FAKIR MOHAN UNIVERSITY
P.G. Department of Mathematics
M.A/M.Sc. (Mathematics) COURSE STRUCTURE
(Effective from 2020-21 Sessions)

SEMESTER-I

PAPER NO.	PAPER NAME	MARKS		CREDIT
		END SEM ASSESSMENT	INTERNAL ASSESSMENT	
M101	ALGEBRA	80	20	4
M102	REAL ANALYSIS	80	20	4
M103	ORDINARY DIFFERENTIAL EQUATIONS	80	20	4
M104	COMPLEX ANALYSIS	80	20	4
M105	ADVANCED LINEAR ALGEBRA	80	20	4
ML106	C-PROGRAMMING LANGUAGE (LAB)	50		2
MS107	SEMINAR	50		2
TOTAL		600		24

SEMESTER-II

PAPER NO.	PAPER NAME	MARKS		CREDIT
		END SEM ASSESSMENT	INTERNAL ASSESSMENT	
M201	TOPOLOGY	80	20	4
M202	MEASURE & INTEGRATION	80	20	4
M203	MATHEMATICAL METHODS	80	20	4
M204	NUMERICAL ANALYSIS	80	20	4
M205	PROBABILITY THEORY	80	20	4
ML206	NUMERICAL ANALYSIS LAB (C++)	50		2
MS207	SEMINAR	50		2
TOTAL		600		24

SEMESTER-III

PAPER NO.	PAPER NAME	MARKS		CREDIT
		END SEM ASSESSMENT	INTERNAL ASSESSMENT	
M301	FUNCTIONAL ANALYSIS	80	20	4
M302	PARTIAL DIFFERENTIAL EQUATION	80	20	4
M303	OPERATIONS RESEARCH	80	20	4
M304	MATHEMATICAL STATISTICS (CBCS)	80	20	4
M305	ELECTIVE-I	80	20	4
ML306	MATLAB/MATHEMATICA LAB	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	80	20	4
M402	GRAPH THEORY	80	20	4
M403	ELECTIVE-II	80	20	4
M404	ELECTIVE-III	80	20	4
M405	PROJECT (Thesis/Report, Seminar, Presentation, Viva-Voce)	200		8
TOTAL		600		24

ELECTIVE-I
NUMBER THEORY & CRYPTOGRAPHY
THEORY OF RELATIVITY & GRAVITATION
APPLIED STOCHASTIC PROCESS
HARMONIC ANALYSIS
COMBINATORICS
ACTUARIAL MATHEMATICS
FUZZY SETS AND THEIR APPLICATIONS

ELECTIVE-II
INTRODUCTION TO COSMOLOGY
BANACH ALGEBRA
ALGEBRAIC CODING THEORY
NUMERICAL SOLUTIONS OF DIFFERENTIAL EQUATIONS

ELECTIVE-III
MATHEMATICAL FINANCE
ADVANCED ANALYSIS
ANALYTIC NUMBER THEORY
OPERATOR THEORY

SEMESTER-I

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M101	Algebra	4	20	80

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-I 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	Groups, Cyclic group, Permutation groups, Normal subgroups, quotient groups, Isomorphism theorems, Automorphisms, Finitely generated abelian groups, Invariants of a finite abelian group, Sylow theorems, Rings, ideals, Maximal and primal ideals.	12
II	Unique factorization domains, Principal ideal domains, Euclidean domains, Polynomial rings over UFD, Modules: Definition and examples, Submodules and direct sums, R-homomorphisms and quotient modules.	12
III	Algebraic extension of fields: Irreducible polynomials and Eisenstein criterion, Adjunction of roots, Algebraic extensions, Algebraically closed fields, Normal and separable extensions: Splitting fields, Normal extensions, Multiple roots, Finite fields, Separable extensions.	12

IV	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 cyclotomic polynomials, Cyclic extensions, Polynomials solvable by radicals	12
	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	20	80

Objectives	To give basic materials to students so that they can easily undersand 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.
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, Metric space, examples, limit points, Open sets, closed sets, R as a metric space, 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

	Equicontinuous Functions.	
III	Riemann integration,RiemannStieltjes 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, Fundamental theoremsof Calculus.	18
IV	Functions of Several variables, Differentiation in R^n, Partial Derivatives, Directional Derivatives,Jacobians, Inverse function theorem, Implicit function theorem,	10
	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	20	80

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, Power series solution and special functions.	12
II	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 ; Strum Liouville Problem, Green's functions, Picard's throrem.	12

III	Existence and Uniqueness of Solutions: Successive approximations, Picard's Theorem, Non Uniqueness of solutions, Continuation and dependence on initial conditions, Existence of solutions in the large, Existence and uniqueness of solution of systems.	12
IV	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.	12
	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	20	80

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	12

	function, Logarithmic function. Complex power, branches of multivalued function, with reference to arg(z), The linear transformation, cross ratio and conformal mapping	
II	Complex line integral and Cauchy theorem, Cauchy integral formula, The index of a closed curve, 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	12
III	Taylor series, Classification of singularities, poles, absolute convergence, Laurent series development, Maximum modulo theorem, Schwartz's Lemma	12
IV	Normal families, Arzela's theorem , Residue calculus, Riemann Mapping theorem and Weriestrass theorem, Riemann zeta function,	12
	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	20	80

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.	12
II	System of Linear equations, Characteristic roots and Vectors, Eigen values, Eigen vectors, Digonalization, Minimal polynomial of a linear transformation, Cayley Hamilton theorem.	12
III	Invariant subspaces, Direct sum decompositions, Invariant direct sums, The primary decomposition theorem, Inner product spaces, Gram-Schmidt orthogonalization process, Orthogonal complements, Gram-Schmidt Theorem	12

IV	Primary decomposition theorem Canonical Forms: Diagonal forms, triangular forms, Jordan form, Rational Canonical form, Quadratic form	12
	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
ML106	C Programming Language (LAB)	2		50

List of programs:

1. Program in C to find the sum and average of the given numbers using for loop, while loop, and do-while loop.
2. Program in C to sum the series $X^1+X^2+X^3+X^4+X^5+\ldots\ldots\ldots+X^n$.
3. Program in C to construct pyramid of digits.
4. Program in C to find average of n numbers using an array.
5. Program in C to print the sum of first 'n' even natural numbers.
6. Program in C 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. Program in C 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. Program in C to read a two dimensional square matrix A and display its transpose.
9. Program in C that prints the factorial of given numbers using i) for loop ii) while loop iii) do…while loop.
10. Program 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. Program in C that print a given numbers whether it is prime or not using i) for loop ii) while loop iii) do…while loop.
12. Program in 'C' 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. Program in C to display a name 27 times using the nested for loop.

14. Program to initialize the member of a structure and to display the contents of the structure on the screen.
15. Program in C to find the sum of given the two numbers using the global variable declaration.
16. A file named DATA contains a series of integer number. 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. Program in C to display the number and its square from 0 to 10 using register variables.
18. Program to read a character from the keyboard and to display it on to the screen using the getchar ( ), getch ( ), putchar ( ) and putch ( ).
19. Program in C to fund the factorial of the given numbers using the recursive function.
20. Program in C to find Fibonacci sequence by recursion.
21. Program in C to find the sum of two nonnegative numbers recursively.
22. Program in C to find minimum and maximum of numbers using recursion.
23. Program in C to search for an element using binary search with recursion.
24. Program to declare a union as a pointer data type and display the contents of the union using pointer operator.
25. Program in C to find the sum of a given non-negative integers using a recursive function. a. Sum = 1 + 2 + 3 + 4 + …… n.
26. Program 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. Program in C to find the sum of given the two numbers using the global variable declaration.
28. Program to display the memory address of a variable using pointer before incrimination and after incrimination.
29. Program in C to find the largest and smallest element in a vector.
30. Program in C to find second largest and smallest element in a vector.
31. Program in C to delete duplicates in a vector.
32. Program in C to add two matrices.
33. Program in C to sort the elements of a vector in ascending order.
34. Program in C to insert an element into the vector.
35. Program in C to delete an element from the vector.
36. Program in C to find the smallest element in an array using pointers.
37. Program to read a character from the keyboard and to display it on to the screen using the getchar ( ), getch ( ), putchar ( ) and putch ( ).

SEMESTER-II

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M201	Topology	4	20	80

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. - Subspace topology, Product topology, and Quotient topology.	12
II	Connectedness, Local connectedness, Path-connectedness, compact Spaces, compactness in metric spaces, locally compacts spaces, compact open topology	12
III	Countability axioms Separation axioms Regular & completely regular space, normal spaces, Urysohn Lemma,Urysohn metrization theorem	12
IV	Tychonoff Theorem, Homotopy, Homotopy equivalences, path homotopy Fundamental Group, covering space fundamental Group of S1.	12
	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 & Integration	4	20	80

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	Further properties of Open sets, Cantor- like sets, Lebesgue Outer measure, Measurable sets, Regularity, Measurable functions, Borel and Lebesgue measurability.	12
II	Integration of Non-negative Functions, Fatou's Lemma, Lebesgue's Monotone Convergence theorem, the General Integral, Lebesgue's Dominated Convergence theorem, Integration of Series, Riemann and Lebesgue Integrals, The Four Derivatives, Functions of Bounded Variation, Lebesgue's Differentiation Theorem, Differentiation and Integration, The Lebesgue Set.	14
III	Measures and Outer measure, Extension of a measure, Uniqueness of the extension, Completion of a Measure, Measure spaces, Integration with respect to a measure.	12
IV	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.	10
	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	Mathematical Method	4	20	80

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	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, Fourier transform as a o of fourier series Aplication to PDE	12
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, Mthod of successive approximation, convolution type equations, solutions of integral differential equation with the aid of laplace transformation	12
III	Fredholm Integral equation: Fredholm equation of the second kind fundamental ,Iterated karnels, constructing the resolvent kernel with aid of iterated kernels, Integral equation with degenerate Kernel characteristic number and eign function, solution of homogeneous integral equation with degenerate kernel –non homogeneous symmetric equation Fredholm alternative	12
IV	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	12
	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	20	80

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	Errors: Root finding for non-linear equations: Bisection method, Iteration methods based on first degree equations(Secant method, Regula-Falsi method, Newton Raphson method), Iteration methods based on second degree equation(Muller method, Chebysev method), Rate of convergence , Iteration methods.	12
II	Interpolations: Lagrange and Newton interpolations, Finite differences, Interpolating polyno- mials using finite differences, Hermite interpolation, Piecewise and Spline interpolation, Approximations.	12
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), Method based on undetermined coefficiencts (Gausses Legendre Integration method, Lobatto integration method, Radon integration method, Gausschebysev Integration method (without derivation), Gauss Laguerre Integration method (without derivation), Gauss-Hermite Integration methods (without derivation), Composite integration methods.	12
IV	Numerical Solution of system of linear equations: Direct methods, Gauss Elimination meth- ods, Gauss-Jordan Elimination method, Triangularization method, Cholesky method, Iteration methods(Jacobi iteration method, Gauss-siedel iteration method,	12

	Iterative method for *A-1*) Eigen value problems(Jacobi method for symmetric matrices) Givers Method for symmetric matrices, Rutishauser method for arbitrary matrices). Numerical solution of ordinary dif- ferential equation: Euler Method, Backward Euler method, Mid-point method, Single Step methods(Tayler series method, Range-kutta method(Second order, Fourth order method).	
	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.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M205	Probability Theory	4	20	80

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	14
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,	12

	Gamma and Chi-Square, and their applications.	
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.	12
IV	Transformation of Variables. Univariate and Doublevariate Case. Limit Theorems,Law of large numbers, convergence in distribution, central limit theorem, Poisson process, Markov chain.	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
ML206	Numerical Analysis Lab (C++)	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	20	80

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	Normed linear spaces, Continuity of linear maps, Equivalent norms, Hahn-Banach theorem for real linear spaces, complex linear spaces and normed linear spaces.	10
II	Banach spaces and examples, Quotient spaces, Uniform boundedness theorem and some of its consequences, Open mapping theorem and Closed graph theorems, Bounded inverse theorem.	12
III	Spectrum of a bounded linear operator, Duals and transpose, Duals of Lp([a; b]) and C([a;b]), Weak and weak* convergence, Reflexive spaces, Weak sequential compactness.	14

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.	12
	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	20	80

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.	12
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, Reduction to canonical forms , solution of linear Homogeneous and non-homogeneous with constant coefficients, Variable coefficients, Monge's method.	12
III	Laplace equation:- Solution by the method of separation of variables and transforms.	12

	Dirichlet's, Neumann's and Churchills problems, Dirichlet's problem for a rectangle, half plane and circle, Solution of Laplace equation in cylindrical and spherical polar coordinates.	
IV	Diffusion equation:-Fundamental solution by the method of variables and integral transforms, 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.	12
	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	20	80

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 , transportation problem: Introduction , solution of TP(North west corner rule, Least cost Method), VogelsAproximation Method) Test for optimality,	12

	Degeneracy in TP, Transportation algorithm (MODI method), Assignment Problem, Hungerian Method	
II	Integer programing problem, Game theory	12
III	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.	12
IV	Non-linear Programing-Method: Introduction, graphical solution, Kuhn-Tucker condition with Non-Negative Contraints, Wolfe's Modified simplex , beals Method, Separable Convex Programing	12
	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	Mathematical Statistics (**CBCS**)	4	20	80

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	12
II	Bivariate distribution, regression lines, regression coefficients, correlation coefficient ,rank correlation, partial and multiple correlations, Regression plane	14
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.	12
IV	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)	10

	test of mean and variance of normal population	
	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 & Cryptography	4	20	80

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 divisors, Euclidean algorithm, Fundamental theorem of arithmetic, Least common multiple, Linear Diophantine equations	12
II	Congruences: Linear congruences, Pollard rho factoring methods, Divisibility test, Complete residue systems, System of linear congruences, The Chinese remainder theorem, Wilson's theorem, Fermat's little theorem, Euler's theorem	12
III	Multiplicative functions, Euler's phi function, Tau and sigma functions, Perfect numbers, Mersenne primes, The Mobius function, Primitive roots and indices, Order of a positive integer, Primality test	12
IV	Cryptology: Affine ciphers, Hill ciphers, Exponentiation ciphers, The RSA	12

	cryptosystem, The Knapsack ciphers	
	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	20	80

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, Transformation formula for mass, density, momentum, energy and force,	12
II	Minkowski-space, Relativistic equation of motion, Four vectors and tensors in Minkowski space, Lagrangian and Hamiltonian formulation of Relativistic Mechanics.	12
III	Principles of equivalence and general covariance, Mach's Principle, Einstein's field equations, Energy momentum tensors, Gravitational equations, Vectors and tensors, Experimental tests of general relativity,	12
IV	Alternatives theories of gravitations, FRW model, Schwarzschild solution, Cosmological solutions in Brans-Dicke Theory, Kaluza's five dimensional theory, Cosmological models, Singularity in cosmological models.	12
	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	Applied Stochastic Process	4	20	80

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	14
II	Branching Processes, Probability Generating Functions, Poisson Process, Arrival, Interarrival Times, Infinitesimal Probabilities, Thinning, Superposition, Uniform Distribution, Spatial Poisson Process, Nonhomogeneous Poisson ProcessContinuous-Time Markov Chains	14
III	Brownian Motion, Introduction, Brownian Motion and Random Walk, Gaussian Process, Transformations and Properties, Variations and Applications, Martingales	10
IV	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	Harmonic Analysis	4	20	80

Objectives	Periodic functions play a vital role in solving many problems in Mathematics and Physics. Fourier analysis is the study of various aspects of periodicity of functions. Harmonic Analysis is a natural generalization of Fourier analysis and is significant for its mathematical aspect.
Pre-Requisites	Complex variables, measure theory and linear spaces.
Course Outcome	This course help students to do research 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 integrals: Definitions and results,The Fourier transform, Convolution, Approximate identities, Fejer's theorem, Unicity theorem, Parselval relation, Fourier Stieltjes Coefficients, The classical kernels.	10
II	Summability, Metric theorems, Pointwisesummability, Positive definite sequences, Herglotz;s theorem, The inequality of Hausdorff and Young, The Fourier integral: Kernels on R. The Plancherel theorem, Another convergence theorem, Poisson summation formula ,Bachner's theorem, Continuity theorem.	16
III	Characters of discrete groups and compact groups, Bochners' theorem, Minkowski's theorem.	12
IV	Hardy spaces: Invariant subspaces, Factoring F and M. Rieza theorem, Theorems of Szego and Beuoling.	10
	Total	48

Text Books:

T1. H. Helson, Harmonic Analysis (Hindustan Book Agency).

Reference Books:

R1. A. Deitmar, A first course in harmonic analysis, Springer.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M305	Combinatorics	4	20	80

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.	12
II	Pigeon-hole principle, generalized inclusion-exclusion principle, Generating functions: Algebra of formal power series, generating function models, calculating generating functions, exponential generating functions, Recurrence relations, divide and conquer relations, solution of recurrence relations, solutions by generating functions.	12
III	Integer partitions, systems of distinct representatives, Polya theory of counting: Necklace problem and Burnside's lemma, cyclic index of a permutation group, Polya's theorems and their immediate applications.	12
IV	Latin squares, Hadamard matrices, Gaussian numbers and q-analogues, Mobius Inversion, combinatorial designs: t-designs, BIBDs, Symmetric designs.	12
	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	20	80

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.	14
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-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.	14
III	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
IV	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	20	80

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. Type of Fuzzy sets. Cartesian products. Algebraic products	12
II	Bounded sum and difference t-norms and t-conorms. The extension Principle- The Zadeh’s extension principle image and inverse image of Fuzzy arithmetic	12
III	Fuzzy Relation and Fuzzy Graphs-Fuzzy equivalence equations. Fuzzy graphs, Similarity relation	12
IV	Possibility theory-Fuzzy measures, Evidence theory necessity measure, Possibility theory versus probability theory	12
	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/Mathematica	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	20	80

Objectives	The objective of this course is to introduce the methods of differentiable manifolds, tensor analysis, vector fields etc. so that students can easily generalize the concept of Differential geometry of curves which they have studied in their graduation level.
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, Topological Manifolds, 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	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, Bilinear Forms, The Riemannian Metric, Riemannian Manifolds as Metric Spaces, Tensors on a Vector Space.	14
III	Tensor Fields, mapping and Covariant Tensors, Symmetrising and Alternating Transformations, Multiplication of Tensors on a Vector Space, Multiplication of Tensor Fields, Exterior Multiplication of Alternating Tensors, Exterior Algebra on Manifolds, Exterior Differentiation.	12
IV	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, 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.	12
	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.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M402	Graph Theory	4	20	80

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, Logical inferences, Methods of proof of logical inferences, First order logic, Inference for quantified propositions, Order relations, Posets, Lattices, Enumerations, Hasse diagrams, Path and closure, Discrete graphs, and adjacency matrices.	12
II	Graphs: Basic concepts, Graph terminology, The Handshaking theorem, Special type of graphs, Hall's marriage theorem, Subgraph, Representing graphs, Graph isomorphism.	12
III	Connectivity: Paths, Euler and Hamilton paths, Shortest-path problem, Planar graphs, Euler's formula, graph colouring, Chromatic numbers, The four colour theorem.	12
IV	Trees: Introduction to trees, Types of trees, properties of trees, application of trees, spanning trees. Network flows: Graphs as models of flow of commodities, flows, Maximal flows, and minimal cuts, Max-flow Min-cut theorem.	12
	Total	48

Text Books:

T1. K.H. Rosen, Discrete Mathematics and its applications, 6^{th} 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.

ELECTIVE-II

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M403	Introduction to Cosmology	4	20	80

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. he Friedman equation, Meaning of theexpansion, Things that go faster thanlight,The fluid equation, The accelerationequation, Mass, energy and vanishingfactors of c2	12
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, Hubble parameter, Density parameter,Deceleration parameter	12
III	Cosmological constant, Fluid description,Cosmological models with cosmological constant, Age of the Universe. Static cosmological models, Newtonian cosmology, Einstein universe, Expanding universe,	12
IV	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.	12
	Total	48

Text Books:

T1: A. Liddle:AnIntroduction to Modern Cosmology, Relativity and Cosmology,

2 rdedition,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	Banach Algebra	4	20	80

Objectives	The objective of this course is to introduce the basic theory of Banach algebra which is the formal setting for understanding properties and spectra of operators on Hilbert spaces.
Pre-Requisites	Algebra, Functional analysis.
Course Outcome	After completing this course, a student can be able to take different courses in Operator algebra, Differential operators, Spectral theory etc. for further studies.
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	Banach Algebras: Introduction, Complex Homomorphisms, Basic Properties of Spectra, Symbolic calculus, The group of Invertible elements.	10
II	Ideals and homomorphisms, Gelfand transforms, Involutions, Applications to noncommutative algebras, Positive functional.	12
III	Bounded Operators on Hilbert spaces: Basic facts, Bounded Operators, A Commutativity Theorem, Resolutions of the Identity, The Spectral Theorem.	13
IV	Eigenvalues of normal operators, positive operators and square roots, The group of invertible operators, A characterization of B* algebras.	13
	Total	48

Text Books:

T1. W. Rudin, Functional Analysis (Tata McGraw Hill)

Reference Books:

R1. R. Larsen, Banach Algebras, an introduction (Marcel Dekker)

R2. R.G. Douglas, Banach Algebra techniques in Operator Theory (Academic Press)

R3. I. Gohbera and S. Goldberg, Basic Operator theory (Birkhauser).

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M403	Algebraic Coding Theory	4	20	80

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	12
II	Hamming codes, Golay codes, Reed-Muller codes, Codes derived from Hadamard matrices. Bounds on codes: Sphere packing bound, Perfect codes, Gilbert-Varshamov bound, Singleton bound, MDS codes, Plotkin bound	12
III	Weight distribution of codes, MacWilliams Identities. 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	12
IV	Hamming and Golay codes as cyclic codes, BCH codes, Reed-Solomon codes, Quadratic residue codes, Graphical codes, Convolutional codes	12
	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	20	80

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.	14
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), 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	12
III	Consistency, Convergance and Stability of Finite Difference Methods, Introduction to Finite Volume Method, 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	12
IV	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.	10
	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

ELECTIVE-II

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
M404	Mathematical Finance	4	20	80

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.	12
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.	12
IV	Stochastic Processes, Marcov Processes, Random walks, Arithmetic Brownian motion, Geometric Brownian motion, Martingles, Stochastic integrals, Ito integral, Ito's lemma, Mean-reverting processes	14
	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
M404	Advanced Analysis	4	20	80

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,The Raydon-Nikodim theorem, Lebesgue Decomposition Theorem, Extension theorem (Caratheodary), Riesz representation theorem for $L^p(p > 1)$.	12
II	Lebesgue-Stieltjes measure, Absolutely continuous functions, Integration by parts, Product measures, Change of Variable, Riesz representation theorem for C(I).	12
III	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.	12
IV	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.	12
	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
M404	Analytic Number Theory	4	20	80

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	12
II	Average of arithmetical function, Elementary theorem in distribution of primes numbers	12
III	Congruences, quadratic residues and Reciprocity law	12
IV	Ramanujan Sum, Reimann zeta function	12
	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
M404	Operator Theory	4	20	80

Objectives	Most of linear algebra involves the study of transformations between linear spaces which preserve the linear structure, that is, linear transformations. Such is also the case in the study of Hilbert spaces. The objective of this course is mainly to study bounded linear transformations acting on Hilbert spaces.
Pre-Requisites	Functional Analysis
Course Outcome	After completing this course, a student will gain some fundamental concepts in Operator theory which helps him/her for further studies in other areas of mathematics and physics such as algebraic topology, differential geometry, quantum mechanics 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	The Adjoint Operator, Normal and Self-adjoint Operators, Projections and subspaces, Multiplication Operators and Maximal Abelian Algebras, The Bilateral shift operator, C* algebras, The Gelfand-Naimark theorem, The Spectral theorem.	12
II	The Functional Calculus, The square root of positive operators, The unilateral shift operator, The polar decomposition, weak and strong operator topologies.	12
III	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.	12
IV	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.	12
	Total	48

Text Books:

T1. R.G. Douglas, Banach Algebra Techniques in Operator Theory (Academic Press).

Reference Books:

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

R2. I. Goehberg and S. Goldberg, Basic Operator Theory (Birkhauser).

R3. J. Conway, A course in operator theory (American Mathematical Society).