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) PROGRAMME

(2 YEARS; 4 SEMESTERS)

Mathematics is the backbone of the 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: 20

ELEGIBILITY: As per institute policy/UGC norms.

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. Analyze 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	MEASURE THEORY 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	MATHEMATICAL METHODS	4	1	0	5
5	MA 8205	TENSORS AND DIFFERENTIAL GEOMETRY	4	1	0	5
6	MA-8251	C++ PROGRAMMING	0	0	2	1
		TOTAL	20	5	2	26

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	OPERATIONS RESEARCH	4	1	0	5
3	MA 9103	MATHEMATICAL STATISTICS	4	1	0	5
4	MA 9104	NUMERICAL ANALYSIS	4	0	0	4
5	MA 9152	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	SEMINAR / PROBLEM SOLVING	0	2	0	2
4	MA 9251	SOFTWARE LAB USING MATHEMATICA, MATLAB AND LATEX	0	0	6	3
7	MA 920--	ELECTIVE-II**	4	1	0	5
8	MA 920--	ELECTIVE-III**	4	1	0	5
		TOTAL	16	6	6	25

**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 COSMOLOGY

MA 9106 WAVELET ANALYSIS

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 FLUID DYNAMICS

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, compactness, 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. 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, subsequences, 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 Integral, Properties of integral, integration and differentiation, Fundamental theorem of Calculus, 1^{st} and 2^{nd} mean value theorems for Riemann Stieltje's integral.

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) Recognize the difference between pointwise and uniform convergence of a sequence of functions.
5) Illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability and integrability.
6) Determine the Riemann-Stieltje's integrability of a bonded function and prove a selection of theorems and 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						
CO2	S					S						

CO3	S					S						
CO4	S					S						
CO5	S					S						
CO6	S					S						

RECOMMENDED BOOKS

1. Walter Rudin, Principles of Mathematical Analysis, 3rd edition, McGraw-Hill (2013).
2. H.L. Royden , Real Analysis, 3rd edition, Macmillan, New York &London 1988.
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, G.C.D and L.C.M., Primes, Fermat numbers, congruences and residues, theorems of Euler, Fermat and Wilson, solutions of congruences, linear congruences, Chinese remainder theorem.

UNIT II

Arithmetical functions $\phi(n)$, $\mu(n)$ and $d(n)$and $\sigma(n)$, Moebius inversion formula, perfect numbers, congruences of higher degree, congruences of prime power moduli and prime modulus, power residue.

UNIT III

Primitive roots and Indices, Quadratic residue, Legendre symbols, lemma of Gauss and reciprocity law. Jacobi symbol, Farey series, rational approximation, Hurwitz theorem, irrational numbers, irrationality of e and π. Representation of the real numbers by decimals.

UNIT IV

Finite continued fractions, simple continued fractions, infinite simple continued fractions, periodic continued fractions, approximation by convergence, best possible approximation, Pell's equations, Lagrange four square theorem.

Course Outcomes (CO):

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

1) Understand the operations with congruences, and solve linear congruence equations
2) Understand the usage of theorems: Chinese Remainder Theorem, Euler's theorem, Fermat's theorem, Wilson's theorem.
3) Determine the solubility of quadratic congruence by computation of Legendre symbol.
4) Understand continue 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											
CO2	S											
CO3	S											
CO4	S											

Books Recommended:

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, fundamental theorem of 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

Ideals, Ring homomorphism, algebra of ideals, sum and direct sum of ideals, maximal and prime ideals, Nilpotent and nil ideals, Fields and their examples, characteristic of a field.

UNIT- IV

Algebraic extensions, the degree of field extension, adjunction of roots, splitting field, finite fields, algebraically closed fields, extension of algebraic closure.

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. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, Basic Abstract Algebra, Cambridge University Press (1997).
2. Surjeet Singh and Qazi Zameeruddin, Modern Algebra, Vikas Publishing House (2006).
3. I.N. Herstein, Topics in Algebra, Wiley Eastern (2005).
4. I.N.Herstein, Abstract Algebra, PHI (1996).

5. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House (2008).
6. I. S. Luthar and I. B. S. Passi, Algebra Volume 1: Groups, Narosa Publishing House (2013).
7. Joseph A. Gallian, Contemprary Abstract Algebra, CENGAGE Learning (2014).

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 Newton, Langrage, Kepler, Euler and Legendre and to enable students to formulate mathematical models leading to solutions in physical world.

UNIT –I

Velocity and Acceleration of a particle along a curve, Radial and Transverse components (plane motion), Relative velocity and acceleration. Kinematics of a rigid body rotating about a fixed point. Vector angular velocity, General motion of a rigid body, General rigid body motion as a screw motion.

UNIT –II

Newton's laws of motion. Work, energy and power. Conservative forces. Potential energy. Impulsive forces. Rectilinear particle motion: (i) Uniform accelerated motion (ii) resisted motion (iii) simple harmonic motion (iv) Damped and forced vibrations. Angular momentum of a particle. The cycloid and its dynamical properties. Projectile motion under gravity. Constrained particle motion.

UNIT –III

Motion of a particle under a central force, Use of reciprocal polar co-ordinates, Kepler's laws of planetary motion and Newton's law of gravitation. Moments and products of Inertia, Theorems of parallel and perpendicular axes, Angular momentum of a rigid body about a fixed point and about fixed axes.

UNIT –IV

Canonical Transformation. Cyclic coordinates. Hamiltonian, Hamiltonian principle, Hamiltonian canonical equation of motion, Hamiltonian-Jacobi equation. Principle of least action. Poisson's bracket. Legendre transformation, its properties and applications. Euler's dynamical equations for the motion of a rigid body about a fixed point.

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) Apply it in mathematical and physical domain.

CO/PO Mapping												
COs	POs											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO09	PO10	PO11	PO12
CO1	S	M	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. F. Chorlton, Text Book of Dynamics, CBS Publishers (1998).
2. S. L. Loney, An Elementary Treatise on Dynamics of a particle and of Rigid Body, Cambridge University Press (1913).
3. H. Goldstein, C. Poole and J. Safko, Classical Mechanics, Addison-Wesley (2002).
4. John R. Taylor, Classical Mechanics, University Science Books (2005).

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) Solve the first order linear and non-linear PDE's by using Lagrange's and Charpit's methods, respectively.
5) Determine the solutions of linear PDE's of second and higher order with constant and variable coefficients.
6) Classify second order PDE and solve important classes of second order PDE's such as parabolic, hyperbolic and elliptic equations by separation of variables method.

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						
CO5	S					S						
CO6	S					S						

BOOKS RECOMMENDED:

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 Stability Theory, 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 MEASURE THEORY AND INTEGRATION

L	T	P	C
4	1	0	5

Course Objectives: This course provides the essential foundations of important aspect of mathematical analysis. Measure theory and theory of the integral have numerous applications in other branches of pure and applied mathematics, for example in the theory of (partial) differential equations, functional analysis and fractal geometry. The objective of this course is to give mathematical foundation to probability theory and statistics, and on the real line it gives a natural extension of the Riemann integral which allows for better understanding of the fundamental relations between differentiation and integration.

UNIT-I

Preliminaries, Lebesgue outer measure. Measurable sets. Regularity, Lebesgue measure, Non measurable sets.

UNIT-II

Measurable functions. Borel and Lebesgue measurability. Housdorff measures on the real line, Integration of non negative functions. The general Integral, Integration of series, Riemann and Lebesgue integrals.

UNIT-III

The Four derivates, continuous non differentiable functions. Functions of bounded variation. Lebesgue Differentiation theorem. Differentiation and integration. The Lebesgue set.

UNIT-IV

The L^p-spaces convex functions, Jensen's inequality, 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,
2) Understand basic properties are measurable functions,
3) Understand how measures may be used to construct integrals,
4) Know the basic convergence theorems for the Lebesgue integral,
5) Understand the relation between differentiation and Lebesgue 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						
CO2	S					S						
CO3	S					S						
CO4	S					S						
CO5	S					S						

RECOMMENDED BOOKS

1. H.L. Royden, Real Analysis, Macmillan, New York (1988).
2. G.de Barra, Measure Theory and Integration, Wiley Eastern Ltd. (2012).
3. G.B. Folland, Real Analysis, second edition, John Wiley, New York (1999).
4. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley (1989).
5. P. K. Jain and V. P. Gupta, Lebesgue Measure and Integration, Narosa Publishing House (2010).

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 $\arg z, \quad \log z, \quad z^c$. Mobius transformation, Conformal mapping.

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) Analyze limits and continuity for functions of complex variables.
2) Understand analytic functions, entire functions including 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											
CO2	S											
CO3	S											
CO4	S											

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. 3rd 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, dual spaces, annihilator space of a subspace of a vector space, algebra of linear transformations, singular and non-singular transformations, Rank and Nullity theorem. properties, representation of linear transformations as a matrix, change of basis,
Rank & Nullity theorem, Algebra of linear transformation, dual spaces, dual basis.

UNIT-II

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

UNIT-III

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

UNIT-IV

Inner product spaces, properties, Cauchy Schwarz inequality, orthogonal vectors. Orthogonal complements, orthonormal sets and bases, Gram Schmidt orthogonalization process. Rational canonical forms, Generalized Jordan forms over arbitrary field.

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 (2011).
2. I. N Herstein, Topics in Abstract Algebra, Wiley Eastern Ltd. (2005).
3. J. Gilbert and L. Gilbert, Linear Algebra and Matrix Theory, Academic Press (2013).
4. Vivek Sahai and Vikas Bist, Linear Algebra, Narosa Publishing House (2008).

MA - 8204 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 courses offered in the applied mathematics. The objective of this course is to enable students to apply transforms and variation problem technique for solving differential equations and extremum 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

Functional, Euler-Lagrange equation, variational methods of boundary value problems in ordinary and partial differential equations.

UNIT-III

Review of Laplace transform, Applications of Laplace transform in initial and boundary value problems, Heat equation, Wave equation, Laplace equation.

UNIT-IV

Fourier integral, Fourier transform & properties, Fourier sine and cosine transforms and theorems, Convolution theorem, Applications of Fourier transforms in solving partial differential equations (Laplace, Heat and Wave equations).

Course Outcomes (CO):

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

1) Laplace Transformation to solve initial and boundary value problems.
2) Learn Fourier transformation and its applications to relevant problems.
3) Find solutions of linear integral equations of first and second type (Volterra and Fredhlom)
4) Understand theory of calculus of variations to solve initial and boundary 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										
CO2	S	S										
CO3	S	S										
CO4	S	S										

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-8205 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 technique of differential geometry. Students will be able to apply problem solving with differential geometry, in diverse situation in physics, engineering or other mathematical 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, Definition, nature and representation of surface, curves on a surface, tangent plane and surface normal. The general surface of revolution, Helicoids, Metric on a surface, first fundamental form. Families of curves, intrinsic properties.

UNIT-IV

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

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

1) Explain the concept and language of differential geometry and its role in modern Mathematics.
2) Apply differential geometry techniques to specific research problem in mathematical/ Physical Sciences.
3) 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

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-8251 C++ PROGRAMMING

L	T	P	C
0	0	2	1

INTRODUCTION TO C++: Basic program constructions, Pre processor directives. Header files. Comments & Variables. I/O functions. Arithmetic operators. Library functions. Relational operators.
Decisions: If statement. If else statement. Else if statement. Switch statement. Conditional operator. Logical operators. Break statement. Continue statement. Goto statement.
Structures: Specifying the structure. Structures & classes. Enumerated data types.
Functions: Declaration. Calling. Passing arguments. Returning values. Reference arguments. Returning by reference.
Arrays: Defining arrays. Integer array, non-integer array, character array. Passing arrays to functions. String variables. String constants. User-defined string type.
Files: Basics of file handling in C++.

(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.

RECOMMENDED BOOKS

1) Y. Kanetkar, Let us C, B. P. B. Publications (2008).
2) E. Balaguruswamy, Programming in C++, Tata McGraw-Hill (1992).

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, closed sets, Closure, Dense subsets, Neighbourhoods, Interior, exterior and boundary. Accumulation points and derived sets. Bases and sub bases. Subspaces and relative topology. 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 arcwise connected spaces. Components. Locally connected spaces.

UNIT –III

T_0 and T_1 spaces, T_2 -spaces and sequences. Hausdorffness of one point compactification. Axioms of Countability and Separability . Equidistance separable, second axion and Lindelof 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's Lemma. Tietze Extension 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) Apply the properties of open sets, close sets, interior points, accumulation points and derived sets in deriving the proofs of various theorems.
3) To understand the concepts of countable spaces and separable spaces.
4) Understand the concepts and properties of the compact and connected 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						
CO2	S	S				S						
CO3	S					S						
CO4	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 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. Hyperplane, hypersurfaces, convex sets and their properties, convex functions. Extreme points, 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. Primal and Dual problem. Duality theory, Complimentary Slackness Conditions (CSC), Solution of primal and Dual and vice versa.

UNIT-III

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 analysis of objective function and right hand side vector. Sensitivity analysis of objective function and right hand side vector.

UNIT-IV

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.
Maximum Flow Problem (MFP) and Shortest Path Problem (SPP).Min-Cost Flow Problem (MCFP).

Course Outcomes (CO):

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

1. Formulate some real life problems into LPP.
2. Use the simplex method to find an optimal BFS for the standard LPP and the corresponding Dual Problem.
3. Prove the optimality condition for feasible vectors for LPP and Dual LPP by CSC.
4. Use post-optimality analysis to solve changed problem from the BFS of the old problem.
5. Find the range of a parameter for which a BFS remains optimal by parametric analysis.
6. Sensitivity analysis is to determine the range of values of a single component of C or A or B remains an optimal BFS (all other data is kept fixed at the original values)
7. Find optimal solution of TP and AP

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
CO5	S	S	S	S	M	M	S	M	S	S	M	M
CO6	S	S	S	S	M	M	S	M	S	S	M	M
CO7	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 (1991).
2. S. K. Gupta, Linear Progr[i1iiiii]amming & Network Models, Affiliated East-West Private Ltd. (1985).
3. H.A. Taha, Operations Research, PHI (2007).
4. A. Ravindran, D. T. Phillips and J. J. Solberg, Operation Research: Principles & Practice, John Wiley & Sons (1987).
5. S.S. Rao, Operations Research, Wiley (1978).
6. M. S. Bazaarra, J. J. Jarvis and H. D. Shirali, Nonlinear Programming, John Wiley & Sons (1990)
7. H. S. Kasana and K. D. Kumar, Introductory Operations Research, Springer Verlag (2005).

1

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 using two 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. Moments, Moment generating functions, Characteristic function, discrete and continuous univariate distributions - Binomial, Poisson, exponential, Normal, Gamma distributions. Marginal and conditional distributions, Bi-variate normal distribution.

UNIT-III

Modes of convergence and their interrelationships; Law of large numbers, Central limit theorem, Simple random sampling, stratified sampling, systematic sampling and Probability proportional to size sampling.

UNIT-IV

Standard errors. Chi-square distribution, Student's t distribution and F distribution, Fundamental notions, Neyman-Pearson lemma (without proof). Tests based on normal, t, Chi-square and F distributions.

Course Learning Outcomes: After the completion of this course, the student will be able to:
1) Compute the probability of composite events
2) Understand the random variable, expectation, moments and distributions
3) Know the difference between attributes and variables
4) Know the difference between small and large samples
5) Understand the concept of sampling distribution of a statistic such as mean and s.d.
6) Analyse the correlated data and fit the linear regression model
7) To explain the limitations of the statistical inferences.
8) To apply fundamental concepts in exploratory data analysis.

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
CO5	S	S	S	S	M	M	S	M	S	S	M	M
CO6	S	S	S	S	M	M	S	M	S	S	M	M
CO7	S	S	S	S	M	M	S	M	S	S	M	M
CO8	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. Jacob'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.

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 Ist order ODE by Runge-Kutta method.

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) Learn how to solve initial and boundary value problems numerically.
3) Understand, analyze and solve various problems arising in science and engineering numerically.

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										

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-9152 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 $1/3^{rd}$ rule
    iii) Simpson's $3/8^{th}$ rule iv) Romberg's rule

12. Solution of I^{st} 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 I^{st} order ordinary differential equations using
    i) Runge-Kutta method of III^{rd} order ii) Runge-Kutta method of IV^{th} order

ELECTIVE PAPERS FOR SEMESTER –III (Any one)

MA 9105 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 the area of Cosmology and to get started on research in Cosmology.

UNIT-I

An algebraic field, A vector space, Linear dependence & independence of vectors, Dual vector space, Einstein's summation convention, A quadratic form, Coordinate system in a Vn. Covariant & Contravariant tensors, Mixed tensors. Operations of Contraction and transvection

UNIT-II

Metric of Vn, Angle between two vectors in Vn, Chirstoffel symbols and curvature tensor, Associate curvature tensor, contraction of curvature tensor, problem set.

UNIT-III

Early relativistic Cosmology, the Observational revolution. Modern Friedmann Cosmology. Standard Cosmology. Hubble's Law and its implication, CMB radiation. The EFE. The Schwarzschild and Robertson-Walker metric.

UNIT-IV

Theory behind variation cosmological constant and gravitational constants. Deceleration parameter. New cosmological models. Dark Energy and Dark matter.

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

1. J. V. Narlikar, Introduction to Cosmology, Cambridge University Press.
2. F. Hoyle, G. Burbidge and J. V. Narlikar, A Different Approach to Cosmology, Cambridge University Press (2005).
3. J. N. Islam, An Introduction to Mathematical Cosmology, Cambridge University Press.

MA 9106 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 multi resolution 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.

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 multi resolution 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	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. 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-9107 DISCRETE MATHEMATICS

L	T	P	C
4	1	0	5

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, Eulerian paths, Multi-graphs, Weighted graphs, Trees, Spanning trees, binary trees, rooted trees, planer graphs, Euler's theorem. The Konigsberg Bridge problem and Eulerian graphs, Hamiltonian graphs.

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 mathematical models in the study of networks.
4. Learn how to work with some of the discrete structures which include sets, relations, functions, graphs and recurrence relation.

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. Basics of the modules theory is also covered.

UNIT-I

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

UNIT-II

Splitting fields, Normal extensions, 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 (1997).
2) I.N. Herstein, Topics in Abstract Algebra, Wiley Eastern Ltd (2005).
3) I. N. Herstein, Abstract Algebra, Prentice Hall (1996).
4) Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House (2008).
5) I. S. Luthar, I. B. S. Passi, Algebra Volumes 3 & 4: Modules, Narosa Publishing House (2010).

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 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. Continuity of linear maps. Equivalent norms. Normed spaces of bounded linear maps. Bounded linear functionals. Hahn-Banach theorem and its applications.

UNIT-II

Uniform boundedness principle. Open mapping theorem, Projections on Banach spaces, Closed graph theorem. Dual spaces of l_p and C [a, b], Reflexivity.

UNIT-III

Hilbert spaces, examples, Orthogonality, Orthonormal sets, 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 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 inner product spaces, orthogonality and Hillbert spaces.
3) Distinguish between finite and infinite dimensional spaces.
4) Apply linear operators in the formulation of differential and integral equations.

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					S	
CO3	S					S					S	
CO4	S	S				S						

RECOMMENDED BOOKS

1. G.F.Simmons, Introduction to Topology and Modern Analysis, Tata McGraw-Hill (1963).
2. E. Kreyszig, Introductory Functional Analysis with Applications, Wiley (1978).
3. G. Bachman and L. Narici, Functional Analysis, Courier Corporation (1966).
4. C. Goeffman and G. Pedrick, First Course in Functional Analysis, Prentice Hall (1965).
5. S. Ponnusamy, Foundation of Functional Analysis, Alpha Science International (2002).
6. B. V. Limaye, Functional Analysis, New Age International Publishers(2014).

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, Hamming codes, Cyclic codes like BCH codes, and parity-check matrices .

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, Primitive element of a finite field, Irreducible polynomials over finite fields, minimal polynomials of elements of finite field.

UNIT-II

Vector spaces over finite fields, 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, ISBN Codes, Lower bounds, Sphere covering bounds, Gilbert-Varshamov bound.

UNIT-III

Perfect codes, Hamming codes, Golay codes, Singleton bound and MDS codes, Plotkin bound, Hadamard matrix codes, Nordstrom-Robinson code, Griesmer bound, Construction of linear codes using propagation rules, Reed-Muller codes.

UNIT-IV

Cyclic codes, Generator polynomial of a cyclic code, Generator and parity-check matrices of cyclic codes, Burst-error-correcting codes, BCH codes, Parameters of BCH codes, Decoding of BCH codes.

Course Outcomes (CO):

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

1) Learn basic techniques of algebraic coding theory like Generator matrix and parity-check matrices of different codes and decoding of codes etc.
2) Learn different types of codes like BCH, cyclic and MDS codes, Golay codes, Perfect codes, ISBN codes.
3) Learn about Linear codes, their bases, Generator matrix and parity-check matrices, decoding of linear codes.
4) Understand various bounds in coding theory like sphere covering bounds, singleton bound and Plotkin bound.

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	W	M			S	S			W		
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 (2004).
2) L.R.Vermani, Elements of Algebraic Coding Theory, Chapman and Hall (1996).
3) Steven Roman, Coding and Information Theory, Springer Verlag (1992).
4) Raymond Hill, A First Course in Coding theory, Clarendon Press Oxford (1993).

MA 9203 SEMINAR AND PROBLEM SOLVING

L	T	P	C
0	2	0	2

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.

Manuplating 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, displaying material, declarations. 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 and other floating bodies.

The table of contents, cross references, Bibliography and citation. Making an index or glossary, keyboard input and screen input. 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, errors.

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).

ELECTIVE PAPERS FOR SEMESTER –IV (Any two)

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: Gauss-Seidel, Jacobi's and Relaxation method. Necessary and sufficient conditions for convergence. Jacobi's method 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 in integration.

UNIT-III

Milne's and Adam Bashforth methods. Finite difference method for solving initial value problem. Classification of PDE. Solution of one dimensional heat conduction equation by Crank-Nicolson methods. Convergence and stability. Standard and diagonal five point formula for solving Laplace and Poisson equations.

UNIT-IV

Solution of boundary value problems by weighted residual methods Galerkin, Ritz and orthogonal collocation methods. 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 the process of interpolation by using cubic spline technique and error analysis in this process.
2. Solve the systems of linear equations by using iterative methods such as Gauss-Seidel, Jacobi and Relaxation methods.
3. Understand eigenvalue problem and determine the eigenvalues and eigenvectors by Rayleigh's power method.
4. Solve the systems of nonlinear equations by general Newton's and Iteration methods including their error analysis.
5. Learn the process of numerical integration by using the methods such as Romberg's rule and Gaussian quadrature rule.
6. Solve the Heat conduction equation, Laplace equation, Poisson's equation by using finite difference methods.
7. 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
CO5	S	S	S	S	M	M	S	M	S	S	M	M
CO6	S	S	S	S	M	M	S	M	S	S	M	M
CO7	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

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

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. Two person zero-sum game. 2XN & NX2 game. Graphical method, Algebraic method & LPP method.

UNIT-II

Project planning and control with CPM (Critical Path Method) and PERT (program evaluation and Review Technique). Crashing.

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 & Gradient Projection method.. Constrained optimization with equality constraint by Lagrange's method & Gradient projection method. Constrained optimization with inequality constraint by Kuhn -Tucker condition.

UNIT-IV

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

General Inventory Model,(only deterministic models) Classical EOQ Model with Price Breaks, Multi-item EOQ with Storage Limitation.

Concept of Integer programming. Branch and bound technique, Gomory's cutting plane algorithm.

Concept of system simulation. Monte Carlo method. Simulation of continuous & discrete systems.

Replacement model.

Course Outcomes (CO):

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

1. Formulate some real life problems into different types of OR models.
2. Using game theory one can estimate the risk of playing gamble.
3. Find optimal solution of network problems.
4. Know how to complete a project in stipulated time with optimum cost by PERT & CPM techniques.
5. Solve Birth-Death process by Queuing Theory.
6. Formulate and Solution of Dynamic programming,
7. Solution of Inventory model, Integer programming, System Simulations and to know when to replace a old commodity.

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

CO5	S	S	S	S	M	M	S	M	S	S	M	M
CO6	S	S	S	S	M	M	S	M	S	S	M	M
CO7	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. M. S. Bazaarra, J. J. Jarvis and H. D. Shirali, Nonlinear Programming, John Wiley & Sons (1990)
6. A. Ravindran, D. T. Phillips and J. J. Solberg, Operation Research: Principles & Practice, John Wiley & Sons (1987).

MA-9206 MATHEMATICAL THEORY OF SEISMOLOGY

L	T	P	C
4	1	0	5

Course Objective: The aim of this course is to understand 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 FLUID DYNAMICS

L	T	P	C
4	1	0	5

Course Objectives : This course is intended to introduce basic characteristics of fluid, fluid kinematics, conservative principles, equation of motion, fluid flow through various systems and water wave propagation.

UNIT-I

Definition of a fluid. Fluid properties., Dimensions and units. Stream lines and path lines. Compressible and incompressible flow. Dimensionless numbers. Surface tension. Analysis of capillary effect in a tube.

UNIT-II

Conservation of mass. Energy equation. Linear momentum equation. Continuity equation. Navier-Stokes equation. Bernoulli equation. Applications.

UNIT-III

Laminar and turbulent flow. Steady flow between parallel plates. Flow through circular tubes and circular annuli. Turbulent flow relations. Flow in open channels. Flow through simple pipes. Flow losses in conduits.

UNIT-IV

Definition of ideal fluid flow. Euler's equation of motion. Integration of Euler's equation, Irrotational flow. Stream functions and boundary conditions. Two dimensional flows. Source and sink. Water waves modelling.

Course Outcomes (CO):

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

1) Understand the important Fluid dynamics.
2) Introduce the basic aspects of fluid flow
3) Understand underlying principles
4) Apply in mathematical and physical domain

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	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) V. L. Streeter, E.B. Wylie and K.W. Bedford, Fluid Mechanics, McGraw-Hill (1998).
2) R.W. Fox, A. T. McDonald and P. J. Pritchard, Introduction to Fluid Mechanics, John Wiley & Sons, (2004).
3) D. E. Rutherford, Fluid Dynamics, Oliver and Boyd (1959).
4) F. Chorlton, Fluid Dynamics. C.B. S. Publishers (1985).
5) M.E. O'Neil and F Chorlton, Ideal and Incompressible Fluid Dynamics, John Wiley &Sons (1986).

MA-9208 THEORY OF LINEAR OPERATORS

L	T	P	C
4	1	0	5

Course Objectives: The aim of this course is to provide students basic concepts of normed linear spaces, bounded linear operators and their spectral properties. The objective is to provide the students with knowledge of the elementary theory of Banach algebras, positive operators.

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 solvability of 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											
CO2	S											
CO3	S											
CO4	S											

Recommended Books:

1) E. Kreyszig, Functional Analysis with applications, John Wiley & Sons (2012).
2) P. R. Halmos, Introduction to Hilbert Space and Theory of Spectral Multiplicity, Chelsea Publishing Co.(1957).
3) N. I. Akhiezer and J. T. Glazman, Theory of Linear operators in Hilbert space, Dover Publications (1994).
4) G. Bachman and L. Narici, Functional Analysis, Dover Publications (2003).
5) B. V. Limaye, Functional Analysis, New Age International Publishers (2014).

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

Analytic continuation, Analytic continuation by power series method, Natural boundary, Schwarz reflection principle, Analytic continuation along a path, Monodromy theorem, Runge's theorem, simple connectedness, Mittag-Leffler's theorem.

UNIT-II

Maximum principle, Schwarz's Lemma, Hadamard's three circle theorem, Phragmen-Lindelof theorem, Weierstrass factorization theorem, Factorization of sine function, Gamma function. Entire functions, Jensen's formula, The genus and order of an entire function, Hadamard factorization theorem.

UNIT-III

Harmonic functions, Basic properties, Harmonic functions on a disc, Subharmonic and Superharmonic functions, The Dirichlet problem, Green's function.

UNIT-IV

Normal families of analytic functions, Montel's theorem, Hurwitz's theorem, Riemann mapping theorem, Univalent function, Distortion and Growth theorem for the class of normalized univalent functions, Covering theorem, starlike functions, convex functions, Subordination principle.

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						
CO2	S	S				S						
CO3	S	S				S						
CO4	S	S				S						

RECOMMENDED BOOKS

1. Zeev Nihari, Conformal Mapping, Dover Publications (1975).
2. E.T. Copson, An Introduction to Theory of Functions of a Complex Variable, Oxford University Press (1970).
3. J. B. Conway, Functions of One Complex Variable, Springer (1978).
4. T. W. Gamelin, Complex Analysis, Springer (2003).