FAKIR MOHAN UNIVERSITY
P.G. Department of Mathematics
M.A/M.Sc. (Mathematics) COURSE STRUCTURE
(Effective from 2023-24 Sessions)

SEMESTER-I

PAPER NO.	PAPER NAME	MARKS		CREDIT
		END SEM ASSESSMENT	INTERNAL ASSESSMENT	
M101	ALGEBRA	60	40	4
M102	ADVANCED 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 & STATISTICAL INFERENCE	60	40	4
TOTAL		600		24

SEMESTER-II

PAPER NO.	PAPER NAME	MARKS		CREDIT
		END SEM ASSESSMENT	INTERNAL ASSESSMENT	
M201	POINT SET TOPOLOGY	60	40	4
M202	MEASURE THEORY & INTEGRATION	60	40	4
M203	ADVANCED CALCULUS	60	40	4
M204	PARTIAL DIFFERENTIAL EQUATION	60	40	4
ML205	C/C++ PROGRAMMING LANGUAGE(LAB)	50		2
MS206	SEMINAR	50		2
TOTAL		500		20

SEMESTER-III

PAPER NO.	PAPER NAME	MARKS		CREDIT
		END SEM ASSESSMENT	INTERNAL ASSESSMENT	
M301	FUNCTIONAL ANALYSIS	60	40	4
M302	NUMERICAL ANALYSIS	60	40	4
M303	OPERATIONS RESEARCH	60	40	4
M304	MATHEMATICAL STATISTICS (CBCS)	60	40	4
M305	ELECTIVE-I	60	40	4
ML306	NUMERICAL ANALYSIS LAB (MATLAB/SCILAB)	50		2
MS307	SEMINAR	50		2
TOTAL		600		24
FAKIR MOHAN STUDIES (NON-CREDIT COURSE)				

SEMESTER-IV

PAPER NO.	PAPER NAME	MARKS		CREDIT
		END SEM ASSESSMENT	INTERNAL ASSESSMENT	
M401	DIFFERENTIAL GEOMETRY	60	40	4
M402	DISCRETE MATHEMATICS	60	40	4
M403	ELECTIVE-II	60	40	4
ML404	LaTex	50		2
M405	PROJECT (Thesis/Report, Seminar, Presentation, Viva-Voce)	250		10
TOTAL		600		24

Value added Course

MV207	BIO-STATISTICS	50	50	3

ELECTIVE-I

NUMBER THEORY & FOUNDATIONS OF 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 PROCESSES
MATHEMATICAL FINANCE
ADVANCED ANALYSIS
OPERATOR THEORY
FIXED POINT THEORY
WAVELETS

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 a progressive citizen with commitment to deliver one's responsibilities within the scope of bestowed rights and privileges
4. Continue to obtain pertinent 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	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, rings and have a detailed study of field theory. 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 be able to • Demonstrate a good knowledge of various groups, their properties, rings and ideals • Determine the irreducibility of a polynomial and compute algebraically closed fields • Calculate the splitting fields of a polynomial and examine for normal or separable extensions • Understand the concepts of Galois theory • Exhibit the applications of Galois theory to classical 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	Review on Groups, Subgroups, Normal subgroups, Cyclic groups, Homomorphism, Isomorphism theorems, Automorphism, Rings, Subrings, Ideals, Maximal and Primal ideals, Homomorphism	08
II	Algebraic extension of fields: Irreducible polynomials and Eisenstein criterion, Adjunction of roots, Algebraic extensions, Algebraically closed fields	10
III	Normal and separable extensions: Splitting fields, Normal extensions, Multiple roots, Finite fields, Separable extensions	10
IV	Galois theory: Automorphism groups and fixed fields, Fundamental theorem of Galois	10

	theory, Fundamental theorem of algebra	
V	Applications of Galois theory to classical problems: Roots of unity and Cyclotomic polynomials, 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, 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	Advanced Real Analysis	4	40	60

Objectives	The objective of this course is to familiarize students with various concepts of Real Analysis like sequence and series of functions, Riemann-Stieltjes integral, partial derivatives and directional derivatives for functions of several variables.
Pre-Requisites	Basic concepts of Real Analysis
Course Outcome	Students will be able to • Understand different types of convergence of sequence and series of functions • Learn the theory of Riemann-Stieltjes integrals and aquainted with Functions of bounded variations • Understand Fundamental theorem of Integral Calculus and Mean value theorem for Integrals • Determine different types of derivatives like partial derivatives and directional derivatives for functions of several variables • Know the Inverse Function theorem and Implicit Function theorem and their 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	Countability, Axiom of Choice and Equivalents, 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
II	Properties of monotonic functions, Functions of bounded variation, Total variation, review of Riemann integration, definition of the Riemann-Stieltjes integral, Linear properties, Change of variable in a Riemann-Stieltjes integral, Reduction to a Riemann integral, Reduction of a Riemann-Stieltjes integral to a finite sum	10
III	Euler's summation formula, Riemann's condition, Sufficient and necessary conditions for existence of Riemann-Stieltjes integrals, Mean Value Theorems for Riemann-Stieltjes integrals, Second fundamental theorem of integral calculus, Second Mean-Value Theorem for Riemann integrals, Riemann-Stieltjes integrals depending on a parameter	10
IV	Functions of Several variables, limits and continuity of multivariable functions, partial derivatives, differentiability, chain rule, change of variables, directional derivatives, total derivatives, matrix of a linear transformation, Jacobians	8
V	Functions with nonzero Jacobian determinant, the Inverse function theorem, the Implicit function theorem, Extrema of real-valued functions of one variable, Extrema of real-valued functions of several variables, Extremum problems with side conditions	10
	Total	48

Text Books:

T1. T.M. Apostol, Mathematical Analysis (Narosa), 2nd Edition, Addison-Wesley, 1981

Reference Books:

R1. W. Rudin, Principles of Mathematical Analysis, 3rd Edition, McGraw Hill 1976
R2. H. L. Royden, Real Analysis, 2nd Edition, Macmillan, 1988
R3. S.C. Mallik and S. Arora, Mathematical Analysis, 2nd Edition, New Age International, 1992.

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 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	Continuity, Differentiation, Integrations, Basic Differential Equations
Course Outcome	Students will be able to • Understand second-order linear differential equations, their solutions, and problem-solving techniques. • Gain a strong grasp of power series solutions, special functions. • Learn Picard's theorem, and core concepts of solution existence and uniqueness. • Understanding of non-uniqueness solutions, initial condition dependence in systems of differential equations • Illustrate fundamental matrices and solving linear differential equation systems.
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 solution and special functions. Oscillations of second Order Equations: Fundamental Results, Sturm’s Comparison theorem, Hille-Wintner theorem, Oscillations of $x'' + a(t)x = 0$. Boundary Value Problems: Introduction;	10
III	Strum Liouville Problem, Green’s functions, Picard’s theorem. Existence and Uniqueness of Solutions: Successive approximations, Picard’s Theorem,	10
IV	NonUniqueness of solutions, Continuation and dependence on initial conditions, Existence of solutions in the large, Existence and uniqueness of solution of systems.	10

V	System of Linear Differential Equations: System of first order equations, Existence and Uniqueness theorems, Fundamental Matrix, Homogeneous and NonHomogeneous 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 Equations 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	• Basic knowledge about complex analysis • Idea about Mapping • Student will gain knowledge about advance complex Analysis • It will help them for further studies in Advanced Analysis, Harmonic Analysis etc. • After completing this course, students are expected to be able to work with functions of single complex variable.
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	Sequence of Function, Series of Function, Absolute Convergence, Uniform convergence of Sequence and Series, Power series, Some Important Theorem, Taylor’s Theorem, Some Special Series, Laurent’s Theorem, Classification of Singularities Entire Function, Meromorphic Function, Lagrange’s Expansion, Analytic Continuation	9
II	Residues, Calculation of Residue, The Residue Theorem, Evaluation of Definite Integral, Special Function Used in Evaluating Integral, The Cauchy Principal Value of Integral, Differentiation under the Integral Sign. Leibnitz’s Rule, Summation of Series, Mittag-Leffler’s Expansion Theorem, Some Special Expansions	10
III	Transformation or Mapping, Jacobian of a transformation, Complex Mapping Function, Conformal Mapping, Riemann’s Mapping Theorem, Fixed or Invariant points of Transformation, Some general Transformation, Successive Transformation, The linear Transformation, The Bilinear Transformation, Mapping of Half Plane on to a Circle, The Schwartz –Christoffel Transformation, Transformation of Boundaries in Parametric Form, Some special Mapping.	10
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.	9
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. 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.

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	After successfully completion of this paper students could able to understand • The notion of vector space, basis, dimension, linear transformation and build their foundation linear algebra. • The application of eigen value eigen vector in different field. • Invariant subspaces and decomposition theorem • The idea of inner product space, Gram-Schmidt theorem. • 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	Review on 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. Ramachandra Rao 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 edition (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	After successfully completion of this paper students could able to understand • The notion of classical probability, relative frequency probability and axiomatic probability definition, and random variables and some distribution. • Continuous random variables and their distributions. • More than one random variable and their joint distributions • Transformation of random variables and their applications • 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.

SEMESTER-II

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M201	Point Set 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.
Pre-Requisites	Set theory, Relation functions, Basic real analysis etc.
Course Outcome	After successfully completion of this paper students could able to understand • The idea of point set topology, open sets, closed set in different topologies. • The product topology and quotient topology and Hausdorff space. • Connectedness, compactness and path- connectedness • Metrizable space and first countable and second countable basis • 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.
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, Urysohn Lemma, Urysohn metrization theorem Tychonoff Theorem.	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 provides a foundation for many branches of mathematics such as Harmonic Analysis, Ergodic Theory, theory of Partial Differential Equations 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	Students will be able to • Know about Cantor set and Lebesgue outer measure of a set • Understand the concept of measurable function and measurability of Borel sets • Define notion of abstract integration theory and know about Fatou lemma, Monotone convergence theorem and Lebesgue Dominated convergence theorem • Calculate four derivatives of an extended real valued function • Understand about L^p spaces and its completeness, also different types of convergence in measure and product measure
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	Further properties of open sets, Cantor-like sets, Lebesgue outer measure, Measurable sets, Regularity.	9

II	Measurable functions, Borel sets and their measurability, Properties of measurable functions, Step functions, Simple functions, Operations on measurable functions, Borel measurable function, Non-Borel Lebesgue measurable set, Sequence of functions on measurable sets.	9
III	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, Review of Riemann integral, Lebesgue integrals.	12
IV	The Four Derivatives, Lebesgue's Differentiation Theorem, Differentiation and Integration, The Lebesgue Set.	8
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, Signed measures and the Hahn decomposition, Measurability in a product space, product measure and Fubini's theorem.	10
	Total	48

Text Books:

T1: G. de Barra, Measure Theory and Integration, 2nd Edition, New Age International Publishers, 2013

Reference Books:

R1. I.K. Rana, An Introduction to Measure and Integration, 2nd Edition, Narosa Publishing House, 2007
R2. H. L. Royden, Real Analysis, 2nd Edition, Macmillan, 1988
R3. P.K. Jain, B.P. Gupta, P. Jain, Lebesgue Measure and Integration, 3rd Edition, New age international publisher, 2019

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. • Unit II, III, & IV will provide the knowledge about the Integral equation which will help the student for their higher study in the field. • Student will review and prepare basic knowledge in fractional analysis in order to solve different types.
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	Laplace transform: Definition, Properties, Laplace transform of some elementary function, Convolution Theorem, Inverse Laplace theorem Aplications Fourier transform, Definition Properties Fourier transform of some elementary functions, Convolution,	10
II	Voltera integral equations: basic concepts, relationship between linear diferential equations and Voltera integral equations, Resolvent kernel of voltera integral equations, solution of integral equations by resolvent kernel	9
III	Voltera integral equation: Method of successive approximation, convolution type equations, solutions of integral differential equation with the aid of laplace transformation,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 extremal sufficient conditions for the extremum of a functional conditional extremum moving boundary problem , discontinuous 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, 4th Edition, PHI, 1995.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M204	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	Students will be able to • Possess a strong foundation in first-order PDEs. • Apply the linear superposition principle to linear PDEs. • Converting differential equations into canonical forms and solving linear equations with varying coefficients. • Master Dirichlet's problem, solving it across diverse geometries. • possess a solid comprehension of Duhamel's principle for addressing time-dependent source 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’s method. 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 Renuka Ravindran, 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
ML205	C/C++ Programming Language (LAB)	2		50

List of programs:

1. To find the sum and average of the given numbers using for loop, while loop, and do-while loop.
2. To sum the series $X^1+X^2+X^3+X^4+X^5+\ldots\ldots\ldots+X^n$.
3. To construct pyramid of digits.
4. To find average of n numbers using an array.
5. To print the sum of first 'n' even natural numbers.
6. To read a two-dimensional array and find the sum of the elements in the row-wise and column-wise separately and display the sums of the rows and columns.
7. To print the numbers and its cube from 1 to 10 using following control statements a) if-then-else b) for loop c) while loop d) do-while loop.
8. To read a two dimensional square matrix A and display its transpose.
9. To print the factorial of given numbers using i) for loop ii) while loop iii) do…while loop.
10. To read data from the keyboard, write it to a file called INPUT, again read the same data from the INPUT file, and display it on the screen.
11. To print a given numbers whether it is prime or not using i) for loop ii) while loop iii) do…while loop.

12. To read the students name and its average marks. If a student gets less than 40 then declare that he fails or else the passes. Prepare a computers list of give the list of names in alphabetical order separately for passed and failed students.
13. To display a name 27 times using the nested for loop.
14. To initialize the member of a structure and to display the contents of the structure on the screen.
15. To find the sum of given the two numbers using the global variable declaration.
16. A file named DATA contains a series of integers. Code a program to read these numbers and then write all “odd” numbers to a file to be called ODD and all “even” numbers to a file to be called EVEN.
17. To display the number and its square from 0 to 10 using register variables.
18. To read a character from the keyboard and to display it on to the screen using the getchar ( ), getch ( ), putchar ( ) and putch ( ).
19. To fund the factorial of the given numbers using the recursive function.
20. To find Fibonacci sequence by recursion.
21. To find the sum of two nonnegative numbers recursively.
22. To find minimum and maximum of numbers using recursion.
23. To search for an element using binary search with recursion.
24. To declare a union as a pointer data type and display the contents of the union using pointer operator.
25. To find the sum of a given non-negative integers using a recursive function. a. Sum = 1 + 2 + 3 + 4 + …………… n.
26. To assigns some values to the members of a structure and to display a structure and to display the structure on the video screen using the structure tag.
27. To find the sum of given the two numbers using the global variable declaration.
28. To display the memory address of a variable using pointer before incrimination and after incrimination.
29. To find the largest and smallest element in a vector.
30. To find second largest and smallest element in a vector.
31. To delete duplicates in a vector.
32. To add two matrices.
33. To sort the elements of a vector in ascending order.
34. To insert an element into the vector.
35. To delete an element from the vector.
36. To find the smallest element in an array using pointers.

To read a character from the keyboard and to display it on to the screen using the getchar ( ), getch ( ), putchar ( ) and putch ( ).

<u>SEMESTER-III</u>

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 is to exposed to continuous linear operators defined on Banach and Hilbert spaces and its spectral properties.
Pre-Requisites	Linear Algebra, Real Analysis, Measure and Integration
Course Outcome	Students will be able to • Understand the concept of Normed linear spaces and Banach spaces • Explain Hahn-Banach theorems an calculate duals of normed linear spaces • Explain main theorems on Banach spaces and different types of convergence of sequence of operators and functionals on normed linear spaces and its dual spaces • Understand the Riesz representation theorem, its application, notion of orthogonal complement and its decomposition • Learn the spectral theory of bounded linear operators
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	Review of Metric space, Normed linear space, Banach spaces, properties of normed linear spaces, quotient spaces, Riesz lemma, finite dimensional normed linear spaces, Compactness and finite dimension.	10
II	Linear operators, Bounded and continuous linear operators, linear functional, linear operator and functional on finite dimensional spaces, Hahn-Banach separation theorem, Hahn-Banach theorems for real vector space, complex vector space, normed linear space, duals of normed linear spaces.	11
III	Category theorem, Uniform boundedness principle, Open mapping theorem, Closed graph theorem, bounded inverse theorem, Strong and weak convergence and weak* Convergence of sequences of operators and functional, Reflexive spaces, separable spaces.	11
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.	8
V	Adjoint operator, Hilbert-Adjoint operator, Self-Adjoint, Unitary and normal operators, Spectral theory in finite dimensional normed linear spaces, spectral properties of	8

	bounded linear operators, further properties of resolvent and spectrum of bounded linear operators.	
	Total	48

Text Books:

T1. B.V. Limaye, Functional Analysis, 2nd Edition, New Age International, 1996.

Reference Books:

R1. W. Rudin, Functional Analysis, 2nd Edition, McGraw Hill, 1991.
R2. I.J. Maddox, Elements of Functional Analysis, 2nd Edition, Cambridge University Press 1989.
R3. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons, 1978.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M302	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	Students will be able to • Employing Weierstrass's theorem, Taylor's theorem, and diverse approximation techniques to solve problems. • Possess a thorough grasp of numerical methods for solving linear systems. • Learn numerical differentiation and integration methods. • Solve numerical methods for ordinary differential equations. • Understanding of eigenvalue problem-solving, interpolation techniques.
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.
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
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	• Determining the degree of attainment of the goals with the available resources • The goal of this technique is to maximize profit while minimizing cost and resources’. • The output of the TSP is a permutation of the cities , representing the order in which should be visited. • It will help to optimize the NLPP • Network scheduling is a technique which helps to planning scheduling large complex Project
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, Bounded Variable, Parametric Linear Programming, Linear Fractional, Programming, Goal Programming: Categorization, Formulation of linear Goal Programming Problem, Graphical goal Attainment Method, Simplex method GPP	10
II	Integer programming problem,	9
III	Traveling sells man problem, Sequence problem: introduction, processing of jobs	9

	through two machine. Queuing model, general characteristic, Markovian Queing model, M/M/1 model Limited queue Capacity Queue displine.	
IV	Non-linear Programming-Method: Introduction, graphical solution, Kuhn-Tucker condition with Non-Negative Constraints, Wolfe's Modified simplex , Beal's Method, Separable Convex Programming	10
V	Network Scheduling by PERT/CPM: Introduction, Basic Component, Logical Sequencing, Rules of Network Construction, Current activity, Critical Path Analysis, Probability Consideration in PERT, Distinction between PERT and CPM, Application of Network Techniques, Advantages of Network Technique	10
	Total	48

Text Books:

T1. Operations Research-KantiSwarup, P.K. Gupta Manmohan, 9th Edn. 2001, 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	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

ELECTIVE-I

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M305	Number Theory & Foundations of 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 • 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 • Illustrate various multiplicative functions, find primitive roots and check the primality of a number • Solve quadratic congruences and explain continued fractions • 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
M305	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 • Reimanian metric and tensor • Derivation of Einstein field equations
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
M305	Harmonic Analysis	4	40	60

Objectives	This course will provide an introduction to Fourier and Harmonic Analysis on Euclidean Space with an emphasis on real variable methods. The course will focus on the role played 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	Students will be able to • Know Fourier transform in L_1 and L_2 spaces and different summability methods • Understand different types of distributions • Determine interpolation of operators and know about Marcinkiewicz and Riesz-Thorin theorems • Understand the Calderon-Zygmund decomposition via dyadic maximal function • Recognize Hilbert transform and Fourier multipliers on real line
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.	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, 2002.
R4. W. Rudin, Real and complex analysis, 3rd Edition, McGraw-Hill, 1986.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M305	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	08

	functions, exponential generating functions	
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
M305	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. • Able to make a financial goal • Able to make a minimum risk portfolio • Understanding of various insurance policy
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
M305	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	Students will be able to • Learn basic concepts of Fuzzy sets • Understand different properties of Fuzzy sets • Acquainted with Zadeh's extension principle • Understand Fuzzy graphs and relations • Understand real life applications of fuzzy theory
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	10

	Fuzzy arithmetic	
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
ML306	Numerical Analysis using Matlab/Scilab	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-IV

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M401	Differential Geometry	4	40	60

Objectives	The objective of this course is to introduce the concepts like differential manifolds, vector fields, tensor analysis, Riemannian metric etc. so that students can understand how the concept of Analytic geometry and Differential geometry of undergraduate level can be generalized to topological spaces.
Pre-Requisites	Real Analysis, Topology, Measure Theory.
Course Outcome	Students will be able to • Explain differentiability for functions of several variables, define tangent vector at a point in R^n • Define the notion of topological manifold, vector fields on manifolds • Understand the concept of Riemannian metric, tensor field, symmetric and alternative tensors • Define the concept of exterior differentiation of tensor fields and geometry of space curves • Understand the concept of Riemannian manifolds and Riemannian curvature
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	10

	and Mappings.	
III	Bilinear Forms, The Riemannian Metric, Riemannian Manifolds as Metric Spaces, Tensors on a Vector Space, Tensor Fields, mappings and Covariant Tensors, Symmetric and Alternating Tensors, 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, 2nd Edition, Academic Press, New York 2002.

Reference Books:

R1. W. Tu. Loring, An introduction to manifolds, Springer, 2011
R2. T.J. Willmore, Riemannian Geometry, Oxford University Press, 1996

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M402	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	Students will be able to • Acquire knowledge about the fundamentals of Logic and Mathematical Induction • Apply Pigeonhole principle, recurrence relation and generating function to solve problems • Understand basic concepts of Boolean Algebra • Get adequate knowledge of different types of graphs and different types of paths

	• Understand the concept of tree and its 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	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, 2nd Edition, Prentice Hall, 1986.
R2. C.L. Liu, Elements of Discrete Mathematics, 4th edition, Mc-Graw Hill, 2017.

ELECTIVE-II

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M403	Introduction to Cosmology	4	40	60

Objectives	This course will serve as an introduction to Cosmology, which is a fascinating branch of science 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 the fundamentals of modern cosmology via the Mathematics of Newtonian Mechanics starting with 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 • Understand modified gravity • Understand cosmic acceleration and dark energy
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 expansion of the Universe, Particles in the Universe. The Friedman equation, Meaning of the expansion, Things that go faster than light, The fluid equation, The acceleration equation, Mass, energy and vanishing factors 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, Deceleration parameter. 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: An Introduction 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**
M403	Algebraic Coding Theory	4	40	60

Objectives	Study various type of codes, learn the coding problem, find the weight enumerator of codes
Pre-Requisites	Basic concepts of Fields and Vector space
Course Outcome	Students will be able to • Understand basic concepts and techniques in coding theory • Demonstrate knowledge of encoding and decoding procedure • Describe the main coding theory problem • Classify the codes as cyclic codes and construct new codes • Learn important families of 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	Error detection, correction and decoding: Introduction, Communication channels, Maximum likelihood decoding, Hamming distance, Minimum distance decoding, Distance of a code Finite Fields: Fields, Polynomial rings, Structure of finite fields, Minimal polynomials Vector spaces over finite fields	08
II	Linear codes: Linear codes, Hamming weight, Bases for linear codes, Generator matrix and parity-check matrix, Equivalence of linear codes, Encoding with a linear code, Decoding of linear codes, Cosets, Nearest neighbor decoding for linear codes, Syndrome	10

	decoding	
III	Bounds in coding theory: The main coding theory problem, Lower bounds, Sphere-covering bound, Gilbert-Varshamov bound, Hamming bound and Perfect codes, Hamming codes, Golay codes, Singleton bound, MDS codes, Plotkin bound	10
IV	Construction of linear codes: Propagation rules, Reed-Muller codes, Subfield codes Cyclic codes: Definitions, Generator polynomial and check polynomial, Encoding and decoding of cyclic codes	10
V	Some special cyclic codes: BCH codes, Reed-Solomon codes, Quadratic residue codes Weight distribution of codes, MacWilliams Identity	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
M403	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	Students will be able to • Learn multiple-step methods and extrapolation methods. • Possess a strong foundation in solving parabolic partial differential

	equations. • solve hyperbolic PDEs, assess numerical stability via the CFL condition. • Skilled in addressing 2D hyperbolic equations using Lax-Wendroff and Crank-Nicholson schemes. • Possess a robust foundation in the Finite Element Method.
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 modelproblem 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
M403	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 • Random variables and Probability distributions • Stochastic process and conditional expectation • Markov chain and transition matrix • Different form of Poisson process, exponential distribution and memoryless property • 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 Process Continuous-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**
M403	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 • How to invest in market with minimum risk. • Financial derivatives • Put option and call option • Stochastic calculus • Hedging idea
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-	10

	Stochastic dominance-Relationship between dominance concepts and utility theory.	
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
M403	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	Students will be able to • Learn signed measure and study different types of decompositions • Know Lebesgue-Stieltjes integral • Understand product measure and know Fubini's theorem • Understand about advance complex analysis • It will help further studies in harmonic 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, The Raydon-Nikodim theorem, Lebesgue Decomposition Theorem, 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	Casorati-Weierstrass theorem, Bloch-Landau theorem, Picard's theorems, Mobius transformations, Schwartz lemma, External metrics, Riemann mapping theorem, Argument principle, Rouche's theorem..	10
V	Runge's theorem, Infinite products, Some important theorems on infinite Products, Weierstrass p-function, Weierstrass Theorem for Infinite Product, Mittag-Leffler expansion.	10
	Total	48

Text Books:

T1. G. de Barra, Measure Theory and Integration, 2nd Edition, New Age International Publishers, 2013.

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

Reference Books:

R1. I.K. Rana, An Introduction to Measure and Integration, 2nd Edition, Narosa Publishing House, 2007.
R2. H. L. Royden, Real Analysis, 2nd Edition, Macmillan, 1988.
R3. P.K. Jain, B.P. Gupta, P. Jain, Lebesgue Measure and Integration, 3rd Edition, New age international publisher, 2019.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M403	Operator Theory	4	40	60

Objectives	The objective of this course is to introduce the basic operator theoretic methods and spectra of operators on Hilbert spaces.
Pre-Requisites	Algebra, Functional analysis.
Course Outcome	Students will be able to • Know basic facts for bounded operators • Demonstrate a good knowledge of different types of operators • Understand C* algebras and The Gelfand-Naimark theorem • Know different type of operators and their ideals • Calculate spectrum of different types of operators
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 facts, bounded operators, a commutative theorem, Resolutions of the Identity, The Spectral Theorem, Eigenvalues of normal operators.	10
II	The Adjoint Operator, Normal and Self-adjoint Operators, Projections and subspaces, Multiplication Operators and Maximal Abelian Algebras, The Bilateral shift operator.	10
III	C* algebras, The Gelfand-Naimark theorem, The Spectral theorem, The Functional Calculus, The square root of positive operators, The unilateral shift operator.	10
IV	The polar decomposition, weak and strong operator topologies, The ideals of finite rank and compact operators, Approximation of compact operators, Examples, The Calkin Algebra and Fredholm Operators, The Index of Fredholm Operators, Voltera Integral Operators.	10
V	Toeplitz Operators, The Spectral Inclusion Theorem, The spectrum of self-adjoint Toeplitz operators, The spectrum of analytic Toeplitz operators, The C* algebra generated by the unilateral shift.	8
	Total	48

Text Books:

T1. W. Rudin, Functional Analysis, 2nd Edition, Tata McGraw Hill, 1991.

T2. R.G. Douglas, Banach Algebra techniques in Operator Theory, Academic Press, 1998.

Reference Books:

R1. R. Larsen, Banach Algebras, an introduction, Marcel Dekker, 1973.
R2. I. Gohberg and S. Goldberg, Basic Operator theory, Birkhauser, 2001.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M403	Fixed point theory	4	40	60

Objectives	Fixed point theorems play a very significant role in solving the boundary value problems, eigen value problems, differential equations, random differential equations, integral equations and so on. The objective of this course is to provide some basics in topological as well as metric fixed point theory.
Pre-Requisites	Functional Analysis, Topology
Course Outcome	Students will be able to • Know Banach contraction principle and its application • Learn Brouwer fixed point theorems and its use to find fixed points for different maps • Solve second order boundary value problems of ODEs by Banach contraction principle • Understand Schauder and Sadovskii's fixed point theorems • Find fixed points of functions in partially ordered spaces
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	Review of Metric space, Normed linear space, Banach contraction principle.	10
II	Metric generalization of Banach contraction principle, fixed points of non-expansive maps and set valued maps, Brower fixed point theorem.	10
III	Application of the Banach contraction principle to linear operator equations, differential equations, classical solution for a boundary value problem for a second order ordinary differential equation.	10
IV	Schauder's fixed point theorem, condensing map, fixed points for condensing maps, the modulus of convexity and normal structure, Sadovskii's fixed point theorem, set-valued mappings.	10

V	Fixed point theorems in partially ordered spaces.	8
	Total	48

Text Books:

T1: An Introduction to Metric spaces and Fixed point theory- M.A. Khamsi and W.A. Kirk, John Wiely and Sons, New York, 2001.

Reference Books:

R1. Fixed point theory, An Introduction-V.I. Istratescu, D. Reidel Publishing Co. 1981
R2. Topics in Metric Fixed Point Theory- K. Goebel and W.A. Kirk, Cambridge University Press 1990
R3. Fixed point theory and best approximation: The KKM-map Principle- S.P. Singh, B. Watson and P. Srivastava, Kulwer Academic Publishers, 1997.
R4. Iterative Approximation to Fixed Points, Lecture Notes in Mathematics- V. Berinde, Springer, 2007

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M403	Wavelets	4	40	60

Objectives	Wavelet analysis can be defined as an alternative to the classical windowed Fourier analysis. The goal is to measure the local frequency content of a signal with distinct resolutions. The building blocks of a windowed Fourier analysis are sines and cosines (waves) multiplied by a sliding window. In a Wavelet Analysis, the window is translated and dilated by arbitrary translations and dilations. Wavelets are applicable in field of Mathematics, Physics, signal or image processing and numerical analysis.
Pre-Requisites	Functional Analysis, Linear Algebra, Fourier Series
Course Outcome	Students will be able to • Know elementary ideas of signal processing • Understand how to construct Wavelets from MRA and construction of different types of Wavelets • Learn different types of transforms and application of Wavelets • Describe different types of function spaces using Wavelets • Demonstrate the theory of Frames from translation, dilation 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	Review of Fourier Analysis, Elementary ideas of signal processing, From Fourier Analysis to Wavelet Analysis, Windowed Fourier Transforms: Time frequency localization, the reconstruction formulae.	10
II	Multiresolution analysis, Construction of Wavelets from MRA, construction of compactly supported wavelets, Band limited Wavelets, Franklin wavelets on real line, Introduction to spline analysis, spline wavelets on real line.	10
III	Discrete transforms and algorithms, Discrete Fourier transform and the fast Fourier transform, Discrete cosine transform and the first cosine transform, Decomposition and reconstruction algorithm for Wavelets, Application of Wavelets.	10
IV	Representation of functions by Wavelets, Characterizations of function spaces using Wavelets, Non existence of smooth Wavelets in $H^2(R)$.	8
V	Theory of Frames, the reconstruction formula, Balian-Low theorem for frame, frame from translation and dilation, smooth frames for $H^2(R)$, orthogonal Wavelets.	10
	Total	48

Text Books:

T1: E. Hernandez & G.L. Weiss, A first course in Wavelets, CRC Press.
T2: C.K. Chui, An Introduction to Wavelets, Academic Press 1992.
Reference Books:

R1. Kahane & R. Lemaire, Fourier Series & Wavelets, Gordon & Breach
R2. G. Kaiser, A friendly guide to Wavelets, Bikhauser 1994
R3. I. Daubechies, Ten Lectures on Wavelets, Society for Industrial and Applied Mathematics, 1992

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
ML404	LaTeX	2		50

Topics to be covered:

1. Introduction to TeX and LaTeX, Creating and typesetting a simple LaTeX document.
2. Adding basic information to documents, Environments, Footnotes, Sectioning, Displayed material.
3. Accents and symbols; Mathematical typesetting (elementary and advanced): Subscript/ Superscript, Fractions, Roots, Ellipsis.

4. Mathematical symbols, Arrays, Delimiters, Multiline formulas.
5. Putting one thing above another, Spacing and changing style in math mode.
6. Table preparation.
7. Pictures and graphics in LaTeX, Simple pictures using PSTricks, TirZ, Plotting of functions.
8. Bibliography, Table of Contents, Index
9. Beamer, Frames, Setting up beamer document, Enhancing beamer presentation.

Value added Course

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
MV207	**Bio-statistics**	3	50	50

Syllabus

UNIT-I. Sampling Distributions, Law of large numbers and Central Limit Theorem: Concepts of random sample and statistic; distribution of sample mean from a normal population; chi-square distribution; F and t statistics, distributions (no derivations) and their applications. Chi-square test for goodness of fit, Central Limit Theorem 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-IV: Hypothesis testing Testing on the Mean and Variance,

Unit-V: Linear Regression & Correlation

References

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