POST GRADUATE DEPARTMENT OF MATHEMATICS

UNIVERSITY OF KASHMIR, SRINAGAR - 190006

Course Structure for 2018 onwards (CBCS Advanced)

Semester – I				
Course Type	**Course Code**	**Title of the Course**	**No. of Credits**	**Teacher**
Core (CR)	MM18101CR	Advanced Abstract Algebra – I	04	
	MM 18102CR	Real Analysis – I	04	
	MM 18103CR	Topology	04	
	MM18104CR	**Theory of Probability**	**02**	
Discipline Centric Electives (DCE)	MM 18105DCE	Theory of Matrices	04	
	MM 18106DCE	Theory of Numbers-I	04	
	MM18107DCE	Numerical Analysis	04	
Generic Electives (GE)	MM 18001GE	Numerical Methods	02	
Open Electives (OE)	MM 18001OE	Calculus	02	

General Instructions for the Candidates

1. The two year (4 semester) PG programmes is of 96 credit weightage i.e., 24 credits/semester (24x4=96).
2. Out of 24 credits in a semester a candidate has to obtain 14 credits compulsorily from "**Core Courses**", while the remaining 10 credits can be obtained from the "**Electives**" in the following manner:
   - A candidate can obtain a maximum of 8 credits within his/her own Department out of the specializations offered by the Department as **Discipline Centric-Electives**.
   - 2 credits shall be obtained by a candidate from the **Electives** offered by the Department other than his/her own. The candidate shall be free to obtain either 2 credits from the **Generic** (within School) or two credits from **Open Electives**.
   - At least 2 credits out of 8 credits slatted for OE/GE category shall be obtained from online UGC SWAYAM platform during the 4 semester Programme.

Semester – II				
Course Type	**Course Code**	**Title of the Course**	**No. of Credits**	**Teacher**
Core (CR)	MM 18201CR	Discrete Mathematics	04	
	MM 18202CR	Real Analysis – II	04	
	MM 18203CR	Complex Analysis-I	04	
	MM18204CR	Advanced Calculus	02	
Discipline Centric Electives (DCE)	MM 18205DCE	Theory of Numbers – II	04	
	MM 18206DCE	Operation Research	04	
	MM 18207DCE	Mathematical Modelling	02	
	MM 18208DCE	Integral Equations	02	
	MM18209DCE	**Fourier Series and Laplace Transform**	**02**	
	MM18002GE	Complex Variables	02	
Open Electives (OE)	MM 18002OE	Matrix Algebra	02	

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Semester – III				
Course Type	**Course Code**	**Title of the Course**	**No. of Credits**	**Teacher**
Core (CR)	MM 18301CR	Ordinary Differential Equations	04	
	MM 18302CR	Complex Analysis-II	04	
	MM 18303CR	Functional Analysis-I	04	
	MM18304CR	**Fourier Analysis**	**02**	
Discipline Centric Electives (DCE)	MM 18305DCE	Advanced Graph Theory	04	
	MM 18306DCE	Abstract Measure Theory	**04**	
	MM 18307DCE	Mathematical Biology	04	
	MM 18308DCE	Wavelet Theory	04	
Generic Electives (GE)	**MM 18003GE**	**Laplace and Fourier Transformation**	**02**	
Open Electives (OE)	MM 18003OE	Introduction to Mathematical Modelling	02	

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    - A candidate can obtain a maximum of 8 credits within his/her own Department out of the specializations offered by the Department as **Discipline Centric-Electives**.
    - 2 credits shall be obtained by a candidate from the **Electives** offered by the Department other than his/her own. The candidate shall be free to obtain either 2 credits from the **Generic** (within School) or two credits from **Open Electives.**
    - At least 2 credits out of 8 credits slatted for OE/GE category shall be obtained from online UGC SWAYAM platform during the 4 semester Programme.

Semester – IV				
Course Type	**Course Code**	**Title of the Course**	**No. of Credits**	**Teacher**
Core (CR)	MM18401CR	Partial Differential Equations	04	
	MM18402CR	Differential Geometry	04	
	MM18403CR	Advanced Abstract Algebra-II	04	
	MM18404CR	**Linear Algebra**	**02**	
Discipline Centric Electives (DCE)	MM18405DCE	Analytic Theory of Polynomials	04	
	MM18406DCE	Mathematical Statistics	04	
	MM18407DCE	Functional Analysis – II	04	
	MM18408DCE	Non-Linear Analysis	04	
	MM18409DCE	Advanced Topics in Topology and Modern Analysis	04	
	MM18410DCE	Project	04	
Open Electives (OE)	**MM18004OE**	**Discrete Mathematics**	**02**	

General Instructions for the Candidates

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   - A candidate can obtain a maximum of 8 credits within his/her own Department out of the specializations offered by the Department as **Discipline Centric-Electives**.
   - 2 credits shall be obtained by a candidate from the **Electives** offered by the Department other than his/her own. The candidate shall obtain 2 credits from the **Generic** (within School).
   - At least 2 credits out of 8 credits slatted for OE/GE category shall be obtained from online UGC SWAYAM platform during the 4 semester Programme.

The Academic Tour shall be conducted by the Department every year for outgoing students (4th semester).

SEMESTER-I

ADVANCED ABSTRACT ALGEBRA-I

Course No: **MM18101CR**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To enable the student to understand in a unifying way the properties and constructions that are similar for various algebraic structures.

UNIT-I

Definitions and examples of semi-groups and monoids, criteria for the semi-groups to be a group, cyclic groups, structure theorem for cyclic groups, endomorphism, automorphism, inner automorphism and outer automorphism, center of a group, Cauchy's and Sylow's theorem for abelian groups, permutation groups, symmetric groups, alternating groups, simple groups, simplicity of the alternating group A_n for $n \geq 5$.

UNIT-II

Normalizer, conjugate classes, class equation of a finite group and its applications, Cauchy's and Sylow's theorems for finite groups, double cosets, second and third parts of Sylow's theorem, direct product of groups, finite abelian groups, normal and subnormal series, composition series, Jordan Holder theorem for finite groups, Zassenhaus lemma, Schreir's refinement theorem, Solvable groups.

UNIT-III

Brief review of rings, integral domain, ideals, the field of quotients of an integral domain, embedding of an Integral domain, Euclidean rings with examples such as $Z[\sqrt{-1}]$, $Z[\sqrt{2}]$, principal ideal rings(PIR), unique factorization domains(UFD) and Euclidean domains, greatest common divisor, lowest common multiple in rings, relationships between Euclidean rings, P.I.R.'s and U.F.D.

UNIT-IV

Polynomial rings, the division algorithm for polynomials, irreducible polynomials, polynomials and the rational field, primitive polynomials, contraction of polynomials, Gauss lemma, Integer monic polynomial, Eisenstein's irreducibility criterion, cyclotomic polynomials, polynomial rings and commutative rings.

Recommended Books

1. P. B. Bhatacharaya and S.K.Jain, Basic Abstract Algebra.
2. J. B. Fragleigh, A First Course in Abstract Algebra.
3. J. A. Gallian, Contemporary Abstract Algebra.
4. I. N. Heristein, Topics in Algebra.
5. K. S. Miller, Elements of Modern Abstract Algebra.
6. Surjeet Singh and Qazi Zameer-ud-Din, Modern Algebra, Vikas Publishing House Private Limited.

REAL ANALYSIS - I

Course No: **MM18102CR**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To study the behavior and properties of real numbers, sequences and series of real numbers and real valued functions and generalized integration in order to tackle daily life problems arising from physical phenomenon.

UNIT-I

Integration : Definition and existence of Riemann – Stieltje's integral , behavior of upper and lower sums under refinement, necessary and sufficient conditions for RS-integrability of continuous and monotonic functions, reduction of an RS-integral to a Riemann integral, basic properties of RS-integrals, differentiability of an indefinite integral of continuous functions, the fundamental theorem of calculus for Riemann integrals.

UNIT-II

Improper integrals: integration of unbounded functions with finite limit of integration, comparison tests for convergence, Cauchy's test, infinite range of integration, absolute convergence, integrand as a product of functions, Abel's and Dirichlet's test.
Inequalities: arithmetic-geometric means equality, inequalities of Cauchy Schwartz, Jensen, Holder & Minkowski, inequality on the product of arithmetic means of two sets of positive numbers**.**

UNIT-III

Infinite series: Carleman's theorem, conditional and absolute convergence, multiplication of series, Merten's theorem, Dirichlet's theorem, Riemann's rearrangement theorem. Young's form of Taylor's theorem, generalized second derivative, Bernstein's theorem and Abel's limit theorem.

UNIT-IV

Sequences and series of functions: point wise and uniform convergence, Cauchy criterion for uniform convergence, M_n--test, Weiestrass M-test, Abel's and Dirichlet's test for uniform convergence, uniform convergence and continuity, R- integration and differentiation, Weiestrass approximation theorem, example of continuous nowhere differentiable functions.

Recommended Books:

1. R. Goldberg, Methods of Real Analysis.
2. W. Rudin, Principles of Mathematical Analysis.
3. J. M. Apostol, Mathematical Analysis.
4. S.M.Shah and Saxen, Real Analysis.
5. A.J.White, Real Analysis , An Introduction.
6. L.Royden, Real Analysis.
7. S.C.Malik and Gupta, Real Analysis.

TOPOLOGY

Course No: **MM18103CR**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: In inculcate the students to study the properties that are preserved through deformations, twisting and stretching of objects without tearing.

UNIT-I

Review of countable and uncountable sets, Schroeder-Bernstein theorem, axiom of choice and its various equivalent forms, definition and examples of metric spaces, open and closed sets, completeness in metric spaces, Baire's category theorem, and applications to the (1) non-existence of a function which is continuous precisely at irrationals (ii) impossibility of approximating the characteristic of rationals on [0, 1] by a sequence of continuous functions.

UNIT -II

Completion of a metric space, Cantor's intersection theorem with examples to demonstrate that each of the conditions in the theorem is essential, uniformly continuous mappings with examples and counter examples, extending uniformity continuous maps, Banach's contraction principle with applications to the inverse function theorem in R.

UNIT T-III

Topological spaces; definition and examples, elementary properties, Kuratowski's axioms, continuous mappings and their characterizations, pasting lemma, convergence of nets and continuity in terms of nets, bases and sub bases for a topology, lower limit topology, concepts of first countability, second countability, separability and their relationships, counter examples and behavior under subspaces, product topology and weak topology, compactness and its various characterizations.

UNIT -IV

Heine-Borel theorem, Tychnoff's theorem, compactness, sequential compactness and total boundedness in metric spaces, Lebesgue's covering lemma, continuous maps on a compact space, separation axioms T_i

$\left(i = 1, 2, 3, 3\frac{1}{2}, 4\right)$ and their permanence properties, connectedness, local connectedness, their relationship and basic properties, connected sets in R, Urysohn's lemma, Urysohn's metrization theorem, Tietize's extension theorem, one point compactification.

Recommended Books:

1. G.F.Simmons, Introduction to Topology and Modern Analysis.
2. J. Munkres, Topology.
3. K.D. Joshi, Introduction to General Topology.
4. J.L.Kelley, General Topology.
5. Murdeshwar, General Topology.
6. S.T. Hu, Introduction to General Topology.

THEORY OF PROBABILITY

Course No: **MM18104CR**	Total Credits: **02**
Examination:	Total Marks: 50
(a). Assessment	Max. Marks: 10
(b). Theory	Max. Marks: 40
Time Duration: 1¼ hrs	Min.Pass Marks: 20

Objectives: To make the students understand random experiments and their behavior in order to measure degree of occurrence of events in various situations.

UNIT-I

The probability set functions, its properties, probability density function, the distribution function and its properties, mathematical expectations, some special mathematical expectations, inequalities of Markov, Chebyshev and Jensen.

UNIT-II

Conditional probability, independent events, Baye's theorem, distribution of two and more random variables, marginal and conditional distributions, conditional means and variances, correlation coefficient, stochastic independence and its various criteria.

Recommended Books:

1. Hogg and Craig, An Introduction to the Mathematical Statistics.
2. Mood and Grayball, An Introduction to the Mathematical Statistics.

THEORY OF MATRICES

Course No: **MM18105DCE** Total Credits: **04**
Examination: Total Marks: 100
(a). Assessment Max. Marks: 20
(b). Theory Max. Marks: 80
Time Duration: 2 ½ hrs Min. Pass Marks: 40

Objectives: To inculcate the students to understand and apply the techniques of matrices like linear transformations from a vector space to itself such as reflection, rotation and sharing to solve multivariate problems arising in different disciplines of science and technology.

UNIT-I

Eigen values and eigen vectors of a matrix and their determination, similarity of matrices, two similar matrices have the same eigen values, algebraic and geometric multiplicity, necessary and sufficient condition for a square matrix of order n to be similar to a diagonal matrix, orthogonal reduction of real matrices.

UNIT-II

Orthogonality of the eigen vectors of a Hermitian matrix, the necessary and sufficient condition for a square matrix of order n to be similar to a diagonal matrix . If A is a real symmetric matrix then there exists an orthogonal matrix P such that $P^{-1}AP = P`AP$ is a diagonal matrix whose diagonal elements are the eigen values of A, semi–diagonal or triangular form, Schur's theorem, normal matrices, necessary and sufficient condition for a square matrix to be unitarily similar to a diagonal matrix.

UNIT-III

Quadratic forms: the Kroneckers and Lagranges reduction, reduction by orthogonal transformation of real quadratic forms, necessary and sufficient condition for a quadratic form to be positive definite, rank, index and signature of a quadratic form. If $A=[a_{ij}]$ is a positive definite matrix of order n, then $|A| \leq a_{11}a_{22}\ldots a_{nn}$.

UNIT IV

Gram matrices: the Gram matrix BB\` is always positive definite or positive semi-definite, Hadamard's inequality, If B=[b_{ij}]is an arbitrary non- singular real square matrix of order n, then |B| ≤ $\prod_{i=1}^{n}[\sum_{k=1}^{n} b_{ik}]$, functions of symmetric matrices, positive definite square root of a positive definite matrix, the infinite n-fold integral

$$I_n = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\cdots\int_{-\infty}^{\infty} e^{-X'AX}\,dX \ ,$$

where $dX = dx_1 dx_2 \cdots dx_n$. If A is a positive definite matrix, then $I_n = \frac{\pi^{n/2}}{|A|^{1/2}}$.

If A and B are positive definite matrices, then $|\lambda A + (1-\lambda)B| \geq |A|^{\lambda}|B|^{1-\lambda}$ for 0≤λ≤1,

perturbation of roots of polynomials, companion matrix, Hadamard's theorem, Gerishgorian Disk theorem, Taussky's theorem.

Recommended Books:

1 Richard Bellman, Introduction to Matrix Analysis, McGraw Hill Book Company.
2 Franz E. Hohn, Elementary Matrix Algebra, American Publishing company Pvt. Ltd.
3 Shanti Narayan, A Text Book of Matrices, S. Chand and Company Ltd.
4 Rajendra Bhatia, Matrix Analysis, Springer.

THEORY OF NUMBERS-I

Course No: **MM18106DCE** Total Credits: **04**
Examination: Total Marks: 100
(a). Assessment Max. Marks: 20
(b). Theory Max. Marks: 80
Time Duration: 2 ½ hrs Min.Pass Marks: 40

Objectives: To equip the student with the properties of numbers and the relationship between different sorts of numbers in order to tackle different problems of the real number system.

UNIT-I

Divisibility, the division algorithm and its uniqueness, Greatest common divisor and its properties. The Euclidean algorithm, Prime numbers. Euclid's first theorem, Fundamental Theorem of Arithmetic, Divisor of n, Radix-representation Linear Diophantine equations. Necessary and sufficient condition for solvability of linear Diophantine equations, Positive solutions.

UNIT-II

Sequence of primes, Euclid's Second theorem, Infinitude of primes of the form 4n+3 and of the form 6n+5. No polynomial f(x) with integral coefficients can represent primes for all integral values of x or for all sufficiently large x. Fermat Numbers and their properties. Fermat Numbers are relatively prime. There are arbitrary large gaps in the sequence of primes. Congruences, Complete Residue System (CRS), Reduced Residue System (RRS) and their properties. Fermat and Euler's theorems with applications.

UNIT-III

Euler's ф-function, ф (mn) = ф (m) ф (n) where (m, n) =1, $\sum_{d/m}\phi(d) = n$ and $\phi(m) = m\prod_{p}\left(1-\frac{1}{p}\right)$ for m>1. Wilson's theorem and its application to the solution the congruence of $x^2 \equiv -1 \pmod{p}$, Solutions of linear Congruence's. The necessary and sufficient condition for the solution of $a_1x_1+a_2x_2+\ldots+a_nx_n \equiv c \pmod{m}$. Chinese Remainder Theorm.Congruences of higher degree F(x) ≡ 0 (mod m), where F(x) is a Polynomials. Congruence's with prime power, Congruences with prime modulus and related results. Lagrange's theorem, viz , the polynomial congruence F(x) ≡ 0 (mod p) of degree n has at most n roots.

UNIT-IV

Factor theorem and its generalization. Polynomial congruences $F(x_1,x_2....x_n) \equiv 0$ (mod p) in several variables. Equivalence of polynomials. Theorem on the number of solutions of congruences: Chevalley's theorem, Warning's theorem. Quadratic forms over a field of characteristic ≠ 2 Equivalence of Quadratic forms. Witt's theorem. Representation of Field Elements. Hermite's theorem on the minima of a positive definite quadratic form and its application to the sum of two, three and four squares.

Recommended Books:

1. W. J . Leveque, Topics in Number Theory, Vol. I and II Addition Wesley Publishing Company, INC.
2. I. Niven and H.S Zuckerman, An introduction of the Theory of Numbers.
3. Boevich and Shaferivich, Number Theory, I.R, Academic Press.

References:

1. T.M Apostal, Analytic Number Theory, Springer Verlag.
2. G.H Hardy and Wright, An introduction to the theory of Numbers.
3. J.P. Serre, A course in Arithmetic, GTM Vol. Springer Verlag 1973.
4. E. Landau, An Elementary Number Theory.

NUMERICAL ANALYSIS

Course No: **MM18107DCE**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To provide the student with different techniques in order to find approximate numerical solutions to the problems where exact solutions are not available.

UNIT-I

Introduction to numerical methods, Bisection method, Method of False position, Secant method, Method of iterations, Newton-Raphson method, Ramanunjan's method, Convergence of iteration methods, Solution of system of linear algebraic equations: Dircet methods, Matrix inverse method, Gaussian elimination method, Gauss Jacobi, Eigen value problem.

UNIT-II

Finite difference operators: Backward, Forward and Central difference operators, Shift operator, Relation between operators, Interpolations with equal and unequal intervals, Newton's forward interpolation formula, Lagrange's and Hermite interpolation formula, Linear and quadratic spline interpolations.

UNIT-III

Numerical differentiation, Formulae for derivatives, Derivative using Newton's forward interpolation formula, Difference interpolating formula, Maxima and minima of tabulated functions.

Numerical integration, Trapezoidal rule, Simpson's one-third rule, Boole's rule, Errors in numerical integration formula.

UNIT-IV

Numerical solution for the initial value problems for ODE'S, Taylor's series method, Euler's method, Runge-Kutta Method, Picard's method of successive approximations, Boundary value problems in PDE's, Finite difference methods for solution, Classification of second order PDE's, Finite difference approximations for partial derivatives, Solution of one-dimensional Laplace, Heat and wave equations.

References:

1. M.K.Jain, S.R.K.Iyengar, R.K.Jain, Numerical methods for scientific and engineering computation, New Age International Publishers.
2. S.S.Sastry, Introductory methods of numerical analysis, PHI Learning.
3. B.S.Grewal, Numerical methods in engineering & science, KHANNA PUBLISHERS.

NUMERICAL METHODS

Course No: **MM18001GE**	Total Credits: **02**
Examination:	Total Marks: 50
(a). Assessment	Max. Marks: 10
(b). Theory	Max. Marks: 40
Time Duration: 2 ½ hrs	Min.Pass Marks: 20

Objectives: To provide the student with different techniques in order to find approximate numerical solutions to the problems where exact solutions are not available.

UNIT -I

Solution of algebraic and transcendental and polynomial equations, bisection method, iteration method based on first degree equation, secant method, regula-falsi method, Newton-Raphson method, rate of convergence of Newton-Raphson method & secant method, system of linear algebraic equation, Gauss elimination method, Gauss Jordan method.

UNIT -II

Interpolation and approximation of finite difference operators, Newton's forward, backward interpolation, central difference interpolation, Lagrange's interpolation, Newton Divided Difference interpolation, Hermite interpolation, Spline interpolation, numerical differentiation and Integration.

Recommended Books:

1. M.K. Jain, Numerical solution of differential equations, Wiley Eastern (1979), Second Edition.
2. D.V. Griffiths and I.M. Smith, Numerical Methods for Engineers, Blackwell Scientific Publications (1991).

REFERENCES:

1. S.C. Chapra, and P.C. Raymond, Numerical Methods for Engineers, Tata McGraw Hill, New Delhi (2000)
2. R.L. Burden, and J. Douglas Faires, Numerical Analysis, P.W.S. Kent Publishing Company, Boston (1989), Fourth edition.
3. S.S. Sastry, Introductory methods of Numerical analysis, Prentice- Hall of India, New Delhi (1998).
4. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical methods for scientific and Engineering computation, Wiley Eastern (1993)

CALCULUS

Course No: **MM18001OE**	Total Credits: **02**
Examination:	Total Marks: 50
(a). Assessment	Max. Marks: 10
(b). Theory	Max. Marks: 40
Time Duration: 2 ½ hrs	Min.Pass Marks: 20

Objectives: To make the student understand the basic concepts in differentiation and integration and apply them to the day to day problems.

UNIT -I

Functions, the idea of limits, techniques for computing limits, infinite limits, continuity, derivative, rules for differentiation, derivatives as rate of change, applications of the derivative, maxima and minima, increasing and decreasing functions, mean value theorem and its applications, indeterminate forms, partial differentiation, Euler's theorem.

UNIT -II

Indefinite integral, techniques of integration, definite integral, area of a bounded region, first Order ordinary differential equations and their salutations, variables separable method, homogeneous form, equations reducible to homogeneous form, linear differential equations of the form $dy/dx + Py = Q$ and equations reducible to this form.

Recommended Books:

1. A.Aziz, S.D.Chopra and M.L.Kochar, Differential Calculus, Kapoor Publications.
2. William L.Briggs and Lyle Cochran, Calculus, Pearson.
3. S.D.Chopra and M.L.Kochar, Intgeral Calculus, Kapoor Publications.
4. R.K.Jain and S.R.K. Lyengar, Advanced Engineering Mathematics, Narosa.

SEMESTER-II

DISCRETE MATHEMATICS

Course No: **MM 18201CR**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To expose the students to the theory of graphs and combinatorics and to make them aware of their applications in different branches of science.

UNIT -I

Graphs, traversibility and degrees

Introduction of graphs, paths and cycles, operations on graphs, bipartite graphs and Konigs theorem, Euler graphs and Euler's theorem, Konigsberg bridge problem, Hamiltonian graphs and Dirac's theorem, degree sequences, Wang-Kleitman theorem, Havel-Hakimi theorem, Hakimi's theorem, Erdos-Gallai theorem, degree sets.

UNIT -II

Trees and Signed graphs

Trees and their properties, centres in trees, binary and spanning trees, degrees in trees, Cayley's theorem, fundamental cycles, generation of trees, Helly property, signed graphs, balanced signed graphs and characterizations.

UNIT -III

Connectivity and Planarity

Cut-sets and their properties, vertex connectivity, edge connectivity, Whitney's theorem, Menger's theorem (vertex and edge form), properties of a bond, block graphs, planar graphs, Kuratowski's two graphs, embedding on a sphere, Euler's formula, Kuratowski's theorem, geometric dual, Whitney's theorem on duality, regular polyhedras.

UNIT -IV

Matrices and Digraphs

Incidence matrix *A(G)*, modified incidence matrix A_f, cycle matrix *B(G)*, fundamental cycle matrix B_f, cut-set matrix *C(G)*, fundamental cut set matrix C_f, relation between A_f , B_f and C_f , path matrix, adjacency matrix, matrix tree theorem, types of digraphs, types of connectedness, Euler digraphs, Hamiltonian digraphs, arborescence, matrices in digraphs, Camions theorem, tournaments, characterization of score sequences, Landau's theorem, oriented graphs and Avery's theorem.

A. <u>Recommended Books:</u>

1. R. Balakrishnan, K. Ranganathan, A Text Book of Graph Theory, Springer-Verlag, New York.
2. B. Bollobas, Extremal Graph Theory, Academic Press.
3. F. Harary, Graph Theory, Addison-Wesley.
4. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall.
5. S. Pirzada, An Introduction to Graph Theory, Universities Press, Orient Blackswan, 2012.
6. W. T. Tutte, Graph Theory, Cambridge University Press.
7. D. B. West, Introduction to Graph Theory, Prentice Hall.

REAL ANALYSIS - II

Course No: **MM 18202CR**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To provide the students the notions of length, area and volume with respect to different measures viz., Lebesque and Borel measure in order to overcome problems arising from Riemann Integration.

UNIT -I

Measure theory: definition of outer measure and its basic properties, outer measure of an interval as its length, countable additivity of the outer measure, Borel measurable sets and Lebesgue measurability of Borel sets, Cantor set, existence of non- measurable sets and of measurable sets which are not Borel, outer measure of monotonic sequences of sets.

UNIT -II

Measurable functions and their characterization, algebra of measurable functions, Stienhauss theorem on sets of positive measure, Ostrovisk's theorem on measurable solution of $f(x+y)= f(x) + f(y)$, $x, y \in R$, convergence a.e., convergence in measure and almost uniform convergence, their relationship on sets of finite measure, Egoroff's theorem.

UNIT -III

Lebesgue integral of a bounded function, equivalence of L-integrability and measurability for bounded functions, Riemann integral as a Lebesgue integral, basic properties of Lebesgue –integral of a bounded function, fundamental theorem of calculus for bounded derivatives, necessary and sufficient condition for Riemann integrability on [a, b], L- integral of non- negative measurable functions and their basic properties, Fatou's lemma and monotone convergence theorem, L–integral of an arbitrary measurable function and basic properties, dominated convergence theorem and its applications.

UNIT -IV

Absolute continuity and bounded variation, their relationships and counter examples, indefinite integral of an L-integrable function and its absolute continuity, necessary and sufficient condition for bounded variation, Vitali's covering lemma and a.e., differentiability of a monotone function f and $\int f' \leq f(b) - f(a)$.

Recommended Books:

1. L. Royden, Real Analysis (PHI).
2. R. Goldberg, Methods of Real Analysis.
3. G. De. Barra, Measure theory and Integration (Narosa).
4. I. K. Rana , An Introduction to Measure and Integration.
5. W. Rudin, Principles of Mathematical Analysis.
6. Chae, Lebesgue Integration.
7. T. M. Apostol, Mathematical Analysis.
8. S. M. Shah and Saxena, Real Analysis.

COMPLEX ANALYSIS - I

Course No: **MM 18203CR** Total Credits: **04**
Examination: Total Marks: 100
(a). Assessment Max. Marks: 20
(b). Theory Max. Marks: 80
Time Duration: 2 ½ hrs Min.Pass Marks: 40

Objectives: To enable the students to understand the extensions of the real analysis problems to the complex domain in order to solve harder problems pertaining to the different disciplines.

UNIT -I

Continuity and differentiability of complex functions, C-R equations and analytic functions, necessary and sufficient condition for a function to be analytic, complex integration, Cauchy Goursat theorem, Cauchy's integral formula, higher order derivatives, Morera's theorem, Cauchy's inequality.

UNIT -II

Liouville's Theorem and its generalization, fundamental theorem of algebra, Taylor's theorem, maximum modulus theorem, Schwarz lemma and its generalizations, zeros of an analytic function and their isolated character, identity theorem, argument principle , Rouche's theorem and its applications.

UNIT -III

Laurant's theorem, classification of singularities, removable singularity, Riemann's theorem, poles and behaviour of a function at a pole, essential singularity, Casorati-Weiersstras theorem on essential singularity, infinite products, convergence and divergence of infinite product, absolute convergence, necessary and sufficient conditions for convergence and absolute convergence.

UNIT -IV

Mobius transformations, their properties and classification, fixed points, cross ratio, inverse points and critical points, conformal mapping, linear transformations carry circles to circles and inverse points to inverse points, mappings of (i) upper half plane on to the unit disc, (ii) unit disc on to the unit disc, (iii) left half plane on to the unit disc and (iv) circle on to a circle. The transformations w = z^2 and $w = \frac{1}{2}\left(z + \frac{1}{z}\right)$.

Recommended Books:

1. L.Ahlfors, Complex Analysis.

2. E.C.Titchmarsh, Theory of Functions.

3. J.B.Conway, Functions of a Complex Variable-1.

4. Richard Silverman, Complex Analysis.

5. H.A.Priestly, Introduction to complex Analysis.

6. Z.Nehari, Conformal Mappings.

ADVANCED CALCULUS

Course No: **MM18204CR**	Total Credits: **02**
Examination:	Total Marks: 50
(a). Assessment	Max. Marks: 10
(b). Theory	Max. Marks: 40
Time Duration: 1 ¼ hrs	Min.Pass Marks: 20

Objectives: To extend the ideas of a function of one variable to several variables in order to solve extremal problems of analysis.

UNIT-I

Functions of several variables in R^n, the directional derivative, directional derivative and continuity, total derivative, matrix of a linear function, Jacobian matrix, chain rule, mean value theorem for differentiable functions.

UNIT-II

Sufficient conditions for differentiability and for the equality of mixed partials, Taylor's theorem for functions from R^n and R, inverse and implicit function theorem in R^n , extremum problems for functions on R^n, Lagrange's multiplier's, multiple Riemann Integral and change of variable formula for multiple Riemann integrals.

Recommended Books:

1. W.Rudin, Principles of Mathematical Analysis.
2. T.M.Apostol, Mathematical Analysis.
3. S.M.Shah and Saxen, Real Analysis.

THEORY OF NUMBERS -II

Course No: **MM 18205DCE** Total Credits: **04**
Examination: Total Marks: 100
(a). Assessment Max. Marks: 20
(b). Theory Max. Marks: 80
Time Duration: 2 ½ hrs Min.Pass Marks: 40

Objectives: To identify certain number theoretic functions and their properties in order to study real number system in depth for their applications.

UNIT -I

Integers belonging to a given exponent (mod p) and related results, converse of Fermat's theorem; If $d/p-1$, the congruence $x^d \equiv 1(\mathrm{mod}\ p)$, has exactly d-solutions; If any integer belongs to t (mod p), then exactly ϕ(t) incongruent numbers belong to t(mod p), primitive roots, there are ϕ (p-1) primitive roots of an odd prime p, any power of an odd prime has a primitive root, the function λ (m) and its properties, $a^{\lambda(m)} \equiv 1(\mathrm{mod}\ m)$, where (a , m)=1, there is always an integer which belongs to λ(m) (mod m), primitive λ-roots of m, the numbers having primitive roots are 1,2, 4, p^{α} and $2p^{\alpha}$, where p is an odd prime.

UNIT -II

Quadratic residues, Euler criterion, the Legendre symbol and its properties, Lemma of Gauss, the law of a quadratic reciprocity, characterization of primes of which 2,-2, 3,-3, 5, 6 and 10 are quadratic residues or non residues, Jacobi symbol and its properties, the reciprocity law for Jacobi symbol.

UNIT -III

Number theoretic functions, some simple properties of τ(n),σ(n), ϕ(n) and μ(n). Mobius inversion formula. Perfect numbers. Necessary and sufficient condition for an even number to be perfect, the function [x] and its properties, average order of magnitudes of τ(n), σ(n), ϕ(n), Farey fractions, rational approximation.

UNIT -IV

Simple continued fractions, application of the theory of infinite continued fractions to the approximation of irrationals by rationals, Hurwitz theorem, Relation between Riemann Zeta function and the set of primes, characters, the L-Function L(S, x) and its properties, Dirichlet's theorem on infinity of primes in an arithmetic progression.

Recommended Books

1. W. J. Leveque Topics in Number Theory, Vol. I and II Addition Wesley Publishing Company, INC.
2. I. Niven and H.S Zucherman, An introduction of the Theory of Numbers
3. Boevich and Shafeviech, Number Theory,I.R Academic Press.

REFERENCES:

1. T.M Apostal, Analytic Number Theory, Springer International.
2. G.H Hardy and Wright, An introduction to the theory of Numbers.
3. J.P. Serre, A course in Arithmetic, GTM Vol. Springer Verlag 1973.
4. E. Landau, An Elementary Number Theory.

OPERATION RESERACH

Course No: **MM 18206DCE** Total Credits: **04**
Examination: Total Marks: 100
(a). Assessment Max. Marks: 20
(b). Theory Max. Marks: 80
Time Duration: 2 ½ hrs Min.Pass Marks: 40

Objectives: To equip the student with methods and trends for taking management decisions and networking.

UNIT –I

Definition of operation research, main phases of OR study, linear programming problems (LPP), applications to industrial problems –optimal product links and activity levels, convex sets and convex functions, simplex method and extreme point theorems, Big M and Two phase methods of solving LPP.

UNIT -II

Revised simplex method, assignment problem, Hungarian method, transportation problem, and mathematical formulation of transportation problem, methods of solving (North-West Corner rule, Vogel's method and U.V. method), concept and applications of duality, formulation of dual problem, duality theorems (weak duality and strong duality theorems), dual simplex method, primal- dual relations, complementary slackness theorems and conditions.

UNIT -III

Sensitivity Analysis: changes in the coefficients of the objective function and right hand side constants of constraints, adding a new constraint and a new variable, Project management: PERT and CIM, probability of completing a project.

UNIT -IV

Game theory: Two person zero sum games, games with pure strategies, games with mixed strategies, Min. Max. principle, dominance rule, finding solution of 2 x 2, 2 x m, 2 x m games, equivalence between game theory and linear programming problem(LPP), simplex method for game problem.

Recommended Books:

1.C.W.Curchman, R.L. Ackoff and E.L.Arnoff, (1957) Introduction to Operation Research.
2. F. S Hiller and G.J. Lieberman, Introduction to Operations Research (Sixth Edition), McGraw Hill International, Industries Series, 1995.
3. G. Hadley, Linear programming problem, Narosa publishing House, 1995.
4. S.I.Gauss , Linear Programming, Wiley Eastern.
5. Kanti Swarup, P.K Gupta and M.M.Singh M. M, Operation Research; Sultan Chand & Sons.

MATHEMATICAL MODELLING

Course No. **MM 18207DCE**	Total Credits: **02**
Examination:	Total Marks: 50
(a). Assessment	Max. Marks: 10
(b). Theory	Max. Marks: 40
Time Duration: 1 ¼ hrs	Min.Pass Marks: 20

Objectives: To provide the students a system using mathematical concepts and language for developing a mathematical model for certain day to day problems.

UNIT -I

Introduction to mathematical modeling, types of modeling, classification of mathematical models, formulation, solution and interpretation of a model, linear growth and decay models, non-linear growth and decay models, continuous population models for single species, logistic growth model, discrete models, age structured populations, delay models, Fibonacci's rabbits, the golden ratio, compartment models, limitations of mathematical models.

UNIT -II

Mathematical models in ecology and epidemiology: models for interacting populations, types of interactions, Lotka-Voltera system and stability analysis of the interactions like prey-predator, competition and symbiosis, infectious disease modelling, simple and general epidemic models viz SI, SIS, SIR epidemic disease models, vaccination, the SIR endemic disease model.

Books Recommended

1. J. N. Kapur, Mathematical Modelling, New Age International Publishers.
2. J.D. Murray Mathematical Biology (An Introduction, Vol. I and II), Springer Verlag.
3. J.N. Kapur, Mathematical Model in Biology and Medicines.
4. S. I. Rubinow, Introduction to Mathematical Biology, John Wiley and Sons, 1975.
5. M. R. Cullen, Linear Models in Biology, Ellis Harwood Ltd.
6. Jaffrey R. Chasnov, Mathematical Biology, Hong Kong Press.

INTEGRAL EQUATIONS

Course No. **MM 18208DCE**	Total Credits: **02**
Examination:	Total Marks: 50
(a). Assessment	Max. Marks: 10
(b). Theory	Max. Marks: 40
Time Duration: 1 ¼ hrs	Min.Pass Marks: 20

Objectives: To acquaint the student with tackling integral equations that include energy transfer, heat equation, oscillation of a string etc., that may enable them to solve different type of differential equations.

UNIT -I

Linear integral equations of the first and second kinds, Volterra and Fredholm integral equations, relations between differential and integral equations, solution of Volterra and Fredholm integral equations by the methods of successive substitutions and successive approximations, iterated and resolvent kernels, Neumann series, reciprocal functions, Volterra's solutions of Fredholm equations.

UNIT -II

Fredholm theorems, Fredholm associated equation, solution of integral equations using Fredholm's determinant and minor, homogeneous integral equations, integral equations with separable kernels, the Fredholm alternatives, symmetric kernels, Hilbert Schmidt theory for symmetric kernels, applications of integral equations to differential equations, initial value problem, boundary value problem, Dirac-Delta function, Green's function approach.

Books Recomended:

1. R.P. Kanwal, Linear Integral Equations (Theory and Technique), Academic Press Birkhauser-1997.
2. W.V. Lovitt, Linear Integral Equations, Dover Publications, Inc. New York, 1950.
3. K.F. Riley, M.P. Hobson and S.T. Bence, Mathematical Methods for Physics and Engineering Cambridge University Press, U.K., 1997.

References:

1. M.D. Raisinghania, Integral Equations and Boundary Value Problems, S.C. Chand India, 2007.
2. Shanti Swarup, Integral Equations (&Boundary Value Problems), Krishna Prakashan Media (P) Ltd. Meerut, India, 2014.

FOURIER SERIES AND LAPLACE TRANSFORM

Course No: **MM 18209DCE** Total Credits: **02**
(a). Assessment Max. Marks: 10
(b). Theory Max. Marks: 40
Time Duration: 1 ¼ hrs Min.Pass Marks: 20

Objectives: To study how the Fourier series is extended to a periodic signal in the form of Fourier transform in order to analyze periodic signals.

UNIT-I

Fourier Series: Introduction, Periodic functions: Properties, Even & Odd functions. Special wave forms: Square wave, Sawtoothed wave, Triangular wave. Euler's Formulae for Fourier Series, Fourier Series for functions of period 2π, Fourier Series for functions of period 2L, Dirichlet's conditions, Sum of Fourier series. If f(x) is bounded and integrable function on $(-\pi,\pi)$ and if a_n, b_n are its Fourier coefficients, then $\sum (a_n^2 + b_n^2)$ converges. Half Range Series for sine and cosine functions, examples. Riemann Lebseque theorem.

UNIT-II

Definition, Laplace transform of elementary functions, Properties of Laplace transforms viz Linearity, translation, Change of Scale property etc. Laplace transform as periodic functions, Dirac-Delta function, Inverse Laplace transform, Laplace transform for derivatives, Laplace transform for integrals, Convolution theorem, Solution of ordinary differential equations with constant coefficients, Applications of partial differential equations.

Recommended Books:

1. **Churchill,** "Fourier Series & Boundary Value Problems"
2. **Davies, Brian**, Integral Transforms and Their Applications, Springer
3. **Erwin, Kreysigz**, Advanced Engineering Mathematics, Willey Eastern Pub.,
4. **K.S. Rao,** Introduction to Partial Differential Equations, K.S. Rao, PHI, India.

COMPLEX VARIABLES

Course No. **MM 18002GE**	Total Credits: **02**
Examination:	Total Marks: 50
(a). Assessment	Max. Marks: 10
(b). Theory	Max. Marks: 40
Time Duration: 1 ¼ hrs	Min.Pass Marks: 20

Objectives: To enable the students to understand basic concepts of complex variables as an extension of real number system.

UNIT -I

Review of complex numbers, De-Movier's theorem and it's applications, functions of a complex variable, continuity and differentiability of complex functions, analytic functions, CR equations, complex integration, Cauchy's theorem (statement only), Cauchy's integral formulae, Liouville's theorem, Fundamental theorem of algebra.

UNIT -II

Maximum modulus principle (statement only), determination of maximum modulus of e^z, sin z, cos z etc, expansion of an analytic function in a power series, Taylor's and Laurant's theorems (statements only), classification of singularities, zeros of analytic functions, argument principle, Rouche's theorem and its applications.

Books Recomended:

1. W.Rudin, Complex Analysis.
2. Alfhors, Complex Analysis.
3. S. Ponaswamy, Foundations of Complex Analysis.
4. Schaum series, Complex Variables.

MATRIX ALGEBRA

Course No. **MM 18002OE**	Total Credits: **02**
Examination:	Total Marks: 50
(a). Assessment	Max. Marks: 10
(b). Theory	Max. Marks: 40
Time Duration: 1 ¼ hrs	Min.Pass Marks: 20

Objectives: To enable the student understand the basic concepts of matrices in order to solve real life problems through solution of equations.

UNIT -I

Matrices, types, adjoint and inverse of a matrix, partition of a matrix, matrix polynomials, characteristic equation of a matrix, Caley Hamilton theorem, elementary transformations, rank of a matrix, determination of rank.

UNIT - II

Normal form with examples, solution of equations, homogenous and non-homogeneous equations, linear dependence and independence, orthogonal and unitary matrices and their determination, eigen values and eigen vectors and their determination, similarity of matrices with examples.

Books Recommended

1. Franz E. Hohn, Elementary Matrix Algebra, American Publishing company Pvt.ltd.
2. Shanti Narayan, A Text Book of Matrices, S. Chand and company Ltd.
3. Rajendra Bhatia , Matrix Analysis Springer.
4. A.Aziz, N.A.Rather and B.A.Zargar, Elementary Matrix Algebra , KBD.

SEMESTER-III

ORDINARY DIFFRENTIAL EQUATIONS

Course No: **MM 18301CR**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To enable the student to solve initial value problems pertaining to ordinary differential equations for various applications day to day life.

UNIT -I

First order ODE, singular solutions, p-discriminate and c-discriminate, initial value problem of first order ODE, general theory of Homogeneous and non-homogeneous linear ODE, simultaneous linear equations with constant coefficients, normal form, factorization of operators. method of variation of parameters, Picard's theorem on the existence and uniqueness of solutions to an initial value problem.

UNIT -II

Solution in Series: (i) roots of an indicial equation, unequal and differing by a quantity not an integer. (ii) roots of an indicial equation, which are equal. (iii) roots of an indicial equation differing by an integer making a coefficient infinite. (iv) roots of an indicial equation differing by an integer making a coefficient indeterminate.

Simultaneous equation $dx/P = dy/Q = dz/R$ and its solutions by use of multipliers and a second integral found by the help of first, total differential equations Pdx + Qdy +Rdz = 0, necessary and sufficient condition that an equation may be integrable, geometric interpretation of the Pdx + Qdy + Rdz =0.

UNIT -III

Existence of solutions, initial value problem, Ascoli- lemma, Cauchy Piano existence theorem, uniqueness of solutions with examples, Lipchitz condition and Gronwall inequality, method of successive approximation, Picard-Lindlof theorem, continuation of solutions, system of differential equations, dependence of solutions on initial conditions and parameters.

UNIT -IV

Maximal and minimal solutions of the system of ordinary differential equations, Cartheodary theorem, linear differential equations, linear homogeneous equations, linear system with constant coefficients, linear systems with periodic coefficients, fundamental matrix and its properties, non-homogeneous linear systems, variation of constant formula, Wronskian and its properties.

Recommended Books:

1. H.T.H. Piaggio, Differential Equations, CBS Publishers and Distributors, New Delhi.
2. P.Hartmen, Ordinary Differential Equations.
3. W.T.Reid, Ordinary Differential Equations.
4. E.A.Coddington and N.Levinson, Theory of Ordinary Differential Equations.

1. D. Somasundaram, Ordinary Differential Equations, Narosa Publishers, New Delhi.

COMPLEX ANALYSIS-II

Course No: **MM 18302CR** Total Credits: **04**
Examination: Total Marks: 100
(a). Assessment Max. Marks: 20
(b). Theory Max. Marks: 80
Time Duration: 2 ½ hrs Min.Pass Marks: 40

Objectives: The main aim of this course is to solve definite integrals by the method of Contour integration, bounds for the range of the analytic functions and concept of analytic continuation of a power series in order to have an understanding about the behavior of functions in complex domain.

UNIT -I

Calculus of Residues, Cauchy's residue theorem, evaluation of integrals by the method of residues, Parseval's Identity, branches of many-valued functions with special reference to arg(z), Log z and z^n , Blashke's theorem.

UNIT -II

Poisson integral formula for circle and half plane, Poisson-Jensen formula, Estermann's uniqueness theorem, Carlemann's theorem and the uniqueness theorem associated with it, Hadamard's three circle theorem, Log M(r) and Log I_2 (r) as convex functions of log r, Theorem of Borel and Caratheodory.

UNIT -III

Power series: Cauchy-Hadamard formula for the radius of convergence, Picard's theorem on power series: If $a_n > a_{n+1}$ and lim a_n=0, then the series $\sum a_n z^n$ has radius of convergence equal to 1 and the series converges for $|z|=1$ except possibly at z =1, a power series represents an analytic function within the circle of convergence, Hadamard- Pringsheim theorem, the principle of analytic continuation, uniqueness of analytic continuation, power series method of analytic continuation, functions with natural boundaries e.g., $\sum z^{n!}$, $\sum z^{2^n}$, Schwarz reflection principle.

UNIT -IV

Functions with positive real part, Borel’s theorem, univalent functions, area theorem, Bieberbach’s conjecture (statement only) and Koebe’s ¼ theorem.

space of analytic functions, Bloch’s theorem, Schottky’s theorem, a - points of an analytic function, Picard’s theorem for integral functions, Landau’s theorem.

Recommended Books:

1. L.V. Ahlfors, Complex Analysis.
2. E. C.Tichtmarsh, Theory of Functions.
3. J. B. Conway, Functions of a Complex Variable-I.
4. Richard Silverman, Complex Analysis.
5. Z. Nehari, Conformal Mappings.
6. A.I. Markushevish, Theory of Functions of a Complex Variable.

FUNCTIONAL ANALYSIS-I

Course No: **MM 18303CR** Total Credits: **04**
Examination: Total Marks: 100
(a). Assessment Max. Marks: 20
(b). Theory Max. Marks: 80
Time Duration: 2 ½ hrs Min.Pass Marks: 40

Objectives: To extend the concepts of real and complex domain to abstract spaces in order to gain insight in the real world phenomenon.

BANACH SPACE:

UNIT -I

Banach Spaces: definition and examples, subspaces, quotient spaces, continuous linear operators and their characterization, completeness of the space L(X,Y) of bounded linear operators (and its converse), incompleteness of C[a, b], under the integral norm, finite dimensional Banach spaces, equivalence of norms on finite dimensional space and its consequences, dual of a normed linear space, Hahn Banach theorem (extension form) and its applications, complemented subspaces, duals of l_p^n, C_o , l_p ($p\geq1$), C[a, b].

UNIT -II

Uniform boundedness, principle and weak boundedness, dimension of an ∞-dimensional Banach space, conjugate of a continuous linear operator and its properties, Banach-Steinhauss theorem, open mapping and closed graph theorems, counterexamples to Banach-Steinhauss, open mapping theorem and closed graph theorems for incomplete domain and range spaces, separable Banach spaces and the separability of some concrete Banach spaces (C_o, C[0,1], l_p, $p\geq1$), reflexive Banach Spaces, closed subspace and the dual of a reflexive Banach space, examples of reflexive and non-reflexive Banach spaces.

UNIT -III

HILBERT SPACE:

Hilbert spaces: definition and examples, Cauchy's Schwartz inequality, parallogram law, orthonormal (o.n) systems, Bessel's inequality and Parseval's Identity for complete orthonormal systems, Riesz-Fischer theorem, Gram Schmidt process, o.n basis in separable Hilbert spaces.

UNIT -IV

Projection theorem, Riesz Representation theorem, counter example to the projection theorem and Riesz representation theorem for incomplete spaces, Hilbert property of the dual of a Hilbert space and counter examples of incomplete inner product spaces, reflexivity of Hilbert space, adjoint of a Hilbert space operator, weak convergence and Bolzano-Weirstrass property in Hilbert Spaces, normal and unitary operators, finite dimensional spectral theorem for normal operators.

Recommended Books:

1. B.V.Limaya, Functional Analysis.
2. C.Goffman G. Pedrick, A First Course in Functional Analysis.
3. L.A. Lusternick & V.J. Sobolov, Elements of Functional Analysis.
4. J.B. Conway, A Course in Functional Analysis.

FOURIER ANALYSIS

Course No. **MM 18304CR** Total Credits: **02**
(a). Assessment Max. Marks: 10
(b). Theory Max. Marks: 40
Time Duration: 1 ¼ hrs Min.Pass Marks: 20

Objectives: The primary object of this course is to give conceptual knowledge of Fourier Series and its applications to heat flow and vibrating string problems.

UNIT -I

Fourier Series

Motivation and definition of Fourier series, Fourier series over the interval of length 2π, change of the interval, the complex exponential Fourier series, criteria for the convergence of Fourier series, Riemann-Lebesgue lemma, convergence at a point of continuity and at a point of discontinuity, uniform convergence and convergence in mean of the Fourier series.

UNIT -II

Derivatives and Integrals of Fourier Series

Differentiation of Fourier series, differentiation of the sine and cosine series, convergence theorems related to the derived Fourier series, integration of Fourier series, applications of Fourier series to Heat flow and Vibrating string problems.

Books Recommended:

1. E.M. Stein and R. Shakarchi, Fourier Analysis, An introduction, Princeton University Press, 2002.
2. K. B. Howell, Principles of Fourier Analysis, Chapman & Hall/ CRC, Press, 2001.
3. Lokenath Debnath, Wavelet Transforms and their Applications, Birkhauser, 2002.
4. G. P. Tolstov, Fourier Series, Dover, 1972.
5. Zygmund, Trigonometric Series (2nd Ed., Volume I & II Combined), Cambridge University Press, 1959.

References:

1. G. Loukas, Modern Fourier Analysis, Springer, 2011.
2. K. Ahmad and F. A. Shah, Introduction to Wavelets with Applications, Real World Education Publishers, New Delhi, 2013.
3. G. B. Folland, Fourier Analysis and Its Applications, Brooks/Cole Publishing, 1992.
4. M. Pinsky, Introduction to Fourier Analysis and Wavelets, Brooks/Cole Publishing, 2002.

ADVANCED GRAPH THOERY

Course No: **MM 18305DCE**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To expose the student to the various concepts of graph theory in order to model many types of relations and processes in physical, biological, social and information systems.

UNIT -I

Colorings

Vertex coloring, chromatic number $\chi(G)$, bounds for $\chi(G)$, Brook's theorem, edge coloring, Vizing's theorem, map coloring, six color theorem, five color theorem, every graph is four colourable iff every cubic bridgeless plane map is 4-colorable, every planar graph is 4-colorable iff $\chi'(G)=3$, Heawood map-coloring theorem, uniquely colorable graphs

UNIT -II

Matchings

Matchings and 1-factors, Berge's theorem, Hall's theorem, 1-factor theorem of Tutte, antifactor sets, f-factor theorem, f-factor theorem implies1-factor theorem, Erdos- Gallai theorem follows from f-factor theorem, degree factors, k-factor theorem, factorization of K_n.

UNIT -III

Edge graphs and eccentricity sequences

Edge graphs, Whitney's theorem on edge graphs, Beineke's theorem, edge graphs of trees, edge graphs and traversibility, total graphs, eccentricity sequences and sets, Lesniak theorem for trees, construction of trees, neighbourhoods, Lesniak theorem graphs.

UNIT -IV

Groups in graphs and graph spectra

Automorphism groups of graphs, graph with a given group, Frucht's theorem, Cayley digraph, spectrum of a graph, spectrum of some graphs-regular graph, compliment of a graph, edge graph, complete graph, complete bipartite, cycle and path, Laplacian spectrum, energy of a graph, Laplacian energy.

Recommended Books:

1. R. Balakrishnan, K. Ranganathan, A Text Book of Graph Theory, Springer-Verlag, New York
2. B. Bollobas, Extremal Graph Theory, Academic Press.
3. F. Harary, Graph Theory, Addison-Wesley.
4. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall
5. S. Pirzada, An Introduction to Graph Theory, Universities Press, Orient Blackswan, 2012
6. W. T. Tutte, Graph Theory, Cambridge University Press.
7. D. B. West, Introduction to Graph Theory, Prentice Hall

ABSTRACT MEASURE THEORY

Course No: **MM 17306DCE** Total Credits: **04**
Examination: Total Marks: 100
(a). Assessment Max. Marks: 20
(b). Theory Max. Marks: 80
Time Duration: 2 ½ hrs Min.Pass Marks: 40

Objectives: To extend the concept of measure to abstract spaces for various measures in order to obtain corresponding analogs of various results of Lebesgue measure.

CREDIT-I

Semi-ring, ring, algebra and σ- algebra of sets, measures on semi-rings, outer measure associated with a set function and basic properties, measurable sets associated with an outer measure as a σ- algebra , outer measure induced by a measure, non measurable sets.

CREDIT-II

Finite and σ- Finite measure spaces, Measurable sets of finite measure space, Improper Riemann integral as a Lebesgue integral, calculation of some improper Riemann integrable functions, Approximation of integrable functions, Riemann Lebesgue lemma.

CREDIT-III

Product measures and product σ- algebra, measurable rectangles, monotone class and elementary sets, expressing a double integral as an iterated integral, examples of non-integrable functions whose iterated integrals exist (and are equal), Integration on product spaces, Fubini theorem.

CREDIT-IV

For $f \in L_1$ [a, b], $F^{/}= f$ a.e. on [a, b]. If f is absolutely continuous on (a, b) with f(x)=0 a.e, then f = constant. Characterization of an absolutely continuous function as an indefinite Lebesgue integral. Non-Lebesgue integrability of f where f (x) = $x^2\sin(1/ x^2)$, f (0) =0 on [0, 1]. Fundamental theorem of calculus for the Lebesgue integral. A brief introduction to L_p spaces. Holder's and Minkowki's inequalities.

Recommended Books:

1.C.D.Aliprantis and O.Burkinshaw, Principles of Real Analysis
2.Goldberg , R. : Methods of Real Analysis
3.T.M.Apostol : Mathematical Analysis

Suggested Readings:

1.Royden, L: Real Analysis (PHI)
2.Chae, S.B. Lebesgue Integration(Springer Verlag).
3.Rudin, W. Principles of Mathematicals Analysis(McGraw Hill).
4.Barra ,De. G. : Measure theory and Integration (Narosa)
5.Rana ,I.K. : An Introduction to Measure and Integration, Narosa Publications.

MATHEMATICAL BIOLOGY

Course No: **MM 18307DCE**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To apply mathematical and statistical techniques including ODES/PDES, numerical methods, hypothesis testing, regression, matrices etc. in the context of biological systems.

UNIT -I

Diffusion in biology: Fick's law of diffusion, Fick's perfusion law, membrane transport, diffusion through a slab, convective transport, trancapillary exchange, heat transport in biological tissues, oxygen transport through red cells, gas exchange in lungs, the ideal gas law and solubility of gases, the equation of gas transport in one Alveolus.

UNIT -II

Biofluid mechanics: introduction, various types of fluid flows, viscosity, basic equation of fluid, mechanics, continuity equation, equation of motion, the circulatory system, systemic and pulmonary circulation, the circulation in heart, blood composition, arteries and arterioles, models in blood flow, Poiseulle's flow and its applications, the pulse wave.

UNIT -III

Tracers in physiological systems: compartment systems, the one compartment system, discrete and continuous transfers, ecomatrix, the continuous infusion, the two compartment system, bath-tub models, three-compartment system, the leaky compartment and the closed systems, elementary pharmacokinetics, parameter estimation in two compartment models, basic introduction to n-compartment systems.

UNIT -IV

Biochemical reactions and population genetics: the law of mass action, enzyme kinetics, Michael's- Menten theory, competitive inhibition, Allosteric inhibition, enzyme-substrate-inhibitor system, cooperative properties of enzymes, the cooperative dimer, haemoglobin. haploid and diploid genetics, spread of favourite allele, mutation-selection balance, heterosis, frequency dependent selection.

Books Recommended

1. J.D. Murray, Mathematical Biology, CRC Press
2. S.I. Rubinow, Introduction to Mathematical Biology, John Wiley and Sons.
3. Guyton and Hall, Medical Physiology.
4. S.C. Hoppersteadt and C.S. Peskin, Mathematics in Medicine and Life Sciences, Springer-Verlag
5. J.R. Chesnov, Lecture notes in Mathematical Biology, Hong Kong Press
6. J. N. Kapur, Mathematical methods in Biology and Medicine, New Age Publishers
7. D. Ingram and R.F. Bloch, Mathematical methods in Medicine, John Wiley and Sons.

WAVELET THEORY

Course No: **MM 18308DCE**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To study powerful wavelet basic functions and find efficient methods for their competitions in order to study signal processing.

UNIT -I

Time Frequency Analysis and Wavelet Transforms

Gabor transforms, basic properties of Gabor transforms, continuous and discrete wavelet transforms with examples, basic properties of wavelet transforms, examples of Haar wavelet, Mexican hat wavelet and their Fourier transforms, dyadic orthonormal wavelet bases for $L^2(\mathbb{R})$.

UNIT -II

Multiresolution Analysis and Construction of Wavelets

Definition and examples of multiresolution analysis (MRA), properties of scaling functions and orthonormal wavelet bases, construction of orthonormal wavelets with special reference to Haar wavelet, Franklin wavelet and Battle-Lemarie wavelet, Spline wavelets, construction of compactly supported wavelets, Daubechie's wavelets and algorithms.

UNIT -III

Other Wavelet Constructions and Characterizations

Introduction to basic equations, some applications of basic equations, characterization of MRA wavelets and scaling functions, construction of biorthogonal wavelets, wavelet packets, definition and examples of wavelets in higher dimensions.

UNIT -IV

Further Extensions of Multiresolution Analysis

Periodic multiresolution analysis and the construction of periodic wavelets, multiresolution analysis associated with integer dilation factor (M-band wavelets), harmonic wavelets, properties of harmonic scaling functions.

Recommended Books:

1. L. Debnath, Wavelet Transforms and their Applications, Birkhauser, 2002.
2. I. Daubechies, Ten Lectures on Wavelets, CBS-NSF Regional Conferences in Applied Mathematics, 61, SIAM, Philadelphia, PA, 1992.
3. K. Ahmad and F. A. Shah, Introduction to Wavelets with Applications, Real World Education Publishers, New Delhi, 2013.

References:

1. C. K. Chui, An Introduction to Wavelets, Academic Press, New York, 1992.
2. M. Pinsky, Introduction to Fourier Analysis and Wavelets, Brooks/Cole, 2002.
3. E. Hernandez and G. Weiss, A First Course on Wavelets, CRC Press,New York (1996).

LAPLACE AND FOURIER TRANSFORMATIONS

Course No: **MM 18003GE**	Total Credits: **02**
(a). Assessment	Max. Marks: 10
(b). Theory	Max. Marks: 40
Time Duration: 1 ¼ hrs	Min.Pass Marks: 20

Objectives: To formulate and solve differential equations, illustrate Laplace and Fourier transform through practical applications and solve initial and boundary value problems using Laplace/Fourier transform.

UNIT -I

Definition of Laplace transformation and some examples on Laplace transformation of elementary functions, piecewise continuity, sufficient conditions for the existence of Laplace transform, linearity property, first and second translation (shifting property), Laplace transform of derivatives, Laplace transform of integrals, Inverse Laplace transform, Inverse Laplace transform of derivatives and integrals, the convolution property, methods of finding inverse Laplace transform, the complex inversion formula, the Heaviside expansion formula.

UNIT -II

Periodic functions, Definition and examples of Fourier series, Drichlet's conditions, determination of Fourier coefficients, even and odd functions and their Fourier expansion, change of interval, half range series.

Fourier transform, inverse Fourier transform, Fourier sine and cosine transforms and their inversion, properties of Fourier transforms, Fourier transform of the derivative, convolution theorem, discrete Fourier transform and fast Fourier transform and their properties.

Recommended Books

1. Murrey R. Spiegel, Laplace Transforms, Schaum's outline series.
2. I. N. Sneddon: The use of Integral Transforms, McGraw-Hill, Singapore 1972.
3. R. R. Goldberg, Fourier Transforms, Cambridge University Press, 1961.
4. D. Brain, Integral Transforms and their applications, Springer, 2002.

INTRODUCTION TO MATHEMATICAL MODELLING

Course No: **MM 18003OE**	Total Credits: **02**
(a). Assessment	Max. Marks: 10
(b). Theory	Max. Marks: 40
Time Duration: 1 ¼ hrs	Min.Pass Marks: 20

Objectives: To enable the student to formulate mathematical models of real life problems and find their solutions.

UNIT -I

Introduction to mathematical modeling, types of modeling, classification of mathematical models, formulation, solution and interpretation of a model, models in population dynamics, linear growth and decay models, non-linear growth and decay models, continuous population models for single species, delay models, logistic growth model, discrete models, age structured populations, Fibonacci's rabbits, the golden ratio, compartment models, limitations of mathematical models.

UNIT -II

Mathematical modeling through system of ordinary differential equations, compartment models through system of ODE's, modeling in economics, medicine, international trade, gravitation; planetary motion; basic theory of linear difference equations with constant coefficients, mathematical models through difference equations in population dynamics, finance and genetics, modeling through graphs.

Books Recommended:

1. J. N. Kapur, Mathematical Modelling, New Age International Publishers.
2. Neil Gerschenfeld : The nature of Mathematical modeling, Cambridge University Press, 1999.
3. A. C. Fowler : Mathematical Models in Applied Sciences, Cambridge University Press, 1997.
4. M. R. Cullen, Linear Models in Biology, Ellis Harwood Ltd.
5. J.N. Kapur, Mathematical Model in Biology and Medicines.

SEMESTER-IV

PARTIAL DIFFRENTIAL EQUATIONS

Course No: **MM 18401CR**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To familiarize the students with the fundamental concepts of PDE's and their solutions in the context of Laplace, Heat and Wave equations.

UNIT -I

Introduction to partial differential equations, partial differential equations of first order, linear and non-linear partial differential equations, Lagrange's method for the solution of linear partial differential equations, Charpits method and Jacobi methods for the solution of non-linear partial differential equations, initial-value problems for quasi-linear first-order equations, Cauchy's method of characteristics.

UNIT -II

Origin of second order partial differential equations, linear partial differential equations with constant coefficients, methods for solution of second order partial differential equations, classification of second order partial differential equations, canonical forms, adjoint operators, Riemann's method, Monge's method for the solution of non-linear partial differential equations.

UNIT -III

Derivation of Laplace and heat equations, boundary value problems, Drichlet's and Neumann problems for a circle and sphere; solutions by separation of variables method, cylindrical coordinates and spherical polar coordinate system, maximum-minimum principle, uniqueness theorem, Sturm-Liouville theory.

UNIT -IV

Derivation of wave equation, D' Alembert's solution of one dimensional wave equation, separation of variables method, periodic solutions; method of eigen functions, Duhamel's principle for wave equation, Laplace and Fourier transforms and their applications to partial differential equations, Green function method and its applications.

Recommended Books:

1. Robert C. McOwen, Partial Differential Equations-Methods and Applications, Pearson Education, Delhi, 2004.
2. L. C. Evans, Partial Differential Equations, GTM, AMS, 1998
3. Diran Basmadjian, The Art of Modelling in Science and Engineering, Chapman & Hall/CRC, 1999.
4. E. DiBenedetto, Partial Differential Equations, Birkhauser, Boston, 1995.
5. F. John, Partial Differential Equations, 3rd ed., Narosa Publ. Co., New Delhi,1979.
6. E. Zauderer, Partial Differential Equations of Applied Mathematics, 2nd ed., John Wiley and Sons, New York, 1989

DIFFRENTIAL GEOMETRY

Course No: **MM 18402CR**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To inculcate the students to study the geometric properties of curves, surfaces and their higher-dimensional analogs using the methods of calculus.

UNIT -I

Curves: differentiable curves, regular point, parameterization of curves, arc-length, arc-length is independent of parameterization, unit speed curves, plane curves, curvature of plane curves, osculating circle, centre of curvature. computation of curvature of plane curves, directed curvature, examples, straight line, circle, ellipse, tractrix, evolutes and involutes, space curves, tangent vector, unit normal vector and unit binormal vector to a space curve, curvature and torsion of a space curve, the Frenet-Serret theorem, first fundamental theorem of space curves, intrinsic equation of a curve, computation of curvature and torsion, characterization of helices and curves on sphere in terms of their curvature and torsion, evolutes and involutes of space curves.

UNIT -II

Surfaces: regular surfaces with examples, coordinate charts or curvilinear coordinates, change of coordinates, tangent plane at a regular point, normal to the surface, orientable surface, differentiable mapping between regular surfaces and their differential, fundamental form or a metric of a surface, line element, invariance of a line element under change of coordinates, angle between two curves, condition of orthogonality of coordinate curves, area of bounded region, invariance of area under change of coordinates.

UNIT -III

Curvature of a Surface: normal curvature, Euler's work on principal curvature, qualitative behavior of a surface near a point with prescribed principal curvatures, the Gauss map and its differential, the differential of Gauss is self-adjoint, second fundamental form, normal curvature in terms of second fundamental form. Meunier theorem, Gaussian curvature, Weingarten equation, Gaussian curvature K(p)= (eg-f2)/EG-F2, surface of revolution, surfaces with constant positive or negative Gaussian curvature, Gaussian curvature in terms of area, line of curvature, Rodrigue's formula for line of curvature, equivalence of surfaces, isometry between surfaces, local isometry, and characterization of local isometry.

UNIT -IV

Christoffel symbols, expressing Christoffel symbols in terms of metric coefficients and their derivative, Theorema egrerium (Gaussian curvature is intrinsic), isometric surfaces have same Gaussian curvatures at corresponding points, Gauss equations and Manardi Codazzi equations for surfaces, fundamental theorem for regular surface. (Statement only).

Geodesics: geodesic curvature, geodesic curvature is intrinsic, equations of geodesic, geodesic on sphere and pseudo sphere, geodesic as distance minimizing curves. Gauss-Bonnet theorem (statement only), geodesic triangle on sphere, implication of Gauss-Bonnet theorem for geodesic triangle.

Recommended Books:

1. John Mc Cleary, Geometry from a differentiable Viewpoint. (Cambridge Univ. Press).
2. W. Klingenberg, A course in Differential Geometry (Spring Verlag).
3. C. E. Weatherburn, Differential Geometry of Three dimensions.
4. T. Willmore, An Introduction to Differential Geometry.
5. J. M. Lee, Riemannian Manifolds, An Introduction to Curvature.

ADVANCED ABSTRACT ALGEBRA-II

Course No: **MM 18403CR**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To expose the students to Galios theory in problem solving context and to apply the group theoretic information to deduce results about fields and polynomials.

UNIT -I

Relation and ordering, partially ordered sets, lattices, properties of lattices, lattices as algebraic systems, sub-lattices, direct product and homomorphism, modular lattices, complete lattices, bounds of lattices, distributive Lattice, complemented lattices.

UNIT -II

Modules, sub-modules, quotient modules, homomorphism and isomorphism theorem, cyclic modules, simple modules, semi-simple modules, Schuer's lemma, free modules, ascending chain condition and maximum condition, and their equivalence, descending chain condition and minimum condition and their equivalence, direct sums of modules, finitely generated modules.

UNIT -III

Fields: Prime fields and their structure, extensions of fields, algebraic numbers and algebraic extensions of a field, roots of polynomials, remainder and factor theorems, splitting field of a polynomial, existence and uniqueness of splitting fields of polynomials , simple extension of a field.

UNIT -IV

Separable and in-separable extensions, the primitive element theorem, finite fields, perfect fields, the elements of Galois theory, automorphisms of fields, normal extensions, fundamental theorem of Galois theory, construction with straight edge and compass, R^n is a field iff n = 1, 2.

Recommended Books:

1. I. N. Heristein, Topics in Algebra.
2. K. S. Miller, Elements of Modern Abstract Algera.
3. Surjeet Singh and Qazi Zameer-ud-din, Modern Algebra, Vikas Publishers Pvt. Limited.

LINEAR ALGEBRA

Course No: **MM 18404CR** Total Credits: **02**
(a). Assessment Max. Marks: 10
(b). Theory Max. Marks: 40
Time Duration: 1 ¼ hrs Min.Pass Marks: 20

Objectives: To inculcate the students to study linear functions and their representations through matrices and vector spaces.

UNIT -I

Linear transformation, algebra of linear transformations, linear operators, invertible linear transformations, matrix representation of a Linear transformation, linear functionals, dual spaces, dual basis, anhilators, eigen values and eigen-vectors of linear transformation, diagonalization, similarity of linear transformation.

UNIT -II

Canonical forms: triangular form, invariance, invariant direct sum decomposition, primary decomposition, nilpotent operators, Jordon canonical form, cyclic subspaces, rational canonical form, quotient spaces, bilinear forms, alternating bilinear forms, symmetric bilinear forms, quadratic forms.

Books Recommended:

1. Robort A. Beezer, A first course in linear algebra.
2. John B. Fraleigh and Raymond, Linear Algebra.
3. A. K. Sharma, Linear Algebra.
4. Vivek Sahai and Vikas Bist, Linear Algebra.

ANALYTIC THEORY OF POLYNOMIALS

Course No: **MM 18405DCE**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To expose to the study of polynomials, their extremal problems, zeros, critical points and their location.

UNIT -I

Introduction, the fundamental theorem of algebra (revisited), symmetric polynomials, the continuity theorem, orthogonal polynomials, general properties, the classical orthogonal polynomials, tools from matrix analysis.

UNIT -II

Critical points in terms of zeros, fundamental results and critical points, convex hulls and Gauss-Lucas theorem, some applications of Gauss-Lucas theorem, extensions of Gauss-Lucas theorem, average distance from a line or a point, real polynomials and Jenson's theorem, extensions of Jenson's theorem.

UNIT -III

Derivative estimates on the unit interval, inequalities of S. Bernstein and A. Markov, extensions of higher order derivatives, two other extensions, dependence of the bounds on the zeros, some special classes, Bernstein Theorem on unit disk and its generalization, L^p analog of Bernstein's inequality.

UNIT -IV

Coefficient estimates, polynomials on the unit circles, coefficients of real trigonometric polynomials, polynomials on the unit interval.

(Scope of above syllabus as given in the book "Analytic Theory of Polynomials" by Rahman and Schmeisser)

Recommended Books:

1. Q. I. Rahman and G.Schmeisser, Analytic Theory of Polynomials.
2. Morris Marden, Geometry of Polynomials.
3. G. V. Milovanovic, D.S.Mitrinovic and Th. M. Rassias, Topics in Polynomials, Extremal Properties, Problems, Inequalities, Zeroes.
4. G. Polya and G. Szego, Problems and Theorems in Analysis (Springer Verlag New York Heidelberg Berlin).

MATHEMATICAL STATISTICS

Course No: **MM 18406DCE**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To provide the student with a solid grounding in probability theory and mathematical statistics for predictions and decisions making.

UNIT -I

Some Special Distributions, Bernoulli, Binomial, trinomial, multinomial, negative binomial, Poisson, gamma, chi-square, beta, Cauchy, exponential, geometric, normal and bivariate normal distributions.

UNIT -II

Distribution of functions of random variables, distribution function method, change of variables method, moment generating function method, t and F distributions, Dirichelet distribution, distribution of order statistics, distribution of X and $\frac{nS^2}{\sigma^2}$, limiting distributions, different modes of convergence, central limit

UNIT -III

Interval estimation, confidence interval for mean, confidence interval for variance, confidence interval for difference of means and confidence interval for the ratio of variances, point estimation, sufficient statistics, Fisher-Neyman criterion, factorization theorem, Rao- Blackwell theorem, best statistic (MvUE), Complete Sufficient Statistic, exponential class of pdfs.

UNIT -IV

Rao-Crammer inequality, efficient and consistent estimators, maximum likelihood estimators (MLE's), testing of hypotheses, definitions and examples, best or most powerful (MP) tests, Neyman Pearson theorem, uniformly most powerful (UMP) tests, likelihood ratio test, chi-square test.

Recommended Books

1. Hogg and Craig, An Introduction to Mathematical Statistics.
2. Mood and Grayball, An Introduction to Mathematical Statistics.

References

1. C. R. Rao, Linear Statistical Inference and its Applications.
2. V. K. Rohatgi, An Introduction to Probability and Statistics.

FUNCTIONAL ANALYSIS-II

Course No: **MM 18407DCE**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To enable the student to understand the properties of Banach spaces in terms of bounded linear operators, separability and reflexivity of such spaces.

UNIT -I

Relationship between analytic and geometric forms of Hahn-Banach theorem, applications of Hahn-Banach theorem, Banach limits, Markov-Kakutani theorem for a commuting family of maps, complemented subspaces of Banach spaces, complentability of dual of a Banach space in its bidual, uncomplementability of co in l_∞.

UNIT -II

Dual of subspaces, quotient spaces of a normed linear space, weak and weak* topologies on a Banach space, Goldstine's theorem, Banach Alaoglu theorem and its simple consequences, Banch's closed range theorem, injective and surjective bounded linear mappings between Banach spaces.

UNIT -III

l_∞ and C[0,1] as universal separable Banach spaces, l_1 as quotient universal separable Banach spaces, Reflexivity of Banach spaces and weak compactness, Completeness of Lp[a,b], extreme points, Krein-Milman theorem and its simple consequences.

UNIT -IV

Dual of l_∞, C(X) and L_p spaces. Mazur-Ulam theorem on isometries between real normed spaces, Muntz theoremin C[a,b].

Recommended Books:

1. J. B. Conway, A First Course in Functional Analysis (Springer Verlag).
2. R. E. Megginson, An Introduction to Banach Space theory (Springer Verlag, GTM, Vol. 183)
3. Lawrence Bagget, Functional Analysis, A Primer (Chapman and Hall, 1991).

References:

1. B. Ballobas, Linear Analysis (Camb. Univ.Pres).
2. B. Beauzamy, Introduction to Banach Spaces and their geometry

(North Holland).
3 Walter Rudin, Functional Analysis (Tata McGrawHill).

NON-LINEAR ANALYSIS

Course No: **MM 18408DCE**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To inculcate the students to study various methods to solve problems involving the homogeneous and non-homogeneous operators.

UNIT -I

Convex Sets, best approximation properties, topological properties, separation, nonexpansive operators, projectors onto convex sets, fixed points of nonexpansive operators, averaged nonexpansive operators, Fejer monotone sequences, convex cones, generalized interiors, polar and dual cones, tangent and normal cones, convex functions, variants, between linearity and convexity, uniform and strong convexity, quasiconvexity

UNIT -II

Gateaux Derivative, Frechet Derivative, lower semicontinuous convex functions, subdifferential of convex functions, directional derivatives, characterization of convexity and strict convexity, directional derivatives and subgradients, Gateaux and Frechet differentiability, differentiability and continuity

UNIT -III

Monotone operators, strong notions of monotonicity such as para, cyclic, strict, uniform and strong monotonicity, maximal monotone operator and their properties, bivariate functions and maximal monotonicity, Debrunner-Flor theorem, Minty theorem, Rockfeller's cyclic monotonicity theorem, monotone operators on *R*.

UNIT -III

Reisz-Representation theorem, projection mappings and their properties, characterization of projection onto convex sets and their geometrical interpretation,

Billinear forms and its applications, Lax-Milgram lemma, minimization of functionals, variational inequalities, relationship between abstract minimization problems and variational inequalities, Lions Stampacchia theorem for existence of solution of variational inequality.

<u>Recommended Books:</u>

1. H. H. Bauschke and P. L. Combettes, Convex Analysis and Monotone Operator Theory in Hilbert Spaces, Springer New York, 2011.
2. D. Kinderlehrer and G. Stampacchia, An Introduction to Variational Inequalities and Their Applications, Academic Press, New York, 1980.
3. A. H. Siddiqi, K. Ahmed and Manchanda, P. Introduction to Functional Analysis with Applications, Anamaya Publishers, New Delhi-2006.

<u>References:</u>

1. I. Ekland and R. Temam, Convex Analysis and Variational Problems, W.Takahashi, Nonlinear Functional Analysis, North-Holland Publishing Company-Ammsterdam, 1976.
2. M. C. Joshi and R. K. Bose, Nonlinear Functional Analysis and its Applications, Willey Eastern Limited, 1985.

ADVANCED TOPICS IN TOPOLOGY AND MODERN ANALYSIS

Course No: **MM 18409DCE**	Total Credits: **04**
Examination:	Total Marks: 100
(a). Assessment	Max. Marks: 20
(b). Theory	Max. Marks: 80
Time Duration: 2 ½ hrs	Min.Pass Marks: 40

Objectives: To provide the students an integrated development of modern analysis and topology through the integrating vehicle of uniforms spaces.

UNIT -I

Uniform spaces, definition and examples, uniform topology, metrizability complete regularity of uniform spaces, pre-compactness and compactness in uniform spaces, uniform continuity.

UNIT II

Uniform continuity, uniform continuous maps on compact spaces Cauchy convergence and completeness in uniform spaces, initial uniformity, simple applications to function spaces, Arzela- Ascoli theorem**.**

UNIT -III

Abstract harmonic analysis, definition of a topological group and its basic properties. subgroups and quotient groups, product groups and projective limits, properties of topological groups involving connectedness, invariant metrics and Kakutani theorem, structure theory for compact and locally compact, Abelian groups.

UNIT -IV

Some special theory for compact and locally compact Abelian groups, Haar integral and Haar measure, invariant means defined for all bounded functions, convolution of functions and measures, elements of representation theory, unitary representations of locally compact groups.

Recommended Books:

1. I. M. James, Uniform Spaces, Springer Verlag.
2. K. D. Joshi, Introduction to General Topology.
3. S. K. Berberian, Lectures on Operator Theory and Functional

Analysis, Springer Verlag.
4. G. B. Folland, Real Analysis, John Wiley.

References:

1. G. Murdeshwar, General Topology.
2. E. Hewitt & K.A Ross, Abstract Harmonic Analysis-I, Springer Verlag.

PROJECT

Course No: **MM 18410DCE** Total Credits: **04**
Examination: Total Marks: 100
(a). Assessment Max. Marks: 20
(b). Theory Max. Marks: 80
Time Duration: 2 ½ hrs Min.Pass Marks: 40

Objectives: To develop the skill of writing mathematical topics and presentations of proofs of fundamental results pertaining to the subject

The student opting for project will have to work on the research problem in any one of the following areas:

i. **Complex Analysis**

ii. **Functional Analysis**

iii. **Graph Theory and Algebra**

iv. **Mathematical Biology**

v. **Mathematical Statistics**

The student will be put under the guidance of faculty member of the respective areas. At the end the student will have to submit dissertation. The dissertation will carry 80 marks following which there will be a viva-voce examination carrying 20 marks.

DISCRETE MATHEMATICS

Course No: **MM 18004OE**	Total Credits: **02**
(a). Assessment	Max. Marks: 10
(b). Theory	Max. Marks: 40
Time Duration: 1 ¼ hrs	Min.Pass Marks: 20

Objectives: To introduce the student to various concepts of Boolean Algebra and Lattices to be applied in day to day problems related to networking structure, transportation etc.

CREDIT-I

Lattices: Set operations, product sets, equivalence relations, relation and ordering, partially ordered sets, chain or completely ordered sets, lattices properties, lattices and algebraic systems, sub-lattices, direct product and homomorphism, modular lattices, complete lattices, distributive lattices, complemented lattices.

CREDIT-I

Boolean Algebra: Introduction, binary operations, algebraic structure, Boolean algebra, general properties of Boolean algebra, Boolean expressions, principle of Duality, Boolean algebra as a lattice, sub-Boolean algebra, direct product and homomorphism, representation theorem.

Recommended Books:

1. Discrete Mathematics, Schaum's Outlines, Ind. Edition Tata McGraw-Hill Publishing Company Ltd. New Delhi.
2. A Text Book of Discrete Mathematics, Harish Mittal, Vinay K.Goyal, Deepak K. Goyal, I. K. Int. Publishing House Pvt. Ltd (2010).
3. Discrete Mathematical Structures, Kolman, Busby, Pross, Sixth Edition, PHI Laming Pvt. Ltd. (2010).
4. Discrete Mathematics, Richard Johnsonbaugh, sixth edition, Pearson Prentice Hall (2007).