FAKIR MOHAN UNIVERSITY
P.G. Department of Mathematics, M.A/M.Sc. (Mathematics) Course Structure
(Effective from 2022-23Sessions)

SEMESTER-I

PAPER NO.	PAPER NAME	MARKS		CREDIT
		END SEM ASSESSMENT	INTERNAL ASSESSMENT	
M101	ABSTARCT ALGEBRA	60	40	4
M102	REAL ANALYSIS	60	40	4
M103	ORDINARY DIFFERENTIAL EQUATIONS	60	40	4
M104	COMPLEX ANALYSIS	60	40	4
M105	ADVANCED LINEAR ALGEBRA	60	40	4
M106	PROBABILITY & STATTISTICAL INFERENCE	60	40	4
M107	DISCRETE MATHEMATICS	60	40	4
TOTAL		700		28

SEMESTER-II

PAPER NO.	PAPER NAME	MARKS		CREDIT
		END SEM ASSESSMENT	INTERNAL ASSESSMENT	
M201	TOPOLOGY	60	40	4
M202	MEASURE THEORY & INTEGRATION	60	40	4
M203	ADVANCED CALCULUS	60	40	4
M204	NUMERICAL ANALYSIS	60	40	4
M205	ELECTIVE-I	60	40	4
ML206	NUMERICAL ANALYSIS LAB (MATLAB)	50		2
MS207	SEMINAR	50		2
MV208	BIO-STATISTICS	50	50	3
TOTAL		700		27

SEMESTER-III

PAPER NO.	PAPER NAME	MARKS		CREDIT
		END SEM ASSESSMENT	INTERNAL ASSESSMENT	
M301	FUNCTIONAL ANALYSIS	60	40	4
M302	PARTIAL DIFFERENTIAL EQUATION	60	40	4
M303	OPERATIONS RESEARCH	60	40	4
M304	DIFFERENTIAL GEOMETRY	60	40	4
M305	ELLECTIVE-II	60	40	4
M306	MATHEMATICAL STATISTICS (CBCS)	60	40	4
ML307	LaTex	50		2
MS308	SEMINAR	50		2
TOTAL		700		28
FAKIR MOHAN STUDIES (NON-CREDIT COURSE)				

SEMESTER-IV

PAPER NO.	PAPER NAME	MARKS		CREDIT
		END SEM ASSESSMENT	INTERNAL ASSESSMENT	
M401	PROJECT (Thesis/Report, Seminar, Presentation, Viva-Voce)	200		10
TOTAL		200		10

ELECTIVE-I
NUMBER THEORY & CRYPTOGRAPHY
THEORY OF RELATIVITY & GRAVITATION
HARMONIC ANALYSIS
COMBINATORICS
ACTUARIAL MATHEMATICS
FUZZY SETS AND THEIR APPLICATIONS
ELECTIVE-II
INTRODUCTION TO COSMOLOGY
ALGEBRAIC CODING THEORY
NUMERICAL SOLUTIONS OF DIFFERENTIAL EQUATIONS
APPLIED STOCHASTIC PROCESS
MATHEMATICAL FINANCE
ADVANCED ANALYSIS
ANALYTIC NUMBER THEORY

Programme Outcomes

1. Students will get advanced knowledge of principles, methods and clear perception of numerous powers of mathematical ideas and tools.
2. Inculcate perilous thinking to carry out scientific investigation objectively without being biased with inflexible notions.
3. Create responsiveness to become aprogressive citizen with commitment to deliver one's responsibilities within the scope of bestowed rights and privileges
4. Continue to obtainpertinent knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in mathematical sciences.
5. Prepare students for hunting research or careers in industry in mathematical sciences and similar fields
6. Adequate exposure to global and local concerns that explore them many aspects of Mathematical sciences

Programme Specific Outcomes (PSOs)

1. Prepare and motivate students for research studies in mathematics and related fields.
2. Understanding of the fundamental axioms in mathematics and capability of developing ideas based on them.
3. Support students in preparing (personal guidance, books) for competitive exams e.g. NET, GATE, JEST, DRDO, any national level test.
4. Encourage problem solving skills, thinking, creativity through assignments, project work.
5. Provide knowledge of a wide range of mathematical techniques and application of mathematical methods/tools in other scientific and engineering domains.
6. Deliver innovative knowledge on topics in pure and applied mathematics, empowering the students to pursue higher degrees at reputed academic institutions.

SEMESTER-I

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M101	Abstract Algebra	4	40	60

Objectives	The concept of groups, rings, fields and vector spaces are essential building blocks of Modern algebra and are an integral part of any post graduate course. The objective of the present course Algebra is to deal with groups and rings only and students are encouraged to solve many problems here as this is necessary for any course they take later. This course not only plays a fundamental role in mathematics but also has applications to other areas of science and engineering.
Pre-Requisites	Set theory, Basic concept of matrices
Course Outcome	Students will observe how so much theory can be developed from just a few simple axioms that define group and ring. They will understand the importance of algebraic properties with regard to working within various areas like number systems, matrices, class of functions etc. Knowledge of this course can help students to read field theory, another basic concept of Modern algebra, in the next semester.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Normal subgroups, quotient groups, Isomorphism theorems, Automorphisms, Finitely generated abelian groups, Invariants of a finite abelian group, Sylow theorems	10
II	Rings, ideals, Maximal and primal ideals, Unique factorization domains, Principal ideal domains, Euclidean domains, Polynomial rings over UFD	08
III	Algebraic extension of fields: Irreducible polynomials and Eisenstein criterion, Adjunction of roots, Algebraic extensions, Algebraically closed fields,	10
IV	Normal and separable extensions: Splitting fields, Normal extensions, Multiple roots, Finite fields, Separable extensions.	10
V	Galois theory: Automorphism groups and fixed fields, Fundamental theorem of Galois theory, Fundamental theorem of algebra, Applications of Galois theory to classical problems: Roots of unity and cyclotomicpolynomials, Cyclic extensions, Polynomials solvable by radicals	10
	Total	48

Text Books:

T1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, **Basic Abstract Algebra**, 2nd Edition, Cambridge University Press, 1995.

Reference Books:

R1. I. N. Herstein, Topics in Algebra, John Wiley and Sons; 2nd Revised edition edition, 1975.
R2. J. B. Fraleigh, A first Course in Algebra, Pearson, 7th Ed., 2013.

R3. J. Gallian, Contemporary Abstract algebra, Brooks/Cole Pub Co; 8th edition, 2012.
R4. D.S. Dummit and R.M. Foote, Abstract Algebra, Wiley, 3rd edition, 2011.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M102	Real Analysis	4	40	60

Objectives	The objective of this course is to give basic materials to students so that they can easily understand the structure and topology of real number system, sequences and series of real numbers and functions, Riemann Integration.
Pre-Requisites	Set Theory.
Course Outcome	After completing this course students can make a choice for further studies in Complex Analysis, Functional Analysis, Measure Theory, Differential Geometry, Advanced Analysis, Harmonic Analysis etc.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Relation, Function and Basics of Calculus, Countability, Axiom of Choice and Equivalents, Neighborhood, Interior point, Limit point, Open sets and closed sets in R, Accumulation points, Sequences of real numbers, Cauchy sequence, completeness, Bolzano-Weierstrass theorem, Heine-Borel theorem, Series, convergence, test of convergence.	10
II	Sequence and Series of Functions: Point-wise and Uniform convergence of Sequence and Series of Functions, Cauchy criterion and Weierstrass M-Test for uniform convergence, Uniform Convergence and Continuity, Integrability, Differentiability.	10
III	Riemann integration, Inequalities of upper and lower sums, Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums, Equivalence of two definitions,Riemannintegrability of monotone and continuous functions, Properties of the Riemann integral, Definition and integrability of piecewise continuous and monotone functions.	10
IV	Functions of bounded variation, Total variation, Additive property of total variation, Riemann-Stieltjes integral, linear properties, Integration by parts, Change of variable in a Riemann-Stieltjes integral, Reduction to a Riemann Integral, Reduction of a Reimann-Stieltjes integral to a finite sum, Necessary and sufficient conditions for existence of Riemann-Stieltjes integrals. Mean value theorem for Riemann-Stieltjes integral, Fundamental theorems of Integral Calculus.	10
V	Functions of Several variables, Differentiation in R^n, Partial Derivative, Directional Derivative, Total Derivative, Matrix of a linear transformation, Jacobians, Inverse function theorem, Implicit function theorem,	8
	Total	48

Text Books:

T1. T.M. Apostol, Mathematical Analysis (Narosa).

Reference Books:

R1. W. Rudin, Principles of Mathematical Analysis (Tata McGraw Hill).

R2.H. L. Royden, Real Analysis (Pearson).

R3.S.C. Mallik and S. Arora, Mathematical Analysis (New Age International).

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M103	Ordinary Differential Equations	4	40	60

Objectives	Differential Equations introduced by Leibnitz in 1676 models almost all physical, biological, Chemical, Socio-economic system in nature. The objective of this course is tofamiliarize the students with various methods of solving differential equations and to have a qualitative analysis of the behaviour of solutions along with existence and uniqueness problems. The students have to solve problems to understand the methods.
Pre-Requisites	Continuity, Differentiation, Integrations, Basic Differential Equations
Course Outcome	A student completing the course is able to solve differential equationsand is able to model problems in nature using ODE. This is also prerequisite for taking othercore courses in partial differential equations, stability theory, oscillation problems, Evolutionequations, Dyncmical system, Bifurcation theory, Mathematical modeling etc.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Second order Linear Differential Equations:- General solution, Using a known solution to find the other, Homogeneous equations with constant coefficients, Inverse operator method, Method of variation of parameters,	8
II	Power Series Solutions and Special Functions: Series solution about an ordinary point, Legendre equation and Legendre polynomial, Power series solution about singular points(Frobenius method), Bessel's equation and Bessel functions. Properties of Bessel functions.	10
III	Boundary value problems for ordinary differential equations : Sturm-Liouville problem, Eigen value and eigen functions, Expansion in eigen functions, Green's function, Picard's theorem for boundary value problems.	10
IV	The LaplacesEquation : Boundary value problem for Laplace's equation, fundamental solution, Integral representation and mean value formula for harmonic functions, Green's function for Laplace's equation, Solution of the dirichlet problem for a ball, solution by separation of variables, solution of Laplace's equation for a disc.	10
V	System of Linear Differential Equations: System of first order equations, Existence and Uniqueness theorems, Fundamental Matrix, Homogeneous and Non Homogeneous linear systems with constant Co-efficient, Linear system with periodic Co-efficient.	10
	Total	48

Text Books:

T1:S. G. Deo and V. Raghavendra, Ordinary Differential Equa- tions and stability theory, TATA McGraw Hill Ltd, 1980

Reference Books:

R1: G. F. Simmons, Differential Equations with Applications, McGraw Hill International Edition, 1991.
R2: G. Birkhoff and G. C. Rota-Ordinary Differential Equations-John Wiley and Sons, N.Y., 1989.
R3: Coddington and Levinson, Theory of Ordinary Differential Equations, Krieger Pub Co (June 1984)
R4: Tyn-Myint-U Ordinary Differential Equations, Elsevier North-Holland, 1987.
R5: S. Ahmed, A. Ambrosetti, A textbook on Ordinary Differential Equations Springer Publication.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M104	Complex Analysis	4	40	60

Objectives	The aim of this course is to introduce the theory for functions of a complex variable. Using this the concepts of analytic and mapping properties of function of a complex variable will be illustrated. Then we discuss complex integration, classification of singularities and examine theory and illustrate the application of the calculus of residue in the evaluation of integral.
Pre-Requisites	Real analysis , metric space theory
Course Outcome	After completing this course, students are expected to be able to work with functions of single complex variable. It will help them for further studies in Advanced Analysis, Harmonic Analysis etc.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Function of complex variable continuity and differentiability, Analytic function,C-R equation(Cartesian and polar), Harmonic function,Harmonic conjugate, construction of Analytic function, exponential function, Trigonometric and inverse trigonometric function, Logarithmic function	10
II	Complex power, branches of multivalued function, with reference to arg(z), The linear transformation, cross ratio and conformal mapping, Mobious transformations.	10
III	Cauchy's theorem for rectangle, Cauchy theorem for disc, general form of Cauchy's theorem, harmonic function fundamental Theorem of Algebra Morera's theorem, open mapping theorem, a zero's of complex function	10
IV	Taylor series, Classification of singularities, poles, absolute convergence, Laurent series development, Maximum modulo theorem, Schwartz's Lemma	9
V	Normal families, Arzela's theorem , Residue calculus, Riemann Mapping theorem and	9

	Weriestrass theorem, Riemann zeta function,	
	Total	48

Text Books:T1. L.V. Ahlfors-Complex Analysis, McGraw Hill, 3rd Ed.1979

Reference Books:R1. Brown and Churchill-Complex Variables and Appl. McGraw Hill, 9th Ed
R2. J.B. Conway-Function of one complex variable, Springer, 2nd ed. 1978, 7th printing 1995 ed.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M105	Advanced Linear Algebra	4	40	60

Objectives	The objective of this course is to have a complete understanding of linear algebra. Understanding vector spaces and linear transformations in linear algebra pave the way for any advance course in linear algebra.
Pre-Requisites	Set theory, Relation functions, Matrix operations etc
Course Outcome	The knowledge on this course will provide the basis for further studies in advanced course like commutative algebra, linear groups, modules etc., which forms the basics of higher mathematics.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Vector Spaces, Subspaces, Linear independence, bases, Dimension, Projection, Quotient spaces, Isomorphism of vector spaces, Algebra of matrices, Rank and Inverse of matrix, The Algebra of Linear transformation, Kernel, Range, Matrix representation of a linear transformation, Change of bases, Rank and Nullity theorem.System of Linear equations	10
II	Characteristic roots and Vectors, Eigen values, Eigen vectors, Digonalization, Minimal polynomial of a linear transformation, Cayley Hamilton theorem.	10
III	Invariant subspaces, Direct sum decompositions, Invariant direct sums, The primary decomposition theorem,	10
IV	Inner product spaces, Gram-Schmidt orthogonalization process, Orthogonal complements, Gram-Schmidt Theorem	08
V	Canonical Forms: Diagonal forms, triangular forms, Jordan form, Rational Canonical form, Quadratic form	10
	Total	48

Text Books:

T1:K. Hoffman, R. Kunze. Linear Algebra, Pearson

Reference Books:

R1: A. RamachandraRao and P. Bhimsankaram. Linear Algebra, Hindustan Book Agency; 2nd Revised edition (15 May 2000.

R2: S. Kumaresan-Linear Algebra, Prentice Hall India Learning Private Limited; New title edi- tion (2000).

R3: P.P. Halmos - Finite Dimensional Vector Spaces, Springer; 1st ed. 1958. Corr. 2nd printing 1993 edition (August 20, 1993)

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M106	Probability & Statistical Inference	4	40	60

Objectives	Analysis of the outcome a random experiment and numerical probability of happening of an event is the contents of a first course in probability at undergraduate level.
Pre-Requisites	Set theory, Permutation and combination, Basic probability
Course Outcome	The knowledge on this course will provide the basis for further studies in advanced course like Stochastic process, Statistical Methods etc. which forms the basics of higher mathematics.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Introduction, Sample Spaces, Events, Axioms of Probability; Conditional Probability; Independent Events; Bayes' Theorem. Random Variable of Discrete Type, Probability Distribution, Probability Mass Function (pmf), Cumulative Distribution Function (cdf), Expectation, Variance and Moment Generating Function (MGF), The Probability Generating Function, Standard Discrete Distributions, such as, Uniform, Binomial, Negative Binomial, Hypergeometric, Geometric and Poisson, and their Applications	08
II	Random Variable of Continuous Type, Probability Distribution, Probability Density Function (pdf), c.d.f., Expectation, Variance and MGF. Standard Continuous Distributions, such as, Uniform, Exponential, Normal, Lognormal, Cauchy, Beta, Gamma and Chi-Square, and their applications.	10
III	Chebychev's Inequality, Chebychev's Rule, Empirical Rule. Functions of more than one Random Variables, Joint Distribution, Joint p.d.f and c.d.f, Marginal p.d.f., Independence of Random Variables. Conditional Distributions, Conditional Expectation, Covariance and Correlation.	10
IV	Transformation of Variables. Univariate and Doublevariate Case. Limit Theorems,Law of large numbers, convergence in distribution, central limit theorem, Poisson process,	10
V	Estimations (point and interval). Testing of Hypothesis	10
	Total	48

Text Books:

T1:J.S. Milton, J.C. Arnold, Introduction to Probability and Statistics 'Principles and applications for engineering and the computing sciences, 4th ed., Tata McGraw-Hill Pub.

Reference Books:

R1: Feller, Vol: 1, 2: An Introduction to Probability Theory and Applications, 3rd edition, John Wiley & Sons, 2008.

R2: Sheldon M. Ross: A First Course in Probability, 7th edition, Prentice Hall, 2002.

R3: Richard A. Johnson, Miller & Freund's: Probability & Statistics for Engineers, 6th Edition, Pearson Education Inc., First Indian Reprint, 2001.
R4: Hogg, R. V. and Craig, A. T.: Introduction to Mathematical Statistics, Pearson Education, 2005.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M107	Discrete Mathematics	4	40	60

Objectives	The objective of this course is to introduce the basic concepts of graphs which are used for model networking problems in physical and biological sciences etc.
Pre-Requisites	Set theory
Course Outcome	This course is prerequisite to almost all courses and research in computer science. After completing this course, a student can have the choice to take further research in Network Analysis, Algorithm and Data Analysis and so on.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Fundamentals of logic, Propositional equivalence, predicates and quantifiers, Methods of proofs, mathematical induction, recursive definition and structural induction	08
II	The basics of counting, the Pigeonhole principle, permutations and combinations, recurrence relations, solving recurrence relations, generating functions, inclusion-exclusion principle, application of inclusion-exclusion.	10
III	Boolean Algebra, Duality, Basic theorems, Boolean algebra as lattices, Boolean function, Representing Boolean function, Minimization of Boolean function.	10
IV	Graphs and graph models, Graph terminology and special types of graphs, Representing graphs and graph Isomorphism, connectivity, Euler and Hamilton paths, Planar graphs, Graph coloring.	10
V	Introduction to Trees, Applications of trees, Spanning trees, Minimum Spanning trees.	10
	Total	48

Text Books:

T1. K.H. Rosen, Discrete Mathematics and its applications, 6th edition, McGraw Hill, 2007.

Reference Books:

R1. J.L. Mott, A. Kendel and T.P. Baker: Discrete mathematics for Computer Scientists and Mathematicians, Prentice Hall.

R2. C.L. Liu, Elements of discrete mathematics, 2nd edition, Mc-Graw Hill.

SEMESTER-II

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M201	Topology	4	40	60

Objectives	This is an introductory course in topology, or the study of shape. The objective of this course is to have knowledge on point set topology, topological spaces, Quotient spaces, Product spaces and metric spaces, sequences, continuity of functions, connectedness and compactness, homotopy and covering spaces.
Pre-Requisites	Set theory, Relation functions, Basic real analysis etc.
Course Outcome	On successful completion of the course students will learn to work with abstract topological spaces, both the concrete and the very formal, the non-intuitive and the geometric. They will develop qualitative tools to characterize them (e.g., connectedness, compactness, second countable, Hausdorff...), and develop tools to identify when two are equivalent (homeomorphic).
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Basic concepts of Topology, Examples, Bases, Subbases, closed sets, Limit Points, Continuous functions.	10
II	Subspace topology, Product topology, and Quotient topology.	08
III	Connectedness, Local connectedness, Path-connectedness, Compact Spaces, compactness in metric spaces, locally compacts spaces, compact open topology	12
IV	Countability axioms Separation axioms Regular & completely regular space,	08
V	Normal spaces, UrysohnLemma,Urysohnmetrization theorem Tychonoff Theorem, Homotopy, Homotopy equivalences, path homotopy Fundamental Group	10
	Total	48

Text Books:

T1:J.R. Munkres-Topology - A First Course in Topology, Pearson; 2 edition, 2000.

Reference Books:

R1: Dugundji - Topology, McGraw-Hill Inc.,US (1 April 1988)
R2: Hu- Elements of General Topology, Holden-Day, 1964.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M202	Measure Theory & Integration	4	40	60

Objectives	The objective of this course is to approach integration via measure, rather than the other way round. It is fundamental to many areas of mathematics and probability. Also it has many applications in other fields such as Physics, Economics, Mathematical Finance and so on.
Pre-Requisites	Basic concepts of Real Analysis.
Course Outcome	After completing this subject, students will understand the fundamentals of measure theory which will help them for further studies in Differential Geometry, Advanced Analysis and so on.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Cantor-like sets, Outer measure, Lebesgue outer measure, Measurable ses, Properties of measurable sets, Borel sets and their measurability, Further properties of Measurable sets.	10
II	Measurable functions, Properties of measurable functions, Step functions, Simple functions, Operations on measurable functions, Borel measurable function, Non-BorelLebesgue measurable set, Sequence of functions on measurable sets.	10
III	Lebesgue integral of a bounded function, Properties of Lebesgue integral for bounded measurable function, Integral of non-negative measurable functions, Fatou's Lemma, Lebesgue's Monotone Convergence theorem, General Lebesgue integral,Lebesgue's Dominated Convergence theorem, Integration of series, Riemann and Lebesgue integrals.	10
IV	The Four Derivatives, Functions of Bounded Variation, Lebesgue's Differentiation Theorem, Differentiation and Integration, The Lebesgue Set, Integral of the derivative.	10
V	The L^p Spaces, Convex Functions, Jensen's Inequality, The Inequalities of Holders and Minkowski, Completeness of $L^p(\mu)$, Convergence in Measure, Almost Uniform Convergence, Convergence Diagrams, Counter examples, Measurability in a product space.	8
	Total	48

Text Books:

T1: G. de Barra, Measure Theory and Integration (Woodhead Pub. India(P) LTD.)

Reference Books:

R1. I.K. Rana, An Introduction to Measure and Integration (Narosa Publishing House)

R2. H. L. Royden, Real Analysis (Macmillan Pub. Company)

R3. P.K. Jain, B.P. Gupta, P. Jain, Lebesgue Measure and Integration, New age international publisher.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M203	Advanced Calculus	4	40	60

Objectives	The objective of this course is to prepare a student in basics of Integral transforms, Integral equations and calculus of variations. These tools have engineering applications. Fourier transform and Laplace transform help in studying differential equations and other engineering problems. Calculus of variations and Euler equations are essential in understanding many physical problems and optimization problems.
Pre-Requisites	Differential equation
Course Outcome	A student trained in this course can opt for courses like digital signal processing, variational analysis, Wavelets. This exposes the application of mathematics to various real life problems.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Matrix Calculux : Gradient, Directional derivative, Taylor series, Product rules for matrix-functions,Kronecker product, Hadamard product,Chain rules for composite matrix-functions, First directional derivative,Second directional derivative, directional derivative expressions,higher-order multidimensional Taylor series, Correspondence of gradient to derivative, Tables of gradients and derivatives , Matrix Diferentiation	10
II	Voltera integral equations: basic concepts, relationship between linear diferential equations and Voltera integral eqiuations, Resolvent kernel of voltera integral equations, solution of integral equations by resolvent kernel	9
III	Voltera integral equation:Mthod of successive approximation, convolution type equations, solutions of integral differential equation with the aid of laplacetransformation,Fredholm Integral equation: Fredholm equation of the second kind fundamental ,Iterated karnels, constructing the resolvent kernel with aid of iterated kernels	10
IV	Fredholm Integral equation :Integral equation with degenerate Kernel characteristic number and eign function, solution of homogeneous integral equation with degenerate kernel –non homogeneous symmetric equation,Fredholm alternative	9
V	Calculus of Variation: Variation & its Properties, Euler equation, field of extremalssufficient conditions for the extremum of a functional conditional extremum moving boundary problem , discontionous problems, one sided variations, Ritz method	10
	Total	48

Text Books:T1. Advanced Engineering Mathematics: Erwin Kreyszig Wiley, Eastern Ltd., 5th edition.T2. Calculus of Variations with Application: A. S. Gupta, PHI.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M204	Numerical Analysis	4	40	60

Objectives	Calculation of error and approximation is a necessity in all real life, industrial and scientific computing. The objective of this course is to acquaint students with various methods of finding solution of different type of problems such as locating roots of equations, finding solution of nonlinear equations, systems of linear equations, differential equations, Interpolation and approximation, differentiation, evaluating integration so as to minimize the error and time required to solve the problem and to evaluate approximate eigenavlues by using different methods.
Pre-Requisites	Basic Mathematics
Course Outcome	After getting trained a student can opt for the courses like advanced Numerical analysis and numerical functional analysis. Use of good mathematical software will help in getting the accuracy one need from the computer and can assess the reliability of the numerical results, and determine the effect of round off error or loss of significance.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Approximation of Functions: Weierstrass theorem and Taylor's theorem, Minimax approximation problem, Least square approximation problem, Orthogonal polynomials. Errors, Rate of convergence , Iterative methods.	10
II	Numerical Solution of Systems of Linear Equations: Gaussian Elimination, pivoting and scaling in Gaussian Elimination, Variants of Gaussian Elimination, Error analysis, Residual correction method, Iteration methods, Error prediction and acceleration.	10
III	Differentiation: Methods based on Interpolation, Methods based on Finite Differentials, Methods based on undetermined coefficients, optimum choice of step length, Interpolation method. Integration: Methods based on Interpolation (Trapezoidal rule, Simpson's rule),.	10
IV	Numerical Methods for Ordinary Differential Equations: Existence, uniqueness and stability theory, Euler's method, Multistep methods, Midpoint methods, Trapezoidal method, Low-order predictor-corrector algorithm, Derivation of higher order multistep methods, Convergence and Stability for multistep methods.	10
V	Eigen value problems (Jacobi method for symmetric matrices), error and stability results; Hermite Interpolation, Piecewise polynomial interpolation(Cubic Spline Interpolation, B-Spline curves)	08
	Total	48

Text Books:

T1.M.K. Jain, S.R.K Iyengar, R.K. Jain: Numerical Methods for Scientific and Engineering Computation, Willey Eastern Ltd. New Delhi (1995)

Reference Books:

R1:Rajaraman, V., Computer Oriented Numerical Analysis. Prentice-Hall of India Pvt. Ltd., 2002.
R2: Sharma, J.N., Numerical Methods for Engineers and Scientists, 2nd Edition. Narosa Publ. HouseNew Delhi/Alpha Science International Ltd., Oxford UK, 2007.
R3: Balagurusamy, E., Numerical Methods. New Delhi: Tata McGraw Hill, 1999.
R4: Bradie, B., A Friendly Introduction to Numerical Analysis. Pearson Prentice Hall.

ELECTIVE-I (M205)

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M205	Number Theory & Cryptography	4	40	60

Objectives	To expose students to various properties of numbers, number theoretic functions, congruences. Let them learn how to solve Diophantine equations, congruences. Have a knowledge of basic encrypting and decrypting techniques.
Pre-Requisites	Number system, functions
Course Outcome	Students will be able to recall elementary properties of numbers, use fundamental theorem of arithmetic and solve linear Diophantine equations, relate the theory of congruences to day to day life and solve system of linear congruences, apply the three important theorems in various number theoretic problems, check the primality of a number, demonstrate a working knowledge of various ciphers.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Divisibility: Division Algorithm, Prime and composite numbers, Fibonacci and Lucas Numbers, Fermat numbers, Greatest common divisor, Euclidean algorithm, Fundamental theorem of arithmetic, Least common multiple, Linear Diophantine equations	08
II	Congruences: Linear congruences, Pollard rho factoring method, Divisibility test, Complete residue systems. System of linear congruences: The Chinese remainder theorem, Wilson's theorem, Fermat's little theorem, Euler's theorem, Multiplicative functions,	10
III	Euler's phi function, Tau and sigma functions, The Mobius function, Primitive roots and indices, Order of a positive integer, Primality test	10
IV	Quadratic congruences: Quadratic residues, Legendre symbol, Quadratic reciprocity, Jacobi symbol. Finite continued fractions, Infinite continued fractions	10
V	Cryptology: Affine ciphers, Hill ciphers, Exponentiation ciphers, The RSA cryptosystem, The Knapsack ciphers	10
	Total	48

Text Books:

T1. T. Koshy, Elementary Theory of numbers with Applications, 2nd Edition, Academic Press, 2007.

Reference Books:

R1. D.M. Burton, Elementary number theory, 7th edition, Tata McGraw Hill, 2012.

R2. N. Koblitz, A course in number theory and cryptography, Springer-Verlag.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M205	Theory of Relativity and Gravitation	4	40	60

Objectives	This is an introductory course in Theory of relativity and gravitation. The objective of this course is to have knowledge on Relativity, Gravitation and origin of the Universe.
Pre-Requisites	Differential geometry, Basic Physics
Course Outcome	Understand the basic principles of cosmology. Know the significance the Einstein's theories of special and general relativity. Deal with the cosmological models. Learn various theories of gravitation
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Inertial and non-inertial frames, Special and General Galilean transformations, Lorentz transformation and its geometrical interpretation	08
II	Transformation formula for mass, density, momentum, energy and force.Minkowski-space, Relativistic equation of motion	10
III	Four vectors and tensors in Minkowski space, Lagrangian and Hamiltonian formulation of Relativistic Mechanics.Principles of equivalence and general covariance, Mach's Principle,	10
IV	Einstein's field equations, Energy momentum tensors, Gravitational equations, Vectors and tensors, Experimental tests of general relativity,	10
V	FRW model, Schwarzschild solution, Cosmological solutions in Einstein's field equations, Kaluza's five dimensional theory, Cosmological models, Singularity in cosmological models.	10
	Total	48

Text Books:

T1:S. R. Roy & Raj Bali, Theory of Relativity, Jaipur Publishing House, 2008.

Reference Books:

R1: S. Weinberg, Cosmology, Oxford University Press, 2008.

R2: S. K. Srivastava, General Relativity and Cosmology, PHI Pvt. Ltd., 2008.

R3: J. V. Narlikar, An Introduction to Cosmology, Cambridge University Press, 2002.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M205	Harmonic Analysis	4	40	60

Objectives	This course will provide an introduction to Fourier and Harmonic Analysis on EuclideanSpace with an emphasis on real variable methods. The course will focus on the roleplayed by the action of dilations, rotations, and translations on functions and operators and the extension from the one-dimensional to the multi-dimensional case.
Pre-Requisites	Basic concepts of Real Analysis, Measure theory and Functional Analysis
Course Outcome	This course help students to doresearch in both pure and applied mathematical fields.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Fourier series and Fourier transform in L_1 and L_2: basic properties, inversion, summability methods (Gauss-Weierstrass, Abel), point-wise convergence (briey).	10
II	Schwartz space, tempered distributions, weak derivatives (review), principal-valuedistributions, Fourier transform on distributions.	10
III	Interpolation of operators: weak L_p, Marcinkiewicz and Riesz-Thorin Theorems.	10
IV	Hardy-Littlewood maximal function and Calderon-Zygmund decomposition (via dyadic maximal function).	10
V	Hilbert transform and Fourier multipliers on the real line.	8
	Total	48

Text Books:

T1. J. Duoandikoetxea, Fourier analysis, Graduate Studies in Mathematics, 29. American Mathematical Society, Providence, RI, 2001.

Reference Books:

R1. L. Grafakos, Classical and modern Fourier analysis. Pearson Education, Inc.,Upper Saddle River, NJ, 2004.

R2.E. M. Stein, G. Weiss, Introduction to Fourier analysis on Euclidean spaces.Princeton Mathematical Series, No. 32.Princeton University Press, Princeton,N.J., 1971.

R3. Y. Katzenelson, An Introduction to Harmonic analysis, Cambridge University press.

R4. W. Rudin, Real and complex analysis, McGraw-Hill.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M205	Combinatorics	4	40	60

Objectives	Combinatorial tools play a major role in any computational activity in mathematics starting from pure mathematics to computer science. They help in proving many results and identities in almost all branches of mathematics. This course aims at being a basic course introducing basic methods.
Pre-Requisites	Set theory, basic counting ideas
Course Outcome	A student who has completed this course can opt for new courses like combinatorial topology, combinatorial geometry and analysis in next semester or at higher level of doing mathematics.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Partial order sets, lattices, complements, Boolean algebra, Boolean expressions, counting principle, permutation, combination, multinomial theorem, set partitions, derangements, Stirling numbers.	10
II	Pigeon-hole principle, generalized inclusion-exclusion principle, Generating functions: Algebra of formal power series, generating function models, calculating generating functions, exponential generating functions	08
III	Recurrence relations, divide and conquer relations, solution of recurrence relations, solutions by generating functions, Integer partitions, systems of distinct representatives	10
IV	Polya theory of counting: Necklace problem and Burnside's lemma, cyclic index of a permutation group, Polya's theorems and their immediate applications	10
V	Latin squares, Hadamard matrices, Gaussian numbers and q-analogues, Mobius Inversion, combinatorial designs: t-designs, BIBDs, Symmetric designs.	10
	Total	48

Text Books:

T1. Lint, J. H. van, and Wilson, R. M.: "A Course in Combinatorics", Cambridge University Press , (2nd Ed.) , 2001.

T2. V. K. Balakrishnam, Theory and problems of combinatorics, McGraw-Hill, 1994.

Reference Books:

R1. Sane, S. S.: "Combinatorial Techniques", Hindustan Book Agency, 2013.

R2. Brualdi, R. A.: "Introductory Combinatorics", Pearson Education Inc. (5th Ed.), 2009.

R3. Krishnamurthy, V.: "Combinatorics: Theory and Applications", Affiliated East-West Press, 1985.

R4. Hall, M. Jr.: "Combinatorial Theory", John Wiley & Sons (2nd Ed.), 1986.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M205	Actuarial Mathematics	4	40	60

Objectives	The aim of the Actuarial Mathematics subject is to provide grounding in the mathematical techniques which can be used to model and value cash flows dependent on death, survival, or other uncertain risks and also help to calculate premium and reserve for the insurance company.
Pre-Requisites	Set theory, Relation functions, Basic mathematics.
Course Outcome	On successful completion of the course students will learn, how to invest in market.
Teaching Scheme	25 percent self-study components for students, surprise quiz

Detailed Syllabus

Unit	Topics	Hours
I	The life table-Constructing a life table-Using the life table-The pattern of human mortality-Life table functions at non-integer ages-uniform distribution of deaths (UDD)-constant force of mortality (CFM)-The general pattern of mortality-Select mortality-Constructing select and ultimate life tables-Evaluation of assurances and annuities-Premium conversion equations-Variance of benefits-Expected present values of annuities payable m times each year. Life assurance contracts: Pricing of life insurance contracts, Whole life assurance contracts, Term assurance contracts, Pure endowment contracts, Endowment assurance contracts, Critical illness assurance contracts, Deferred assurance benefits, Mean and Variance of the present value random variable Claim acceleration approximation.	08
II	Life annuity contracts: Whole life annuities payable annually in arrears, Whole life annuities payable annually in advance, Temporary annuities payable annually in arrear, Temporary annuities payable annually in advance, Deferred annuities, Deferred annuities-due, Continuous annuities, Immediate annuity, Mean and Variance of the present value random variable approximations. Net premiums and reserves-The basis-	10
III	The net premium-The insurer's loss random variable-Reserves- Prospective reserve-Retrospective reserves-Conditions for equality of prospective and retrospective reserves-Net premium reserves-Recursive calculation of reserves-Mortality profit-Death strain at risk (DSAR)-Expected death strain (EDS) for a single policy-Actual death strain (ADS) for a single policy-Mortality profit.	10
IV	Variable benefits and with-profit policies-Variable payments-Payments varying at a constant compound rate-Payments changing by a constant monetary amount-With-profit contracts-Types of bonus-Calculating net premiums and net premium reserves for with-profit contracts-Accumulating with-profits contracts.	10
V	Gross premiums and reserves for fixed and variable benefit contracts-Types of expenses incurred in writing a life insurance contract-The influence of inflation on expenses-Gross future loss random variable for standard contracts- Determining gross premiums using the equivalence principle-Gross premium reserves-Equality of gross premium prospective and retrospective reserves.	10
	Total	48

Text Books:

T1: B H Smith "Contingencies of Value", Harvard University Press, 1988.

Reference Books:

R1: Alistair Neil "Life Contingencies", Butterworth-Heinemann Ltd; illustrated edition (1977).

R2: Griffith Davis "Table of Life Contingencies", Longman & Co, 1825: University of California Library.

R3: Micheal M Parmenter, "Theory of Interest and Life contingencies with Pension", 3rd Edition.

R4: Bowers, Newton L et al. – "Actuarial mathematics". 2nd Edition – Society of Actuaries, 1997.

R5: Benjamin, Bernard; Pollard, John H. – "The analysis of mortality and other actuarial statistics" 3rd Edition – Faculty and Institute of Actuaries, 1993.

R6: Gerber, Hans U. – "Life insurance mathematics" 3rd Edition– Springer. Swiss Association of Actuaries, 1997.

R7: Booth, Philip Metal. "Modern actuarial theory and practice"– Chapman & Hall,1999.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M205	Fuzzy sets and their applications	4	40	60

Objectives	Introduce the concept of fuzzy sets and help the students understand the difference between sets and fuzzy sets.
Pre-Requisites	Set theory
Course Outcome	Learn basic concepts of fuzzy sets, Understand real life applications of fuzzy theory, Differentiate between sets and fuzzy sets
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Fuzzy sets - Basic definition a -level sets. Convex fuzzy sets. Basic operations Fuzzy sets.	08
II	Type of Fuzzy sets. Cartesian products. Algebraic products,Bounded sum and difference t-norms and t-conorms.	10
III	The extension Principle- The Zadeh's extension principle image and inverse image of Fuzzy arithmetic	10
IV	Fuzzy Relation and Fuzzy Graphs-Fuzzy equivalence equations. Fuzzy graphs, Similarity relation	10

V	Possibility theory-Fuzzy measures, Evidence theory necessity measure, Possibility theory versus probability theory	10
	Total	48

Text Books:

T1. U. Z. Zimmermann, Fuzzy set theory and its application, Allied publisher, 1991.

Reference Books:

R1. G J Klir and Bo Yuan, Fuzzy set and fuzzy logic, Prentice Hall of India, 1995.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
ML206	Numerical Analysis Lab (MATLAB)	2		50

List of programs:

1. Fixed Point iterative method
2. Newton-Raphson's method
3. Ramanujan's method
4. Gauss Elimination method
5. Gauss-Seidel iterative method
6. Thomas Algorithm
7. Lagrange Interpolation method
8. Cubic Spline Interpolation method
9. Rational function approximation of Pade Numerical integration over rectangular region
10. Gaussian Quadrature method
11. Gauss-Chebyshev method
12. Euler's Method and Modified Euler's Method
13. Runge-Kutta 2nd and 4th Order methods
14. Adam's Predictor-corrector method
15. Finite difference method for BVP (ODE)
16. Finite difference method Laplace/Poisson equations
17. Schmidt Method 8. Crank-Nicolson method
19. Explicit Finite difference method for 1-d wave equation

RECOMMENDED BOOKS:

1. M.K. Jain: Numerical solution of differential equations, Wiley Eastern (1979), Second Edition.
2. C.F. Gerald and P.O. Wheatley : Applied Numerical Methods, Low- priced edition, Pearson Education Asia (2002), Sixth Edition

SEMESTER-III

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M301	Functional Analysis	4	40	60

Objectives	The aim is to introduce different function spaces like normed linear spaces, Banach Spaces, Hilber spaces etc. These spaces are of fundamental importance in many areas including the mathematical formulation of quantum mechanics. Also another object of studying functional analysis are the continuous linear operators defined on Banach and Hilbert spaces which lead naturally to the definition of C*-algebras and Operator Algebras.
Pre-Requisites	Linear Algebra, Real Analysis, Measure and Integration
Course Outcome	Since it is the basic course for all Advanced Analysis course, after completing this course, students can make a choice for further studies in different fields like Operator Theory, Spectral theory, Harmonic Theory, Infinite Dimensional Analysis etc.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Metric space, Examples of metric spaces, Neighborhood, Open set, Closed set, Convergence, Cauchy sequence, Completeness, Completion of metric spaces, Normed linear space, Further properties of normed linear spaces.	10
II	Finite dimensional normed linear spaces and subspaces, Banach space, Compactness and finite dimension, Linear operators, Bounded and continuous linear operators, Linear functional, Linear operator and functional on finite dimensional spaces, Normed linear spaces of operators.	10
III	Dual spaces, Hahn-Banach theorems, Reflexive spaces, Category theorem, Uniform boundedness theorem, open mapping theorem, closed graph theorem, Strong and weak convergence and weak* Convergence of sequences of operators and functional.	10
IV	Inner product spaces, Hilbert spaces and examples, Orthonormal sets, Bessel`s inequality, Complete orthonormal sets and Parseval`s identity, Approximation and Optimization, Projection theorem, Riesz-representation theorem.	10
V	Adjoint operator, Hilbert-Adjoint operator, Self-Adjoint, Unitary and normal operators, Spectral theory in finite dimensional normed linear spaces, spectral properties of bounded linear operators, further properties of resolvent and spectrum.	8
	Total	48

Text Books:

T1. B.V. Limaye, Functional Analysis (New Age International).

Reference Books:

R1. W. Rudin, Functional Analysis (McGraw Hill)

R2. I.J. Maddox, Elements of Functional Analysis (Cambridge University Press).

R3. E. Kreyszig, Introductory Functional Analysis with Applications (John Wiley and Sons).

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M302	Partial Differential Equations	4	40	60

Objectives	The objective of this course is to understand basic methods for solving Partial Differential Equations first order and second order. In the process students will be exposed to Charpit's Method, Jacobi Method and solve wave equation, heat equation, Laplace Equation. They will also learn classification of Partial Differential Equation and handle boundary value problems.
Pre-Requisites	Real analysis, differential equations
Course Outcome	After completing this course, a student will be able to take more courses on wave equation, heat equation, diffusion equation, gas dynamics, non linear evolution equations and integrable models etc. All these courses are importance in engineering and industrial application and in defence problems.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Meaning of Partial differential equation, Classification of first order Partial differential equations, Semi-linear and quasi-linear equations, Pfaffian differential equations, Lagrange's method, Compatible systems, Charpit's method, Jacobi's method.	10
II	Second Order Partial Differential Equations:- Definitions of Linear and Non-Linear equations, Linear Superposition principle, Classification of second-order linear partial differential equations into hyperbolic, parabolic and elliptic PDEs,	10
III	Reduction to canonical forms , solution of linear Homogeneous and non-homogeneous with constant coefficients, Variable coefficients, Monge'smethod.Laplace equation:- Solution by the method of separation of variables and transforms. Dirichlet's, Neumann's and Churchills problems,	10
IV	Dirichlet's problem for a rectangle, half plane and circle, Solution of Laplace equation in cylindrical and spherical polar coordinates.Diffusion equation:-Fundamental solution by the method of variables and integral transforms,	10
V	Duhamel's principle, Solution of the equation in cylindrical and spherical polar coordinates. Solution of boundary value problems:- Green's function method for Hyperbolic, Parabolic and Elliptic equations.	8
	Total	48

Text Books:

T1.Phoolan Prasad and RenukaRavindran, Partial Differential Equations, New Age International, 1985.

Reference Books:

R1. Ian Sneddon, Elements of Partial Differential Equations, International Students Edition.

R2: F. John - Partial Differential Equations, Springer-Verlag, New York, 1978.

R2:Tyn-Myint-U - Partial Differential Equations North Holland Publication, New York, 1987.
R3: T. Amarnath- An elementary course in partial differential equation, Narosa, 1997.
R4: J. N. Sharma, K. Singh, Partial Differential Equations for Engineers and Scienists, Narosa, 2nd Edition.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M303	Operations Research	4	40	60

Objectives	The aim of this course is to learn about management and administration of sociocultural behavior and economic factor that exist as bottleneck to effective implementation and to develop more effective approaches to the programming
Pre-Requisites	Knowledge of probability distribution and statistics and basic calculus
Course Outcome	Understand variety of problem such as assignment transportation, traveling salesman etc.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Revised simplex method, Dual simplex method, Degeneracy in TPTransportation algorithm (MODI method), Assignment Problem, Hungerian MethodTraveling sells man problem,	10
II	Integer programing problem,	9
III	Game theory.	9
IV	Traveling sells man problem, Sequence problem: introduction, processing of jobs through two machine. Queing model, general characteristic, MarkovianQueing model, M/M/1 model Limited queue Capacity Queue displine.	10
V	Non-linear Programing-Method: Introduction, graphical solution, Kuhn-Tucker condition with Non-Negative Contraints, Wolfe's Modified simplex , beals Method, Separable Convex Programing	10
	Total	48

Text Books:

T1. Operations Research (Ninth Edn.2001)-KantiSwarup, P.K. Gupta Manmohan (S.Chand)

Reference Books:

R1. S.D. Sharma, Operations Research, KedarNath& Ram Nath& Co. publisher, Meerut.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M304	Differential Geometry	4	40	60

Objectives	The objective of this course is to inform the students how the concepts of calculus can be applied to understand the geometry of mathematical surfaces such as planes, spheres and manifolds in general.
Pre-Requisites	Real Analysis, Topology, Measure Theory.
Course Outcome	After completing this course, students can make a choice for further study in Several Complex Variable, Hyperbolic Geometry, Projective and Algebraic Geometry etc. which are main components for Mathematical Physics, Relativity and Cosmology.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Preliminary Comments on Rn, Differentiability for Functions of Several Variables, Differentiability of Mappings and Jacobians, The Space of Tangent Vectors at a point of Rn,Another definition of Ta(Rn), Vector Fields on Open subsets of Rn, The Inverse Function Theorem.	10
II	Topological Manifolds,Definition of a Differential Manifold, Example of Differential Manifolds, Differentiable Functions and Mappings, The Tangent Space at a point of a Manifold, Vector Fields, Tangent Covectors, Covectors on Manifolds, Covector Fields and Mappings.	10
III	Bilinear Forms, The Riemannian Metric, Riemannian Manifolds as Metric Spaces, Tensors on a Vector Space, Tensor Fields, mappings and Covariant Tensors, Symmetrising and Alternating Transformations, Multiplication of Tensors on a Vector Space.	10
IV	Multiplication of Tensor Fields, Exterior Multiplication of Alternating Tensors, Exterior Algebra on Manifolds, Exterior Differentiation, Differentiation of Vector Fields along curves in Rn, The Geometry of Space Curves, Differentiation of Vector Fields on Submanifolds of Rn, Formulas for Covariant Derivatives.	10
V	Differentiation on Riemannian Manifolds, The Curvature Tensor, The Riemannian Connection and Exterior Differential Forms, Basic Properties of Riemannian Curvature Tensor, The Curvature Forms and the equations of Structure.	8
	Total	48

Text Books:

T1. W. Boothby, An Introduction to Differentiable Manifolds and Reimannian Geometry (Academic Press, new York)

Reference Books:

R1. W. Tu. Loring, An introduction to manifolds, Springer.

ELECTIVE-II

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M305	Introduction to Cosmology	4	40	60

Objectives	This course will serve as an introduction to Cosmology, which is a fascinating branch ofscience and deals with large scale structure of the Universe as a whole, in particular theorigin, evolution and ultimate fate of the Universe. In this course, we shall introduce thefundamentals of modern cosmology via the Mathematics of Newtonian Mechanics startingwith the observational overview of the Universe.
Pre-Requisites	Theory of Relativity and Gravitation, Differential Geometry
Course Outcome	Understand the basic principles of cosmology. Know the significance the Einstein's theories of special and general relativity. Deal with the cosmological models. Learn various theories of gravitation
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Brief history of cosmological ideas, Static cosmological models,In visible light, In other wavebands,Homogeneity and isotropy, The expansionof the Universe, Particles in the Universe. The Friedman equation, Meaning of theexpansion, Things that go faster thanlight,The fluid equation, The accelerationequation, Mass, energy and vanishingfactors of c2	08
II	Flat, Spherical and Hyperbolic geometries, Infinite and observable Universes, Place of Big Bang, Three values of k, Hubble's law, Expansion and redshift, Matter, Radiation, Mixtures, Particlenumber densities, Evolution including Curvature,	10
III	Hubble parameter, Density parameter,Decelerationparameter.Cosmological constant, Fluid description,Cosmological models with cosmological constant,	10
IV	Age of the Universe. Static cosmological models, Newtonian cosmology, Einstein universe, Expanding universe,	10
V	Friedmann models, Cosmological models with non-zero cosmological term, The early universe, The inflationary universe, Primordial black holes, Dark energy and dark matter, Observational constraints on cosmological parameters, Standard cosmology.	10
	Total	48

Text Books:

T1: A. Liddle:AnIntroduction to Modern Cosmology, Relativity and Cosmology,2nd edition,Wiley (2003).

Reference Books:

R1. S. Weinberg, Gravitation and Cosmology, John Wiley, New York, (1972).
R2. M. Rowan-Robinson, Cosmology, 3rd edition, Oxford University Press (1996).
R3: J. A. Peacock: Cosmological Physics, Cambridge University Press (1999).

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M305	Algebraic Coding Theory	4	40	60

Objectives	Study various type of codes, learn the coding problem, find the weight enumerator of codes
Pre-Requisites	Vector space, finite field
Course Outcome	Understand basic concepts and techniques in coding theory, Demonstrate knowledge of encoding and decoding procedure, Learn important families of algebraic codes, graphical codes and convolutional codes
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	The communication channel, the coding problem, Block codes, Hamming metric, Nearest neighbour decoding, Linear codes, Generator and Parity-check matrices, Dual code, Standard array decoding, Syndrome decoding	10
II	Hamming codes, Golay codes, Reed-Muller codes, Codes derived from Hadamard matrices.	08
III	Bounds on codes: Sphere packing bound, Perfect codes, Gilbert-Varshamov bound, Singleton bound, MDS codes, Plotkinbound,Weight distribution of codes, MacWilliams Identities.	10
IV	Algebra of polynomials, Residue class rings, Finite fields, Cyclic codes, Generator polynomial and check polynomial, Defining set of a cyclic code, BCH bound, Encoding and decoding of cyclic codes	10
V	Hamming and Golay codes as cyclic codes, BCH codes, Reed-Solomon codes, Quadratic residue codes, Graphical codes, Convolutional codes	10
	Total	48

Text Books:

T1. S. Ling and C. Xing: Coding Theory: A First Course, Cambridge University Press.

T2. F.J. MacWilliams and N.J.A. Sloane: The theory of error correcting codes, North Holland Pub.

Reference Books:

R1. V. Pless: Introduction to the theory of error correcting codes, John Wiley.

R2. W.C. Huffman and V. Pless: Fundamentals of error correcting codes, Cambridge University Press.

R3. R.M. Roth: Introduction to coding theory, Cambridge University Press.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M305	Numerical solution of Differential equation	4	40	60

Objectives	The objective of this course is to familiarize the students with various methods of solving differential equations and to have a qualitative analysis of the behaviour of solutions along with existence and uniqueness problems. The students have to solve problems to understand the methods.
Pre-Requisites	Differential equations, Numerical Analysis
Course Outcome	The knowledge on this course will provide the basis for further studies in advanced course in Differential equations and computational mathematics
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Problems for ODE: Multiple-step Methods, Variable Step Size Multistep Methods, Extrapilation. Methods, Higher-order Equations and Systems of Differential equations, Stability, BV problems for ODE: Linear shooting Method, The shooting Method for Non-Linear problems, Finite Difference Methods for Linear Problems.	10
II	Finite Difference Methoods for Parabolic equation in One-Space Variable (Explicit method and its convergence, Fourier Analysis of the error, Implicit and Weighted average methods and their convergence),	10
III	Finite Difference Methoods for Hyperbolic equation in One Space dimension,Characteristics, The CFL condition, Fourier Error analysis of the upward Scheme, The Lax-wendroff Scheme and its Application to Conservation Laws. Consistency, Convergance and Stability of Finite Difference Methods, Introduction to Finite Volume Method,	10
IV	Two Dimensional parabolic equations: Neumann boundary conditions, Convergence, Consistency, stability(stability of initial value Implicit schemes, Peaceman, Richford Scheme, Initial Value Problems, two- dimensional hyperbolic equations, Lax-wendroff scheme, Crack-Nocdson scheme, Stability analysis of two dimensional hyperbolic equation	10
V	Finite Element Method for elliptic model problems, finite element method for the model problem with piecewise linear functions, an error estimate for finite element method for model problem, finite element method for the Poisson equation.	8

Total	48

Text Books:

T1:K. Atkinson, Numerical Solution of Ordinary Differential Equations, Wiley Inter Science.

Reference Books:

R1: K Atkinson, W Han, David E Stewart, Numerical Solution of Ordinary Differential Equations, Wiley Inter Science

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M305	Applied Stochastic Process	4	40	60

Objectives	This is an introductory course in Stochastic Processes. The main objective of this course is to learn about the financial market of world economy.
Pre-Requisites	Probability theory.
Course Outcome	On successful completion of the course students will learn to work with Financial Mathematics and related to real life market.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Conditional Probability, Conditional Expectation, Markov Chains, Markov Chains for the Long Term	08
II	Branching Processes, Probability Generating Functions, Poisson Process, Arrival, Interarrival Times, Infinitesimal Probabilities, Thinning, Superposition,	10
III	Uniform Distribution, Spatial Poisson Process, Nonhomogeneous Poisson ProcessContinuous-Time Markov Chains	10
IV	Brownian Motion, Introduction, Brownian Motion and Random Walk, Gaussian Process, Transformations and Properties, Variations and Applications, Martingales	10
V	A Gentle Introduction to Stochastic Calculus, Introduction, Ito Integral, Stochastic Differential Equations	10
	Total	48

Text Books:

T1: Robert P. Dobrow– Introduction to Stochastic Processes with R, Pearson; 2 edition, 2000.

Reference Books:

R1: A. K. Basu- Introduction to Stochastic Process, Alpha Science
R2: J Medhi-Stochastic Process

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M305	Mathematical Finance	4	40	60

Objectives	The aim of this course is to provide grounding in financial mathematics like simple interest, compound interest and their simple applications to calculate accumulate value, present value and loan calculation, project evaluation, calculation of bond price in tax environment, Investment decision, and idea of stochastic interest rate model.
Pre-Requisites	Set theory, Relation Functions, Probability Theory
Course Outcome	On successful completion of the course students will learn to how to invest in market.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Introduction to financial mathematics- Economic models- Mathematical models- Efficient market hypothesis- The three forms of the efficient markets hypothesis- The evidence for or against each form of the efficient markets hypothesis- Informational efficiency- Volatility tests.	10
II	Consumer choice theory- Utility theory- The expression of economic characteristics in terms of utility functions- Measuring risk aversion-Construction of utility functions- Stochastic dominance-Relationship between dominance concepts and utility theory.	10
III	Measures of investment risk- Measures of risk-Variance of return-Semi-variance of return-Shortfall probabilities-Value at risk-Tail value at risk (TailVar) and expected shortfall-Relationship between risk measures and utility functions.	10
IV	Financial derivatives: Future contracts, options (European and American)	10
V	Martingles, Stochastic integrals, Ito integral, Ito's lemma, Mean-reverting processes	08
	Total	48

Text Books:

T1: Baxter, Martin & Andrew Rennie, Financial calculus; "An introduction to derivative pricing" Cambridge University Press, 1996.

Reference Books:

R1: Panjer, Harry H (ed), "Financial economics: with applications to investments, insurance and pensions", The Actuarial Foundation, 1998.
R2: Elton, Edwin J, Martin J Gruber, Stephen J Brown, & William N Goetzmann, "Modern portfolio theory and investment analysis" (6th edition), John Wiley, 2003.
R3: Hull, John C, "Options, futures and other derivatives" (5th edition), Prentice Hall, 2002.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M305	Advanced Analysis	4	40	60

Objectives	The objective of this course is to understand borel measure in real and complex field.
Pre-Requisites	Calculus, real and complex analysis, topology and measure theory concepts.
Course Outcome	To help the students to undertake further research in Functional analysis, Harmonic analysis and Fourier analysis.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Signed measure and the Hahn decomposition, The Jordan Decomposition,TheRaydon-Nikodim theorem, LebesgueDecompositionTheorem, Bounded linear functional on L^p.	10
II	Lebesgue-Stieltjes measure, Absolutely continuous functions, Integration by parts, Change of Variable, Riesz representation theorem for C(I).	10
III	Measurability in a product space, Product measure and Fubini's theorem, Lebesgue measure in Euclidean space.	8
IV	Spaces of analytic functions, Arzela Ascoli Theorem, Montel's theorem, Weierstrass factorization theorem, Gamma functionand its properties, Riemann Zeta function, Schwarz reflection principle, Monodromy theorem, Harmonic functions on a disc, Harnack's inequality and theorem, Dirichlet problem, Green's function.	10
V	Canonical products, Jensen's formula, Pisson-Jensen formula, Hadamard three circle's theorem, Order of an entire function, Exponent of convergence, Borel's theorem, Hadamard's factorization theorem, The range of an analytic function, Bloch's theorem, The Little Picard's theorem, Schottky's theorem, Montel Caratheodary and the Great Picard theorem.	10
	Total	48

Text Books:

T1. G. de Barra, Measure Theory and Integration (NEW AGE INT.(P)LTD.)

T2. J.B. Conway, Functions of One Complex Variable (Springer-Verlag)

Reference Books:

R1. I.K. Rana, An Introduction to Measure and Integration (Narosa Publishing House)

R2. H. L. Royden, Real Analysis (Macmillan Pub. Company)

R3. P.K. Jain, B.P. Gupta, P. Jain, Lebesgue Measure and Integration, New age international publisher.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M305	Analytic Number Theory	4	40	60

Objectives	A course in Number theory is a must solicited course every mathematics students for its beauty and clarity. The objective of the present course is to expose students to basics of Analytic Number Theory, Arithmetic Function, Distribution of Prime Number, Riemann Zeta function and work of Ramanujam.
Pre-Requisites	Elementary number theory
Course Outcome	At the end of the course students are expected to get interested to solve challenging problems in Number Theory. They will be able to collect and utilize Numerical Information to shape conjuctures in Number Theory. This also prepares to opt for courses in Cryptography, Algebraic Number Theory and Ramanujams Works.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Fundamental Theorem of arithmetic, Arithmetical functions and Dirichlet Multiplication	10
II	Average of arithmetical function	08
III	Elementary theorem in distribution of primes numbers	10
IV	Congruences, quadratic residues and Reciprocity law	10
V	Ramanujan Sum, Reimann zeta function	10
	Total	48

Text Books:

T1. . T.M. Apostol, An Introduction to Analytic Number Theory, Springer, 1976.

Reference Books:

R1. Chandra Shekharan K., Introduction to Analytic Number Theory.

R2. G.H. Hardy and E.W. Wright, Theory of Numbers, Oxford University Press; 6 edition , 2008.

R3. I. Niven and H.S. Zukerman, An Introduction to Theory of Numbers.

R4. Richard Guy, Unsolved Problems in Number Theory. Springer Verlag, John Wiley and Sons; 5th Revised edition edition , 1991.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M306	Mathematical Statistics (**CBCS**)	4	40	60

Objectives	This is an introductory course in mathematical statistics. The objective of this course is to have knowledge on Statistics.
Pre-Requisites	Set theory, Relation functions, Basic real analysis etc.
Course Outcome	To make the students understand the concepts of statistical methods by giving more emphasis to their real life applications.
Teaching Scheme	25 percent self-study components for students. Surprise test and problem solving during lecture hour by forming group among the students. Home assignments.

Detailed Syllabus

Unit	Topics	Hours
I	Idea of population and sample, measures of central tendency, mean, median, mode, partition values, measures of dispersion, moments, skeweness and krtosis	08
II	Bivariate distribution, regression lines, regression coefficients, correlation coefficient ,rank correlation, partial and multiple correlations, Regression plane	10
III	Basic concept of sampling distribution, large sample theory and small sample theory: point estimation of parameters, concepts of bias and standard errors of an estimate, standard errors of sample mean and sample proportion.	10
IV	Point estimation, interval estimation	10
V	Test of significance: Null and alternative hypotheses level of significance, Type –I error & Type-II error, Distributions and chi-square, t and F statistics, (without derivations) test of mean and variance of normal population	10
	Total	48

Text Books:

T1:V.K. Kapoor and S.C. Gupta: Fundamental of Mathematical Statistics

Reference Books:

R1. C.B. Gupta: Fundamental of Statistical Methods

R2. A.M. Goon, M.K. Gupta and B. Dasgupta: Fundamentals of Statistics

SEMESTER-IV

M401: Project work

Value added Course

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
MV -208	**Bio-statistics**	3	50	50

Syllabus

UNIT-I. Sampling Distributions, Law of large numbers and Central LimitTheorem: Concepts of random sample and statistic; distribution of sample mean from a normal population; chi-square distribution; F and t statistics, distributions (noderivations) and their applications. Chi-square test for goodness of fit, Central LimitTheorem for i.i.d case (statement and examples only).Evaluation of probabilities from the binomial and Poisson distributions using central limit theorem.weak law of large numbers (statement and applications only).

Unit-II: Functions of survival time, survival distributions and their applications viz. exponential, gamma, weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shape hazard function. Tests of goodness of fit for survival distributions (WE test for exponential distribution, W-test for lognormal distribution, Chi-square test for uncensored observations

Unit-III: Type I, Type II and progressive or random censoring with biological examples, Estimation of mean survival time and variance of the estimator for type I and type II censored data with numerical examples. Non-parametric methods for estimating survival function and variance of the estimator viz. Acturial and Kaplan –Meier methods.

Unit-IV: Stochastic epidemic models: Simple and general epidemic models (by use of random variable technique

References

Biswas, S. (1995). Applied Stochastic Processes. A Biostatistical and Population Oriented Approach, Wiley Eastern Ltd.

Elandt Johnson R.C. (1971). Probability Models and Statistical Methods in Genetics, John Wiley & Sons.

Collett, D. (2003). Modelling Survival Data in Medical Research, Chapman & Hall/CRC.
Dutta, N. K. (2004).Fundamentals of Biostatistics, Kanishka Publishers.
Gurumani N. (2005) .An Introduction to Biostatistics, MJP Publishers.
Daniel, W. W. (2007). Biostatistics- A Foundation for Analysis in the Health Sciences,Wiley.
Rao, K. V. (2007). Biostatistics – A Manual of Statistical Methods for use in Health Nutrition and Anthropology.
Pagano, M.&Gauvreau, K. (2007). Principles of Biostatistics.

Rohatgi, V.K.&Saleh, A.K.Md. (2001). An Introduction to Probability and Statistics, John Wiley & Sons.
Sundaram, K.R.(2010) Medical Statistics-Principles & Methods, BI Publications,New Delhi