construction of Lebesgue measure using Lebesgue outer measure.Another main objective of the course is to study Lebesgue Integral of measurable functions defined on the real line which gives a natural extension of the Riemann integral which allows for better understanding of the fundamental relations between differentiation and integration and study of L^p spaces of integrable functions.

UNIT-I

Preliminaries- Algebra and sigma algebra of subsets of a set, set function, measure defined on sigma algebras. Lebesgue outer measure. Lebesgue measurable sets, Borel sigma algebra and Lebesgue sigma algebra, Regularity, Lebesgue measure, Non-measurable sets.

UNIT-II

Measurable functions, various characterizations and properties of measurable functions-sum, product and composition , Sequential pointwise Limits and simple approximation of measurable functions Borel and Lebesgue measurability, Littlewoods three principles, Lebesgue Integral of bounded functions over a set of finite measure, Bounded convergence theorem, Integration of non-negative functions, Fatou's Lemma, Monotone Convergence Theorem, The general Lebesgue Integral, Lebesgue Dominant Convergence Theorem, Integration of series, Riemann and Lebesgue integrals.

UNIT-III

Vitali Covers, Differentiation of Monotone functions, The Four derivates, continuous non differentiable functions. Functions of bounded variation. Lebesgue Differentiation theorem. Differentiation of an integral, Absolute continuity. The Lebesgue points and Lebesgue set.

UNIT-IV

Convex functions, Jensen's inequality, The L^p-spaces, Holder and Minkowski inequalities. Completeness of L^p, Convergence in Measure. Almost uniform convergence.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:
1) Understand how Lebesgue measure on R is defined and what are properties of measurable sets and Borel sets.
2) Understand basic properties of Lebesgue measurable functions and Lebegue integrals of such functions,
3) Understand how measures may be used to compute integrals,the relation between differentiation and Lebesgue
integration.
4) Understand the concept of normed spaces/L^p-spaces and convergence in L^p-spaces.

CO/PO Mapping												
(S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
COs	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S	S	S		M	M		M
CO2	S	S	S	S	S	S	S		M	M		M

CO3	S	S	S	S	S	S	S		M	M		M
CO4	S	S	S	S	S	S	S		M	M		M

RECOMMENDED BOOKS

1. H.L. Royden, P.M. Fitzpatrick, Real Analysis, 4rd edition, Prentice Hall of India2010.
2. G.de Barra, Measure Theory and Integration, Wiley Eastern Ltd. (2012).
3. P.K. Jain and V. P. Gupta, Lebesgue Measure and Integration, Narosa Publishing House (2010).
4. G.B. Folland, Real Analysis, second edition, John Wiley, New York (1999).
5. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley (1989).

MA-8202 COMPLEX ANALYSIS

L	T	P	C
4	1	0	5

Course Objectives : This course is aimed to provide an introduction to the theory of function of a complex variable. The concepts of analyticity, Cauchy-Riemann equations and harmonic functions are introduced. Students will acquire the skill of contour integration to evaluate complicated real integrals.

UNIT-I

Review of Complex number system, Function of a complex variable, Limit, Continuity, Uniform continuity, Differentiability, Analytic functions, Cauchy- Riemann equations, Harmonic functions and Harmonic conjugate.

UNIT-II

The exponential function, Trigonometric function, Logarithmic function, Branches of multi-valued functions with reference to $\arg z, \quad \log z, \quad z^c$. Definition of conformal mapping, Bilinear transformation , Cross ratio , the mappings from disc to disc, disc to half plane and half plane to half plane.

UNIT-III

Complex integration, Cauchy-Goursat theorem, Cauchy integral formula, Higher order derivatives, Morera's theorem, Liouville's theorem, Fundamental theorem of algebra, Zeroes of analytic function, maximum modulus principle, Schwarz's Lemma.

UNIT-IV

Taylor's series, Laurent's series, Singularities of complex functions, Casorati- Weierstrass theorem, Poles, Residues, Residue theorem and its applications to real integrals : Integration around unit circle, Integration over semi-circular contours (with and without real poles), Integration over rectangular contours, Argument principle, Rouche's theorem.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:
1) Analyse limits and continuity for functions of complex variables.
2)Understand analytic functions, entire functionsincluding the fundamental theorem of algebra, and conformal Mapping.
3) Evaluate complex contour integrals and apply the Cauchy integral theorem in its various versions, and the Cauchy integral formula.
4)Apply the residue theory for the evaluation of real integrals.

CO/PO Mapping												
(S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
Cos	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S	S	S		M	M	M	
CO2	S	S	S	S	S	S	S		M	M	M	
CO3	S	S	S	S	S	S	S		M	M	M	
CO4	S	S	S	S	S	S	S		M	M	M	

RECOMMENDED BOOKS

1) E. T. Copson, An Introduction to Theory of Functions of a Complex Variable, Oxford University Press (1970).
2) L. V. Ahlfors, Complex Analysis, Tata McGraw-Hill (1979).

3) S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House (2007).
4) R. V. Churchill & J. W. Brown, Complex Variables and Applications, Tata McGraw-Hill (2008).
5) D. G. Zill & P. D. Shanahan, A first course in complex analysis with applications, Jones & Barlett (2010).
6) R. E. Greene and S. G. Krantz, Function theory of one complex variable, American Math. Soc. 3^{rd} Ed.(2006).

MA-8203 LINEAR ALGEBRA

L	T	P	C
4	1	0	5

Course Objectives: The main objective of this course is to understand multidimensional geometry. This encourage students to develop a working knowledge in Linear Algebra like linear transformations, eigenvalues, eigenvectors, canonical forms , Inner product spaces, Gram Schmidt orthogonalization process.

UNIT-I

Vector space of linear transformations, algebra of linear transformations, singular and non-singular transformations, Rank and Nullity theorem. Properties, representation of linear transformations as a matrix and change of basis formula. Dual spaces, dual basis, annihilator space of a subspace of a vector space.

UNIT-II

Eigenvalues and eigenvectors of a linear transformation, relation between characteristic roots of linear transformation and the roots of its minimal polynomial, Cayley Hamilton theorem.

UNIT-III

Canonical forms: similarities of linear transformation, diagonalization, Invariant Subspaces, Reduction to triangular forms, Nilpotent transformation, index of nil potency, Invariants of a Nilpotent transformation, Jordan blocks and Jordan forms. Rational canonical forms.

UNIT-IV

Inner product spaces, properties, Cauchy Schwarz inequality, orthogonal vectors. Orthogonal complements, orthonormal sets and bases, Gram Schmidt orthogonalization process. Bilinear forms, symmetric and Hermitian forms, Quadratic forms and their classification.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:

1) Understand the concepts of vector spaces, basis, dimension and linear transformations.
2) Find the matrices corresponding to linear transformation and different canonical forms like triangular and Jordan canonical forms etc.
3) Understand the concepts of eigenvalues and eigenvectors of a linear transformation.
4) Understand the concepts of Inner product spaces and their properties, Gram Schmidt orthogonalization process

CO/PO Mapping (S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
Cos	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	W	W	M		M	S	S			M		
CO2	S	M	M		S	S	S			S		
CO3	S	S	M		M	S	S			S		
CO4	M	W			W	S	S			M		

RECOMMENDED BOOKS

1. K.Hoffmann & R. Kunze, Linear algebra, PHI.
2. I.N Herstein, Topics in Abstract Algebra, Wiley Eastern Ltd. .
3. J. Gilbert and L. Gilbert, Linear Algebra and Matrix Theory, Academic Press.
4. Vivek Sahai and Vikas Bist, Linear Algebra, Narosa Publishing House.

MA – 8204 OPERATIONS RESEARCH

L	T	P	C
4	1	0	5

Course Objective: Operations research helps in solving real life problems in different environments that needs decisions. This module aims to introduce students to use quantitative methods and techniques for effective decisions-making; model formulation, like LPP, TP, AP Network Problem and their applications.

UNIT-I

Basic concepts and notations of LPP. Mathematical formulation of LPP, Graphical solution. Spanning set, basis, replacing a vector in a basis, Basic solution and Basic Feasible Solutions (BFS) of system of linear equations, BFS by using Gauss-Jordan elimination process and using rank method. Hyperplane, hypersurfaces, convex sets and their properties. Extreme points, adjacent point of a convex set. Standard form of an LPP

UNIT-II

Fundamental theorem. Reduction of Feasible Solution to BFS. Standard format of Simplex method. Two phase method. Big M method. Degeneracy. Nature of the solution of LPP through simplex method. Revised simplex method. Primal and Dual problem. Duality theory, Complimentary Slackness Conditions (CSC), Solution of primal and Dual and vice versa.

UNIT-III

Basic concepts and notations of transportation problem, Balanced and unbalanced transportation problems. Initial BFS of TP using north-west corner rule, Matrix Minima method and Vogel's approximation method. Optimal solutions. Assignment problem. Hungarian method to solve assignment problem.

UNIT-IV

Basic network for CPM and PERT, Time estimates, PERT, PERT calculations, Critical Path Method (CPM) , Calculations for Slack, various float, Project Cost Analysis, Crashing, Resource Allocation in Network Scheduling.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:

1) Formulate some real life problems into LPP and find their solution by graphical method, rank method and Gauss-Jordan technique.
2) Use the simplex, Big M and twophase method to find an optimal BFS for the standard LPP and the corresponding Dual Problem and check the optimal solution for primal LPP and Dual LPP by CSC.
3) Formulate and find the optimal solution of TP and AP.
4) Use CPM and PERT to learn how to manage and complete a project within stipulated time and money.

CO/PO Mapping (S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
Cos	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	M	M	S	M	S	S	M	M
CO2	S	S	S	S	M	M	S	M	S	S	M	M
CO3	S	S	S	S	M	M	S	M	S	S	M	M
CO4	S	S	S	S	M	M	S	M	S	S	M	M

Recommended Books:

1. J. G. Chakravorty and P. R. Ghosh, Linear Programming and game Theory, Moulik Library (2009).
2. S. K. Gupta, Linear Programming & Network Models, Affiliated East-West Private Ltd. (1985).
3. Kanti Swarup, P.K. Gupta & Man Mohan, Operations Research, S. Chand & Sons.(1994).
4. H.A. Taha, Operations Research, PHI (2007).

MA-8205 C- PROGRAMMING

L	T	P	C
3	0	0	3

Course Objective: The course is designed to provide complete knowledge of C programming language to the students. It will enhance their analytical and problem solving skills, which will be ultimately helpful for writing programs in C language.

UNIT- I

Basic program constructions, steps in development of a program, flow charts, algorithm development, structured and object oriented programming, comments, data types, variables, I/O functions, constants arithmetic operators, library functions, logical, relational and binary operators, conditional operator. If statements; if, else, nested if, switch, break, continue, goto, while if statement and for loop.

UNIT- II

Function declaration, void function, call by value, call by reference, return statement. Defining arrays, initialization of arrays, integer array, non-integer array, character array, passing arrays to functions, two dimensional and multidimensional arrays.

UNIT- III

Declaring & initializing string variables, reading string from terminal, writing string to screen, arithmetic operations or characters, putting string together, comparison of two strings, string handling function, declaration of structure, initialization of structure, accessing structure members, array of structures, nested structure, structures & functions, size of structures.

UNIT- IV

Definition of pointers, pointers as function argument, pointers & structure, pointers & arrays, pointers & functions, pointers & strings. Opening and closing a file, reading and writing a file, random access to files, command and arguments. Introduction to C++.

RECOMMENDED BOOKS:

1. B.S. Gottfried, Schaum Outline Series with Programming in C (2010).
2. E. Balagurusamy, Programming in ANSI C, Tata McGraw-Hill (2012).
3. Y. Kanetkar, Let us C, B.P.B. Publications (2016).
4. Ritchie &Kennugthem, C-Programming (1988).
5. Robert Lafore, Object Oriented Programming in Turbo C++, Galgotia Publishers (2002).

MA-8251 C - PROGRAMMINGLAB

L	T	P	C
0	0	2	1

(1) To calculate (i) sum of two numbers. (ii) area of a right angle triangle. (iii) area of a circle having radius r. (iv) roots of a quadratic equation.

(2) Write a programme (i) to sort the given n numbers (both increasing & decreasing order). (ii) Write a given integer in reverse order. (iii) To interchange value of two variables without using third variable. (iv) to interchange value of three numbers without using fourth variable such that value of 'b' is 'a', 'c' is 'b' and 'a' is 'c'.(v) Find the greatest of three numbers. (vi) to convert lowercase character to uppercase using conditional operator. (vii) to calculate gross salary for any basic salary entered through keyboard, where dearness allowance is 40% of basic salary & house rent is 20% of basic salary. (viii) To calculate compound interest. (ix) To convert temperature in degree Fahrenheit to degree Celsius, using formula 'C=(5/9)*(F – 32)'. (x) To check if a number is divisible by a given number.

(3) (i) To find the sum of the series $S = 1 + x^2 + x^4 + \cdots \text{n terms}$. (ii) To calculate HCF of two numbers using functions. (iii) To print Fibonacci series. (iv) To calculate factorial of a given number.

SEMESTER – III

MA-9101 TOPOLOGY

L	T	P	C
4	1	0	5

Course Objectives: This course aims to teach the fundamentals of point set topology and constitute an awareness of need for the topology in Mathematics.

UNIT-I

Definition and examples of topological spaces,Bases and sub bases, Order topology, Product topology, Subspaces and relative topology closed sets, Closure, Dense subsets, Neighbourhoods, Interior, exterior and boundary. Accumulation points and derived sets. Alternative methods of defining a topology in terms of Kuratowski closure operator and neighbourhood systems.

UNIT –II

Continuous functions and homomorphism, Open Mappings, Closed Mappings, Compactness and local compactness. One –point compactification. Connected and arc wise connected spaces. Components. Locally connected spaces.

UNIT –III

$\mathrm{T}_{\mathbf{0}}$ andT_1spaces, T_2 -spaces and sequences. Hausdorffness of one point compactification. Axioms of Countability and Separability. Equivalence of separable, second countable and Lindelof spaces in metric spaces. Equivalence of Compact and countably compact sets in metric spaces.

UNIT –IV

Regular, completely regular, normal and completely normal spaces. Metric spaces as $\boldsymbol{T_2}$**,** completely normal and first axiom spaces. Urysohn Lemma, Tietze Extension Theorem, Urysohan Metrization Theorem.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:

1) Understand to construct topological spaces from metric spaces and using general properties of neighbourhoods, open sets, close sets, basis and sub-basis.
2) Understand the concepts of compact spaces, connected spaces and continuous functions on topological spaces and apply the knowledge deriving the proofs of various theorems.
3) To understand the concepts of various separation axioms, axioms of countability, separable, countable
   compact spaces etc.
4) Understand the concepts and properties of regular, completely regular, normal, completely normal spaces etc. and concept of metrication of topological spaces.

CO/PO Mapping (S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S	S			S			
CO2	S	S	S	S	S	S			S			
CO3	S	S	S	S	S	S			S			
CO4	S	S	S	S	S	S			S			

Recommended Books

1. K.D. Joshi, General Topology, Wiley (1983).
2. J.R. Munkres, Topology: a first course, PHI (2007).
3. W.J. Pervin, Foundation of General Topology, Academic Press (1964).
4. G.F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw-Hill (1963).

MA - 9102 MATHEMATICAL METHODS

L	T	P	C
4	1	0	5

Course Objectives: This course is intended to prepare the students with mathematical tools and techniques that are required in advanced applied mathematics. The objective of this course is to enable students to apply various mathematical methods for solving integral equations, differential equations and initial and boundary value problems.

UNIT-I

Linear integral equations of the first and second kind of Fredholm and Volterra type. Solution by methods of successive substitutions and successive approximations. Fredholm First theorem, Hadamard's Theorem, Fredholm Second and third theorems. Integral Equation with degenerate Kernels, Hibert Schmidt theory: Bessel's inequality. Riesz- Fischer Theorem. Hibert Schmidt theorem.

UNIT-II

Introduction to calculus of variations, functional, Euler-Lagrange equation, isoperimetric problems, solution of boundary value problems by variational methods like Rayleigh Ritz method, collocation method and Galerkin method.

UNIT-III

Laplace transform, inverse Laplace transform and properties, convolution theorem, Applications of Laplace transform for solving differential equation, Applications of Laplace transform for solving boundary value problems likeheat equation, wave equation and Laplace equation.

UNIT-IV

Introduction to Fourier transform and its properties, Fourier sine and cosine transforms and theorems, convolution theorem, finite Fourier transform, applications of Fourier transforms in solving boundary value problems likeheat equation, wave equation and Laplace equation.

Course Outcomes (CO):
Upon completion of this course, the student will be able to:
1) Find solution of Volterra and Fredholm linear integral equations of first and second type.
2) Understand theory of calculus of variations and solve initial and boundary value problems.
3) Understand Laplace Transform and applications to solve initial and boundary value problems.
2) Learn Fourier transformation and its applications to relevant problems.

CO/PO Mapping												
(S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
Cos	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S	S	M		M		W	
CO2	S	S	S	S	S	S	M		M		W	
CO3	S	S	S	S	S	S	M		M		W	
CO4	S	S	S	S	S	S	M		M			

RECOMMENDED BOOKS:

1. J.W. Brown and R. Churchill, Fourier Series and Boundary Value Problems, McGraw-Hill (2011).
2. Peter V. O'Neil, Advanced Engineering Mathematics, CENGAGE Learning (2011).
3. I.N. Sneddon, The Use of Integral Transforms, Tata McGraw-Hill (1985).
4. M. Gelfand & S. V. Fomin, Calculus of Variations, Prentice Hall (1963).

MA 9103 MATHEMATICAL STATISTICS

L	T	P	C
4	1	0	5

Course Objectives: The course aims to shape the attitudes of learners regarding the field of statistics. Specifically, the course aims to motivate in students an intrinsic interest in statistical thinking and Instil the belief that statistics is important for scientific research.

UNIT-I

Karl-Pearson coefficient of correlation and rank correlation. Partial and multiple correlation (three variables case only). Regression Analysis up to three variables.

UNIT-II

Definition of probability using different approaches. Discrete and continuous random variables. Probability mass function. Probability density function. Probability distribution function. Functions of a random variable. Discrete and continuous univariate distributions - Binomial, Poisson, exponential, Normal, Gamma distributions. Moments, Moment generating functions, Characteristic function, Joint distribution function, Marginal and conditional distributions, Bi-variate normal distribution.

UNIT-III

Simple random sampling, stratified sampling, systematic sampling and Probability proportional to size sampling. Standard errors. Chi-square distribution, Student's t distribution and F distribution,

UNIT-IV

Fundamental notions, Tests based on normal, t, Chi-square and F distributions. Analysis of variance: Completely Randomized Design and Randomized Block Design.

Course Learning Outcomes: After the completion of this course, the student will be able to:
1) Analyse the correlated data and fit the linear regression model
2) Compute the probability of composite events
3) Understand the random variable, expectation, moments and distributions
4) Understand the concept of sampling distribution and its importance.

CO/PO Mapping												
(S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
Cos	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	M	M	S	M	S	S	M	M
CO2	S	S	S	S	M	M	S	M	S	S	M	M
CO3	S	S	S	S	M	M	S	M	S	S	M	M
CO4	S	S	S	S	M	M	S	M	S	S	M	M

Recommended Books:

1. P. L. Meyer, Introduction to Probability and Statistical Applications, Oxford &IBH (2007).
2. A. M. Goon, M. K. Gupta and B. Dasgupta, An Outline of Statistical Theory,Vol. I , World Press Pvt. Ltd (2013).
3. R. V. Hogg, J. W. Mckean and A. T. Craig, Introduction of Mathematical Statistics, PHI (2004)
4. T.W. Anderson, An Introduction to Multivariate Statistical Analysis, John Wiley(2003).
5. A. Gupta, Mathematical Probability & Statistics, Academic Publishers (2005).
6. S.C. Gupta & V.K. Kapoor, Fundamentals of Mathematical Statistics , Sultan Chand & Sons(2014).

MA-9104 NUMERICAL ANALYSIS

L	T	P	C
4	0	0	4

Course Objectives : The aim of this course is to provide adequate knowledge of fundamentals of problem solving techniques using C programming. This course provides the knowledge of writing modular, efficient and readable C programs. It will familiarize the students about different numerical techniques e.g. solving algebraic and transcendental equations, large linear system of equations, differential equations, approximating functions by polynomials upto a given desired of accuracy.

UNIT-I

Different types of errors, Error generation, General error formula, Inverse error formula, Error in series approximation, Iterative methods for solving algebraic and transcendental equations viz. Bisection method, Regula-falsi method, Secant method, Successive approximation method, Aitken's Δ^2 -method and Newton-Raphson method, Convergence analysis and convergence order of the methods, Computational efficiency.

UNIT-II

Solution of systems of linear equations, Direct methods viz. Gauss elimination method, Gauss-Jordan method and Factorization method, Conditions of convergence of direct methods, Indirect methods viz. Jacobi's method and Gauss-Seidal method, Conditions of convergence of indirect methods, Ill-conditioned linear systems, Eigen value problem, Rayleigh's power method for finding largest and smallest eigen values and eigen vectors.

UNIT-III

Finite differences, Difference operators and their relations, Fundamental theorem of finite difference calculus, Interpolation with equal intervals, Newton's forward, Newton's backward, Stirling's and Bessel's interpolation formulae, Error in interpolation, Interpolation with unequal intervals, Lagrange's and Newton's divided difference formulae, Numerical differentiation by Newton's forward and backward formulae. Error analysis.

UNIT-IV

Numerical integration by Trapezoidal, Simpson's one-third and Simpson's three-eighth rules, Error in numerical integration, Solution of Initial value problem: Taylor's series method, Picard's method, Euler's and modified Euler's methods, Runge-Kutta methods upto fourth order, Solution of simultaneous I^{st} order ODE by Runge-Kutta method. Stability and convergence analysis of the methods.

Course Learning Outcomes (CLO):
Upon completion of this course, the student will be able to:

1) Learn how to obtain numerical solution of nonlinear equations using bisection, secant, Newton and fixed-point iterations methods and convergence analysis of these methods.
2) Analyse and solve numerically the problems related to linear equations and eigen values and eigen vectors.
3) Know to solve the problem of interpolation with equal and unequal intervals, and its use in numerical differentiation.
4) Learn how to integrate numerically and to solve initial value problems.

CO/PO Mapping (S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
Cos	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S	S	M		M		W	
CO2	S	S	S	S	S	S	M		M		W	
CO3	S	S	S	S	S	S			M		W	
CO4	S	S	S	S	S	S	M		M			

Recommended Books:

1. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Addison-Wesley (2004)
2. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific & Engg. Computation, New Age International (2007).
3. S.D. Conte and De Boor, Numerical Analysis – An Algorithmic Approach, Tata McGraw- Hill(1972).
4. R.S. Gupta, Elements of Numerical Analysis, Macmillan India Ltd. (2008).
5. K.E. Atkinson, An introduction to Numerical Analysis, John Wiley & Sons (1988).

AM-9151

NUMERICAL ANALYSIS LAB

L	T	P	C
0	0	2	1

Programming in C/C++ language based on the following problems:

1. Finding roots of the equation $f(x) = 0$ using
   i) Bisection Method ii) Secant Method iii) Method of false position

2. Finding roots of the equation $f(x) = 0$ using
   i) Iterative Method ii) Newton - Raphson's Method

3. To check consistency and finding Solution of a system of linear algebraic equations using
   i) Gauss elimination Method ii) Gauss - Seidal Method iii) Jacobi Method

4. Solution of a system of linear equations by triangularization method.

5. Finding dominating Eigen value and Eigen vector using Rayleigh's power Method.

6. Interpolation using
   i) Newton's forward difference formula ii) Newton's backward difference formula

7. Interpolation using
   i) Newton's divided difference formula ii) Lagrange's interpolation formula

8. Interpolation using
   i) Gauss's forward formula ii) Gauss's backward difference formula

9. Interpolation using Splines
   i) Linear ii) Quadratic iii) Cubic

10. Numerical differentiation using
   i) Newton's forward interpolation formula ii) Newton's backward interpolation formula

11. Numerical Integration using
   i) Trapezoidal rule ii) Simpson's 1/3rd rule
   iii) Simpson's 3/8th rule iv) Romberg's rule

12. Solution of Ist order ordinary differential equations using
   i) Taylor's series method ii) Picard's method
   iii) Euler's method iv) Euler's modified method

13. Solution of Ist order ordinary differential equations using
   i) Runge-Kutta method of IIIrd order ii) Runge-Kutta method of IVth order

ELECTIVE PAPERS FOR SEMESTER –III (Any one)

MA 9105 GENERAL RELATIVITY &COSMOLOGY

L	T	P	C
4	1	0	5

Course Objectives: This course is intended to provide the background needed to read the current research literature in astrophysics)cosmology(and to get the essential knowledge of astrophysics. This may help the students to intend their research interest in cosmology.

UNIT−I

Space, time and gravitation, Vector and tensors, Contraction of tensors, Covariant differentiation, Riemannian geometry, Space-time curvature, Geodesics, Action principle and energy tensor of matter.

UNIT−II

Relativity to cosmology: Historical background, Einstein universe, Expanding universe, Redshift, Apparent magnitude, Hubble's law. Gravitational equations, Newtonian approximations, The Schwarzschild solution, Experimental tests of general relativity.

UNIT−III

Einstein field equations in cosmology, Energy tensors of the universe, Solution of the Friedmann's equations, Einstein-de Sitter model, Angular size, Radiation backgrounds. The early universe and thermodynamics of the early universe.

UNIT−IV

Cosmological models, Cosmological model with cosmological constant, Universe at the large scales, Homogeneity and isotropy of the universe, Cosmological principle, Cosmological metrics and dynamic nature of the universe.

Course outcome:

On successful completion of this course, students should be able to

1) Apply their knowledge to describe various aspects of Cosmology.
2) Understanding of physical concept associated with the cosmological evolution of the universe.
3) Apply the knowledge to construct the suitable cosmological models of the universe.

CO/PO Mapping												
(S/M/W indicates strength of correlation) S − Strong, M − Medium, W − Weak												
Cos	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	S	M		M	M	S	M
CO2	S	M	M	S	S	S	M		M	M	M	S
CO3	M	S	S	M	S	M	S		M	M	S	M

RECOMMENDED BOOKS

J. V. Narlikar, Introduction to Cosmology, Cambridge University Press.

F. Hoyle, G. Burbidge and J. V. Narlikar, A Different Approach to Cosmology, Cambridge University Press)2005(.

J. N. Islam, An Introduction to Mathematical Cosmology, Cambridge University Press.

MA -9106 FLUID DYNAMICS

L	T	P	C
4	1	0	5

Course Objectives: To introduce basic characteristics of fluid, fluid kinematics, conservative principles, equation of motion, fluid flow through various systems and water wave propagation.

UNIT-I

Fundamental of Fluid Dynamics: Fluid properties. Dimensions and units. Stream lines and path lines. Compressible and incompressible flow. Dimensionless numbers. Conservation of mass. Energy equation. Linear momentum equation. Continuity equation. Navier-Stokes equation. Bernoulli's equation.

UNIT-II

Laminar Flow: Steady flow between parallel plates. Flow through circular tubes and circular annuli. Flow through simple pipes. Flow losses in conduits. Euler's equation of motion. Integration of Euler's equation, Kelvin circulation theorem. Irrotational flow. Stream functions and boundary conditions. Two dimensional flows. Source and sink.

UNIT-III

Water Waves: Introduction.Travelling and standing waves. Gravity waves. Gravity waves in deep and shallow water. Energy of gravity waves. Wave drag on ships. Ship wakes. Gravity waves in flowing fluid and at interface. Steady flow over a corrugated bottom. Surface tension. Capillary waves. Wind driven waves in deep water.

UNIT-IV

Incompressible Aerodynamics: Introduction. Theorem of Kutta and Zhukovskii. Cylindrical airfoils. Zhukoviskii's hypothesis. Vortex sheets. Induced flow. Three dimensional airfoils Aerodynamic forces. Ellipsoidal airfoils.

Course Outcome (CO):

Upon completion of this course, the student will be able to:
1) To understand the important Fluid dynamics.
2) To introduce the basic aspects of fluid flow**.**
3) To understand underlying principles**.**
4) Applications in mathematical and physical domain.

CO/PO Mapping												
COs	POs											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO09	PO10	PO11	PO12
CO1												M
CO2					M							
CO3					M	M						
CO4	M	M	S	M	M						M	

RECOMMENDED BOOKS:

1. Richard Fitzpatrick,Theoretical Fluid Mechanics, IOP Publishing, 2017.
2. B.R. Munson, D.F. Young and T.H. Okiishi, Fundamental of Fluid Mechanics, John Wiley and Sons, 2002.
3. D.E. Rutherford, Fluid Dynamics, Oliver and Boyd, 1959.
4. M.E. O'Neil and F Charlton, Ideal and Incompressible Fluid Dynamics, John Wiley &Sons, 1986.

MA-9107 DISCRETE MATHEMATICS

Course Objectives: Prepare students to develop mathematical logic and mathematical arguments which are required in learning many courses involving mathematics and computer sciences. To motivate students how to solve practical problems using discrete mathematics.

UNIT-I

Mathematical Logic: Statement and notations, proposition and logic operations, connectives (conjunction, disjunction, negation), Statement formulas and truth tables, propositions generated by set, Equivalence of formulas, Tautological implications law of logic, validity using truth table, Rules of inference, consistency of premises and indirect method of proof. Predicates, Statement function, Variables, Quantifiers, Universe of discourse, Inference of the predicate calculus.

UNIT-II

Relation and Function: Binary relations, Properties of binary relation in a set, Equivalence relations, Composition of binary relations, Partial ordering and Partial Order set, Hasse diagram, Function and Pigeonhole Principle. Principle of mathematical induction, Recursive definition, Introduction to primitive function. Polynomials and their recursion, iteration, sequence and discrete functions, generating functions, Recurrence relations and their solutions.

UNIT-III

Lattice and Algebraic systems, Principle of duality, Basic properties of Algebraic systems, Distributed and Complemented Lattices, Boolean Lattices and Boolean Algebra, Uniqueness of finite Boolean Algebra, Boolean functions and Boolean expressions, Normal forms of Boolean expression and simplifications of Boolean expressions, Logical gates and relations of Boolean function.

UNIT-IV

Basic terminology of graph theory, paths, circuits, Graph connectivity, degree, adjacency and matrix representation of graph and their properties, Multi-graphs, Weighted graphs, Trees, Spanning trees, Properties of tree, binary trees, rooted trees, planer graphs, Euler’s theorem for planer graph. The Konigsberg Bridge problem and Eulerian graphs (Eulerian paths and circuit), Hamiltonian graphs and their properties,Kruskal’s algorithmand Prim’s algorithm for findingminimum spanning tree.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:

1) Construct mathematical arguments using logical connectives and quantifiers.
2) Validate the correctness of an argument using statement and predicate calculus.
3) Understand how lattices and Boolean algebra are used as tools and how they help in the study of computer networks.
4) Learn how to work with some of the discrete structures which include sets, relations, functions, graphs and recurrence relations.

CO/PO Mapping (S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	M	S	S	M	S	S	M	M
CO2	S	S	S	S	M	S	S	M	S	S	M	M
CO3	S	S	S	S	M	S	S	M	S	S	M	M
CO4	S	S	S	S	M	S	S	M	S	S	M	M

RECOMMENDED BOOKS

1. J. P. Trembley and R. Manohar, A First Course in Discrete Structure with applications to Computer Science, Tata McGraw-Hill (1999).
2. M. K. Das, Discrete Mathematical Structures, Narosa Publishing House (2007).
3.Babu Ram, Discrete Mathematics, Vinayak Publications (2004).
4. C. L. Liu, Elements of Discrete Mathematics, Tata McGraw-Hill (1978).

MA 9108 ADVANCED ABSTRACT ALGEBRA

L	T	P	C
4	1	0	5

Course Objectives: The main objective of this course is to encourage students to develop a working knowledge of the central ideas of Field Theory like field extensions, splitting field and Galois theory. The concepts of Galois extensions and Fundamental theorem of Galois theory to understand algebra more deeply, are then introduced. More generally some basics of the modules theory are also included.

UNIT-I

Review of Fields and examples, Irreducible polynomials, Gauss Lemma, Eisentein's criterion, Adjunction of roots, Kronecker's theorem, algebraic extensions, algebraically closed fields.

UNIT-II

Splitting fields, normal extensions,separable extension, perfect fields, primitive elements, Lagrange's theorem on primitive elements.

UNIT-III

Automorphism groups and fixed fields, Galois extensions. Fundamental theorem of Galois theory, Fundamental theorem of algebra, Roots of unity and cyclotomic polynomials.

UNIT-IV

Modules, left and right modules over a ring with identity, cyclic modules, free modules, Fundamental structural theorem for finitely generated module, over a PID and its application to finitely generated abelian groups.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:

1) Understand the concepts of fields, their extensions and splitting fields .
2) Understand the concept of prime and irreducible elements.
3) Understand the properties of finite fields and Galois Theory.
4) Understand the basics of module theory, free modules.

CO/PO Mapping

(S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak

Cos	Programme Outcomes (POs)										
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	W	M	M	S	S			W		
CO2	M		W	M	M	S	S			M		
CO3	S	M	M	M	M	S	S			S		
CO4	M	M	W	W	W	S	W			M		

Recommended Books:

1) P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, Cambridge University Press.
2) I.N.Herstein, Topics in Abstract Algebra, Wiley Eastern Ltd.
3) I. N. Herstein, Abstract Algebra, Prentice Hall .
4) Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House.
5) I. S. Luthar, I. B. S. Passi, Algebra Volumes 3 & 4, Narosa Publishing House .

SEMESTER – IV

MA – 9201 FUNCTIONAL ANALYSIS

L	T	P	C
4	1	0	5

Course Objectives: The main aim of this course is to provide the students basic concepts of functional analysis, to facilitate the study of advanced mathematical structures arising in the natural sciences and the engineering sciences and to grasp the newest technical and mathematical literature.

UNIT-I

Normed linear spaces. Banach spaces. Examples of Banach spaces and subspaces, Finite dimensional normed spaces, Equivalent norms, Bounded and Continuous linear maps. Normed spaces of bounded linear maps and Bounded linear functionals, Dual spaces, Dual spaces of l_p and C [a, b], Reflexivity.

UNIT-II

Hahn-Banach theorem and its applications, Uniform boundedness principle, Open mapping theorem Closed graph theorem, Projections on Banach spaces.

UNIT-III

Hilbert spaces, examples, Orthogonality, Orthonormal sets and sequences, Bessel's inequality, Parsevals's theorem. The conjugate space of a Hilbert space.

UNIT-IV

Adjoint operators, Self-adjoint operators, Normal and Unitary operators. Projection operators. Weak convergence. Completely continuous or compact operators, properties of compact operators.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:

1) Understand the normed linear spaces, Banach space and Dual spaces
2) Understand and apply fundamental theorems like Hahn Banach theorem, open mapping theorem, closed graph theorem and principle uniform boundness.
3) Understand inner product spaces, orthogonality and Hilbert spaces.
4) Understand various operators and their properties and apply them in various situations.

CO/PO Mapping (S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
COs	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S	S	S		M	M		
CO2	S	S	S	S	S	S	S		M	M	S	
CO3	S	S	S	S	S	S	S		M	M	S	
CO4	S	S	S	S	S	S	S		M	M		

RECOMMENDED BOOKS

1. E. Kreyszig, Introductory Functional Analysis with Applications, Wiley (1978).
2. B. V. Limaye, Functional Analysis, New Age International Publishers(2014).
3. G.F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw-Hill (1963).
1. C. Goffman and G. Pedrick, First Course in Functional Analysis, PHI, New Delhi, 1987
2. S. Ponnusamy, Foundation of Functional Analysis, Alpha Science International (2002).
3. G. Bachman and L. Narici, Functional Analysis, Courier Corporation (1966).

MA 9202 ALGEBRAIC CODING THEORY

L	T	P	C
4	1	0	5

Course Objectives: The objective of the course is to introduce basic topics of algebraic coding theory like error correction and detection, linear codes and their parameters, various bounds on parameters and Cyclic codes.

UNIT-I

Error detecting and error correcting codes, Decoding principle of maximum likelihood, Hamming distance, Distance of a code, Finite Fields, Construction of finite fields, Irreducible polynomials over finite fields, Vector spaces over finite fields.

UNIT-II

Linear codes, Hamming weight, Bases for linear codes, Generator matrix and parity-check matrix of linear codes, Equivalence of linear codes, Encoding with a linear code, Decoding of linear codes, Syndrome decoding.

UNIT-III

Bounds in coding theory: Sphere covering bounds, Gilbert-Varshamov bound Perfect codes, Hamming bounds and codes, Golay codes, Singleton bound and MDS codes, Plotkin bound, Nordstrom-Robinson code, Griesmer bound, Construction of linear codes using propagation rules.

UNIT-IV

Reed-Muller codes, Cyclic codes, Generator polynomial of a cyclic code, Generator and parity-check matrices of cyclic codes, Burst-error-correcting codes, ISBN Codes.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:

1) Learn basic techniques of algebraic coding theory constructing codes, detecting and correcting errors.
2) Learn about Linear codes, their bases, Generator matrix and parity-check matrices, decoding of linear codes.
3) Learn different types of codes like cyclic and MDS codes, Golay codes, Perfect codes, ISBN codes.
4) Understand various upper and lower bounds on parameters of codes.

CO/PO Mapping (S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
Cos	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M	W		M	S	S			M		
CO2	M	M	W		M	S	S			M		
CO3	M	M	W		M	S	S			M		
CO4	M	M	W		M	S	S			M		

Recommended Books:

1) San Ling and Chaoping Xing, Coding Theory, Cambridge University Press.
2) L.R.Vermani, Elements of Algebraic Coding Theory, Chapman and Hall.
3) Steven Roman, Coding and Information Theory, Springer Verlag.
4) Raymond Hill, A First Course in Coding theory, Clarendon Press Oxford.

MA 9203 TENSORS AND DIFFERENTIAL GEOMETRY

L	T	P	C
4	1	0	5

Course Objectives: The aim of the course is to introduce the concepts and techniques of differential geometry**.** Students will be able to apply problem solving with differential geometry in diverse situation in physics, engineering or in othermathematical context**.**

UNIT-I

Tensor and their transformation laws, Tensor algebra, Contraction, Quotient law, Reciprocal tensors, Kronecker delta, Symmetric and skew- symmetric tensors, Metric tensor, Riemannian space, Christoffel symbols and their transformation laws, Covariant differentiation of a tensor, Riemannian curvature tensor and its properties, Ricci-tensor.

UNIT-II

Theory of space curves introduction, Representation of space curves, Arc length, Tangent, Curvature and Torsion, Contact between curves and surfaces, Betrand curves, Spherical indicatrix, Fundamental existence theorem for space curves.

UNIT-III

The first fundamental form and local intrinsic properties of surfaces, Definitions, Nature and representation of surface, Curves on a surface, Tangent plane and Surface normal. The general surface of revolution, Helicoids, Metric on a surface, Direction coefficients on a surface, First fundamental form. Families of curves, Orthogonal trajectories, Intrinsic properties, Double family of curves .

UNIT-IV

Definition, Differential equation of geodesics, Nature of Geodesics, Canonical geodesics equations, Normal property of geodesic, Geodesic polar coordinate, curvature and torsion.

Course Outcomes: On satisfying the requirements of this course, students will have the knowledge and skills to

1) Apply tensors to the study of elasticity and study of stresses and tensions in the interior of a deformed body.
2) Explain the concept and language of differential geometry and its role in modern Mathematics.
3) Students may apply differential geometry techniques to specific research problem in mathematical/ Physical Sciences.
4) Students may apply the language of differential geometry to solve the complex problems.

CO/PO Mapping (S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
Cos	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	M	M	S		M	S	S	S
CO2	M	S	S	M	S	M	M		M	S	M	M
CO3	S	M	S	S	S	S	S		M	S	S	S
CO4	S	M	S	S	S	S	S		M	S	S	S

RECOMMENDED BOOKS

1. I. S. Sokolnikoff, Tensor Analysis: Theory and Application to Geometry and Mechanics of continua, Wiley Publication (1964).
2. T. J. Willmore, An Introduction to Differential Geometry, Dover Publications (2012).
3. D. Somasundaram, Differential Geometry: A first course, Alpha Science International (2004).
4. R. B. Mishra, Tensors, Hardwari Publications (2002).

MA 9251 SOFTWARE LAB USING MATHEMATICA, MATLAB AND LATEX

L	T	P	C
0	0	6	3

UNIT - I

Running Mathematica

Numerical Calculation: Arithmetic, Exact & approximate result, Some Mathematical functions, Arbitrary-Precision Calculations, Complex Numbers

Building up calculations: Using previous results, Defining variables, Making list of objects, The four kinds of bracketing in Mathematica, Sequence of operations.

Using Mathematica system: The structure of Mathematica, Doing computation in Notebook, Notebooks as documents, Active elements in notebook, Getting Help in the Notebook Front end, Getting Help with a Text Based Interface, Mathematica Packages, Warning and Messages.

Algebraic calculations: Symbolic computation, Values for symbols, Transforming algebraic Expressions, Simplifying Algebraic Expressions, Putting expression into different forms, Simplifying with assumptions, Picking out pieces of algebraic expression, Controlling the display of large expressions, The limits of mathematica.

Symbolic Mathematics: Basic operations, Differentiation, Integration, Sums and products, Equations, Relations and logical operators, Solving equations, Inequalities, Differential equations, Power series, Limits, Integral Transforms, Recurrence equations, Packages for symbolic mathematics, Mathematical notation in Notebook.

Numerical Mathematics: Basic operations, Numerical sums, product and integrals, Numerical equation solving, Numerical Differential equations, Numerical optimization, Manipulating numerical data, Statistics.

Functions and Program: Defining function, Function as procedures, Repetitive operations

Graphics: Basics plotting, Options, Redrawing and combining plots, Contour and Density plot, Two dimensional and three dimensional plots.

Input and Output in Notebook: Entering Greek letters, Entering Two-dimensional input, Editing and Evaluating Two-dimensional expression, Entering formulas, Displaying and printing mathematica notebook.

UNIT - II

Getting started with Matlab : Matlab windows, Matlab environment, Solving problems with Matlab, Key terms. Built in functions in Matlab, Elementary Math functions, Random and Complex numbers, computations, limitations, Special Values and Miscellaneous functions.

Manipulating Matlab matrices, problems with two variables, special matrices. Plotting in Matlab, Two dimensional plots, subplots, Three dimensional plotting, editing plots from the menu bar, creating plots from the workspace window.

User-defined functions in Matlab, Creating function M-files, anonymous functions and function handles, subfunctions. User controlled input and output, Graphical input, Reading and writing data from files. Logical functions and selection structures, flowcharts.

Repetitions structures: For, while and nested loops, improving efficiency of loops. Matrix operations and functions, Solutions of system of linear equations. Other kind of arrays like Multidimensional, character, cell and structure arrays. Symbolic mathematics.

UNIT - III

Getting started with Latex : Preparing an input file, sentences and paragraphs. Simple text-Generating commands, footnotes, formulas. The document class, the title page, sectioning, Changing the type style, symbols from other languages.

Mathematical formulas and symbols, arrays, multiple formulas. Spacing and changing style in math mode, defining commands and Environment, figures.

The table of contents, cross references, Bibliography and citation. Making an index, Other document classes like books, slides and letters.

Document and page styles, line and page breaking, numbering. Length, space and boxes. Centering, line making environments. Fonts and colours.

RECOMMENDED BOOKS

1. S. Wolfram, The Mathematica Book, Wolfram Media.
2. R. K. Bansal, A. K. Goel and M. K. Sharma, Matlab and its Applications in Engg., Pearson (2009).
3. Matlab Fundamentals, Mathworks (2014).
4. Leslie Lamport, A Document Preparation system: Latex, Pearson (1994).

<u>**ELECTIVE PAPERS FOR SEMESTER –IV**</u> <u>(Any two)</u>

MA-9204 ADVANCED NUMERICAL ANALYSIS

L	T	P	C
4	1	0	5

Course Objectives: In this course, students will study methods to obtain numerical results for different kind of physically important PDEs system like Laplace, Poisson and Heat equations.

UNIT-I

Cubic Spline interpolation. Error in interpolating polynomial. Iterative methods for solution of system of linear equations: Relaxation and successive over-relaxation methods. Necessary and sufficient conditions for convergence. Jacobi and Givens methods for finding eigenvalue and corresponding eigenvector.

UNIT-II

General Newton's method. Existence of roots. Stability and convergence under variation of initial approximations. General iterative method for the system: x = g(x) and its sufficient condition for convergence. Romberg's integration, Gaussian integration. Error analysis in integration.

UNIT-III

Predictor Corrector methods: Milne's and Adam Bashforth methods. Finite difference method for solving initial value problem. Classification of PDE. Solutions of parabolic equations by Crank-Nicolson, DuFort methods. Solution of elliptic equation by diagonal five point and standard five point formulae, solution of hyperbolic equations. Stability and convergence analysis.

UNIT-IV

Solution of boundary value problems by weighted residual methods Galerkin method, variational formulation of a given boundary value problem, Ritz method and orthogonal collocation method. Introduction to finite elements method. Solution of boundary value problems by finite element method.

Course Outcomes (CO): Upon completion of this course, the student will be able to:

1) Learn cubic spline technique for interpolation, solution of linear systems by relaxation methods and finding eigenvalues and vectors by Jacobi and Given methods.
2) Solve the systems of nonlinear equations by Newton's and successive Iteration methods, and learn to evaluate the integrals by important methods such as Romberg's and Gaussian quadrature rule.
3) Solve the Heat conduction equation, Laplace equation, Poisson's equation by using finite difference methods.
4) Know how to solve the boundary value problems by Galerkin, Ritz, Orthogonal Collocation and Finite element methods.

CO/PO Mapping (S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
Cos	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	M	M	S	M	S	S	M	M
CO2	S	S	S	S	M	M	S	M	S	S	M	M
CO3	S	S	S	S	M	M	S	M	S	S	M	M
CO4	S	S	S	S	M	M	S	M	S	S	M	M

RECOMMENDED BOOKS

1. Isacson and Keller, Analysis of Numerical methods, John Wiley and Sons (1966).
2. M.K. Jain, Numerical Solution of Differential Equations, New Age International (2014).
3. Prem K. Kytbe, An introduction to boundary element methods, CRC Press (2006).
4. B. P. Demidovich and J.A.Maron, Computational Mathematics, Mir Publishers (1981).
5. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific & Engg. Computation, New Age International (2012).

MA- 9205 ADVANCED OPERATIONS RESEARCH

Course Objective: Operations research helps in solving real life problems in different environments that needs decisions. This module aims to introduce students to use quantitative methods and techniques for effective decisions-making; model formulation, like LPP, TP, AP Network Problem and their applications

UNIT-I

Dual Simplex, Post-optimality analysis, changes in cost vector, changes in right hand side vector, introducing an additional variable, introducing an additional inequality constraint or equality constraint. Parametric and Sensitivity analysis of objective function and right hand side vector.

Network models: Shortest Path Problem (SPP) and Maximum Flow Problem (MFP).

UNIT-II

Introduction to game theory. The maximin & Minimax Criterion. Existence of saddle point. Game without saddle point. Mixed strategy. Solution of 2X2 game. Solution of rectangular game by mixed strategy. Dominance & its use to solve 2X2 game. Twoperson zero-sum game. 2XN & NX2 game. Graphical method, Algebraic method & LPP method.

Basic concept of queuing theory. Analysis of M/M/1/∞./FCFS and M/M/1/C/FCFS with Poisson pattern of arrivals and exponentially distributed service time.

UNIT-III

Classical Optimization theory. Unconstrained optimization by using Fibonacci, Golden section search and Steepest Descend method. Constrained optimization with equality constraint by Lagrange's method & Gradient projection method. Constrained optimization with inequality constraint by Kuhn -Tucker condition and graphical method.

UNIT-IV

Introduction to dynamic programming. Bellman's principle for optimality. Characteristics of dynamic programming problem. Dynamic programming for discrete & continuous variables.

General Inventory Model,(only deterministic models) with no shortages, with no shortage and several production runs of unequal length, Classical EOQ Model with Price Breaks.

Concept of system simulation. Advantages and limitation of simulation, Monte Carlo method. Simulation of queueing system, inventory system, network system.
Introduction to replacement problems and system reliability.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:

1) Use post-optimality analysis to solve changed problem from the solution of the old problem.
2) Using game theory one can estimate the risk in gambling and Solve Birth-Death process by queuing theory. Using network model one can learn to solve real life problems
3) Solve non-linear programming by various methods.
4) Formulate some real life problems into different types of OR models like network modeldynamic programming, inventory model, replacement & system reliability and find their optimum solutions by simulation and other techniques.

CO/PO Mapping (S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
Cos	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	M	M	S	M	S	S	M	M
CO2	S	S	S	S	M	M	S	M	S	S	M	M
CO3	S	S	S	S	M	M	S	M	S	S	M	M
CO4	S	S	S	S	M	M	S	M	S	S	M	M

RECOMMENDED BOOKS:

1. A.H. Taha, Operations Research, PHI (2007).
2. S.D. Sharma, Operations Research, Kedar Nath Ram Nath & Co.(1999).
3. D.S. Hira, System Simulation, S. Chand & Co.(2010)
4. S.S. Rao, Operations Research, Wiley (1978).
5. J. G. Chakravorty and P. R. Ghosh, Linear Programming and game Theory, Moulik Library (2009).
5. Kanti Swarup, P.K. Gupta & Man Mohan, Operations Research, S. Chand & Sons.(1994).

MA-9206 MATHEMATICAL THEORY OF SEISMOLOGY

L	T	P	C
4	1	0	5

Course Objective: The aim of this course is tounderstand earthquake dynamics, its causes and detection mechanism.

UNIT –I

Earth Composition and Structure, Core, mantle and crest. Lithosphere. Asthenosphere. Basic plate kinematics: plate velocity and plate driving forces. Geodynamo and magnetic field.

UNIT –II

Stress tensor, Stress tensor. Stress-strain relationship, Generalized Hooke's law, Poisson ratio, Shear ratio.

UNIT –III

Seismic Waves, Elastic plane waves: Harmonic wave. Wave equation and solution. Snell's law.
Momentum equation. Polarization of P and S waves. Spherical waves. Ray paths for laterally homogeneous models. Ray tracing through velocity gradients. Travel time curves. Spherical earth ray tracing. 3-dimensional ray tracing. Seismic phases. Travel time. Seismic wave energy. SH and SV waves, Surface waves: Love and Rayleigh waves.

UNIT –IV

Seismograph, intensity and Scale,Horizontal and vertical components seismograph. Indicator equation. Theory of undamped and damped seismometer. Seismographs for near and distant earthquakes.Elements of earthquake motion. Intensity of earthquake motion. Scales of Seismic intensity. Duration of earthquake.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:

1)To understand the importance of seismology.

2) To introduce the basic aspects of earth structure and earthquake theory.

3) To understand underlying principles.

4) Apply in mathematical domain.

CO/PO Mapping												
COs	Pos											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO09	PO10	PO11	PO12
CO1	S	S	M	M	S	S	S	S	S	S	M	S
CO2	S	S	S	M	S	S	S	S	S	S	S	S
CO3	S	S	S	S	S	S	S	S	S	S	S	S
CO4	S	S	S	S	S	S	S	S	S	S	S	S

RECOMMENDED BOOKS

1. A. Bedford and D. Drumheller, Introduction to Elastic Wave Propagation, John Wiley & Sons (1994).
2. Peter M. Shearner, Introduction to Seismology, Cambridge University Press (2009).
3. W. M. Ewing, W. S. Jardetzky and F. Press, Elastic Waves in Layered Media, Mc Graw-Hill (1957).
4. C. Davison, A Manual of Seismology, Cambridge University Press (1921).

MA 9207 WAVELET ANALYSIS

L	T	P	C
4	1	0	5

Course Objectives: The principle objective is to provide an introduction to the basic concepts and mythologies of theory of wavelets. The wavelet analysis has an advantage over Fourier analysis and therefore, to prepare the students to understand and analysis the application oriented problems in frontier areas of science.

UNIT-I

Review of vector spaces. Inner products, Orthonormal bases. Reiz systems and frames. Continuous Fourier transform (CFT), Basic properties. Fourier inversion. Continuous time-frequency representation of signals. Uncertainty Principle.

UNIT-II

Wavelet, origin and history. Examples of wavelets. $L^2(R)$ and approximate identities.Continuous wavelet transform (CWT) as a correlation. Constant Q-factor filtering. Interpretation and time frequency resolution. CWT as an operator. Inverse CWT. Relationship Between Wavelet and Fourier Transforms.

UNIT-III

Discrete wavelet transform.Haar scaling functions and function spaces. Wavelet bases of multiresolution analysis (MRA). Daubechies wavelets. Refinement relation with respect to normalized bases. Support of a wavelet system. General Theorems.

UNIT-IV

Evaluation of Scaling and wavelet functions. Designing wavelets (direct approach): Restriction on filter coefficients. Decomposition filters and reconstructing the signal. Interpreting orthonormal MRAs for discrete time signals. Frequency domain characterization of filter coefficients.B-spline wavelets.

Course Outcomes (CO):
Upon completion of this course, the student will be able to:

1) Understand the important wavelet analysis as a mathematical tool.
2) Introduce the basic aspects of wavelet theory.
3) Understand multiresolution analysis and the refinement relation.
4) Apply in mathematical domain.

CO/PO Mapping												
COs	Pos											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO09	PO10	PO11	PO12
CO1									M			S
CO2						M						
CO3						M				M		
CO4	M	S			M						M	

RECOMMENDED BOOKS:

1. M. W. Frazier, An Introduction to Wavelets Through Linear Algebra, Springer (1999).
2. M. W. Altaisky, Wavelets: Theory, Applications, Implementation, Universities Press (2005).
3. R. M. Rao and A.S. Bopardikar, Wavelet Transforms: Theory and Applications, Pearson (1998).
4. M. A. Pinsky, Introduction to Fourier Analysis and Wavelet Analysis, Thomson (2002).

MA-9208 THEORY OF LINEAR OPERATORS

L	T	P	C
4	1	0	5

Course Objectives:The aim of this course is to provide the basic concepts of normed linear spaces, bounded linear operators and their spectral properties. This is the generalization of geometry in higher dimensional spaces.

UNIT-I

Spectral theory in normed linear spaces, resolvent sets and spectrum, spectral properties of bounded linear operators, properties of resolvent and spectrum. Spectral mapping theorem for polynomials, spectral radius of a bounded linear operator on a complex Banach space.

UNIT-II

Elementary theory of Banach algebras, Resolvent set and spectrum, Invertible elements, Resolvent equation, general properties of compact linear operator.

UNIT-III

spectral properties of compact linear operators on normed space, Behaviour of compact linear operators with respect to solvabilityof operator equations. Fredholm type theorems, Fredholm alternative theorem, Fredholm alternative theorem for integral equations.

UNIT-IV

Spectral properties of bounded self-adjoint linear operators on a complex Hilbert space, Positive operators, Monotone sequence theorem for bounded self-adjoint operators on a complex Hilbert space, square root of positive operators. Spectral family of a bounded self-adjoint linear operator and its properties.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:

1) Understand the spectral theory in normed linear spaces.
2) Understand the spectral properties of compact linear operators on normed space and bounded self-adjoint linear operators on a complex Hilbert space .
3) Understand the Positive operators and to find their square root.
4) Understand the Spectral family of a bounded self-adjoint linear operator and its properties.

CO/PO Mapping
(S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak

Cos	Programme Outcomes (POs)										
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S				M	M		
CO2	S	S	S	S	S			M	M	M		
CO3	S	S	S	S	S			M	M	M		
CO4	S	S	S	S	S			M	M	M		

Recommended Books:

1) E. Kreyszig, Functional Analysis with applications, John Wiley& Sons.
2) P. R. Halmos, Introduction to Hilbert Space and Theory of Spectral Multiplicity, Chelsea Publishing Co.
3) N. I. Akhiezer and J. T. Glazman, Theory of Linear operators in Hilbert space, Dover Publications.
4) Rajendra Bhatia,Notes on functional analysis, Hindustan Book Agency.
5) B. V. Limaye, Functional Analysis, New Age International Publishers.

MA-9209 ADVANCED COMPLEX ANALYSIS

L	T	P	C
4	1	0	5

Course Objective: This course will provide a strong foundation of complex analysis and its techniques. Moreover, it will motivate students to pursue Complex analysis at advanced level, too.

UNIT-I

Normal and compact families of analytic functions, Montel's theorem, Hurwitz's theorem, Schwarz's Lemma. Analytic continuation, Analytic continuation by power series method, Natural boundary, Schwarz reflection principle, Monodromy theorem.

UNIT-II

Harmonic functions, Basic properties, mean value theorem, maximum and minimum modulus principles, Harmonic functions on a disc, Harnack's inequality and theorem, Green's function.

UNIT-III

Univalent function, the area theorem, Bieberbach theorem, Koebe ¼ theorem, Distortion and Growth theorem for the class S of normalized univalent functions, Coefficient estimates for members of class S, Littlewood's inequality for the class S.

UNIT-IV

Convex and starlike functions, necessary and sufficient condition for starlike and convex functions, Alexander's theorem, growth and distortion theorems for the classes of normalized convex and starlike functions, close-to-convex functions, Noshiro-Warchawski theorem, Poisson integral formula, Riemann mapping theorem, Convolution by convex functions.

Course Outcomes (CO):

Upon completion of this course, the student will be able to:

1) Understand the concept of analytic continuation and its applications.
2) Study normal families and their properties.
3) Study Riemann mapping theorem, conformal mapping of polygons.
4) Have a thorough knowledge of harmonic functions.

CO/PO Mapping (S/M/W indicates strength of correlation) S – Strong, M – Medium, W – Weak												
Cos	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S	S	S			M	M	
CO2	S	S	S	S	S	S	S			M	M	
CO3	S	S	S	S	S	S	S			M	M	
CO4	S	S	S	S	S	S	S			M	M	

RECOMMENDED BOOKS:

1. Zeev Nihari, Conformal Mapping, Dover Publications (1975).
2. J. B. Conway, Functions of One Complex Variable, Springer (1978).
3. A. W. Goodman, Univalent functions, Vol. I, Mariner Tampa (1983).
4. P. L. Duren, Univalent Functions, Springer-Verlag (1983).
5. D. K. Thomas, N. Tuneski and A. Vasudevarao, Univalent functions- A Primer, De Gruyter, Berlin (2018).