

POST GRADUATE DEPARTMENT OF MATHEMATICS
UNIVERSITY OF KASHMIR, SRINAGAR - 190006



Course Structure for 2015 onwards (CBCS Advanced)

Semester – I				
Course Type	Course Code	Title of the Course	No. of Credits	Teacher
Core (CR)	MM15101CR	Advanced Abstract Algebra – I	04	
	MM 15102CR	Real Analysis – I	04	
	MM 15103CR	Topology	04	
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Discipline Centric Electives (DCE)	MM 15104DCE	Theory of Matrices	04	
	MM 15105DCE	Theory of Numbers-I	02	
	MM 15106DCE	Advanced Calculus	02	
	MM 15107DCE	Probability Theory	02	
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Generic Electives (GE)	MM 15108GE	Introduction to Real Analysis	02	
	MM 15109GE	Numerical Methods	02	
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Open Electives (OE)	MM 15110OE	Calculus	02	
	MM 15111OE	Introduction to Numbers	02	
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General Instructions for the Candidates

1. The two year (4 semester) PG programmes is of 96 credit weightage i.e., 24 credits/semester ($24 \times 4 = 96$).
2. Out of 24 credits in a semester a candidate has to obtain 12 credits compulsorily from “**Core Courses**”, while the remaining 12 credits can be obtained from the “**Electives**” in the following manner:
 - A candidate can obtain a maximum of 6 credits within his/her own Department out of the specializations offered by the Department as **Discipline Centric-Electives**.
 - 6 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 these 6 credits from the **Generic** or **Open Electives** or **a combination of both**.

Semester - II				
Course Type	Course Code	Title of the Course	No. of Credits	Teacher
Core (CR)	MM 15201CR	Discrete Mathematics	04	
	MM 15202CR	Real Analysis – II	04	
	MM 15203CR	Complex Analysis-I	04	
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Discipline Centric Electives (DCE)	MM 15204DCE	Theory of Numbers – II	04	
	MM 15205DCE	Fourier Analysis	04	
	MM 15106DCE	Operation Research	04	
	MM 15207DCE	Numerical Analysis	02	
	MM 15208DCE	Bio-Mathematical Modelling	02	
	MM 15209DCE	Integral Equations	02	
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Generic Electives (GE)	MM 15210GE	Complex Variables	02	
	MM 15211GE	Riemann Integration	02	
	MM 15212GE	Basic Graph Theory	02	
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Open Electives (OE)	MM 15213OE	Matrix Algebra	02	
	MM 15214OE	Differential Equations	02	
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Semester – III				
Course Type	Course Code	Title of the Course	No. of Credits	Teacher
Core (CR)	MM 15301CR	Ordinary Differential Equations	04	
	MM 15302CR	Complex Analysis-II	04	
	MM 15303CR	Functional Analysis-I	04	
Discipline Centric Electives (DCE)	MM 15304DCE	Advanced Graph Theory	04	
	MM 15305DCE	Abstract Measure Theory	02	
	MM 15306DCE	Mathematical Biology	04	
	MM 15307DCE	Wavelet Theory	04	
	MM 15308DCE	Linear Algebra	02	
Generic Electives (GE)	MM 15309GE	Elementary Linear Algebra	02	
	MM 15310GE	Lattices and Boolean Algebra	02	
Open Electives (OE)	MM 15311OE	Introduction to Mathematical Modelling	02	
	MM 15312OE	Complex Integration	02	

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Semester - IV				
Course Type	Course Code	Title of the Course	No. of Credits	Teacher
Core (CR)	MM15401CR	Partial Differential Equations	04	
	MM15402CR	Differential Geometry	04	
	MM15403CR	Advanced Abstract Algebra-II	04	
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Discipline Centric Electives (DCE)	MM15404DCE	Analytic Theory of Polynomials	04	
	MM15405DCE	Mathematical Statistics	04	
	MM15406DCE	Functional Analysis – II	04	
	MM15407DCE	Non-Linear Analysis	04	
	MM15408DCE	Advanced Topics in Topology and Modern Analysis	04	
	MM15409DCE	Latex and Matlab	02	
	MM15410DCE	Project	02	
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Generic Electives (GE)	MM15411GE	Laplace Transformations	02	
	MM15412GE	Fourier Transformations	02	
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Open Electives (OE)	MM15413OE	Applied Group Theory	02	
	MM15414OE	Modules and Vector Spaces	02	
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General Instructions for the Candidates

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 - A candidate can obtain a maximum of 6 credits within his/her own Department out of the specializations offered by the Department as **Discipline Centric-Electives**.
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The Academic Tour shall be conducted by the Department every year for outgoing students (4th semester).

SEMESTER-I

ADVANCED ABSTRACT ALGEBRA-I

Course No: MM15101CR	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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 $n \geq 5$.

CREDIT-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, Schreier's refinement theorem, Solvable groups.

CREDIT-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.

CREDIT-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. Bhattacharaya and S.K.Jain, Basic Abstract Algebra.
2. J. B. Fraleigh, A First Course in Abstract Algebra.
3. J. A. Gallian, Contemporary Abstract Algebra.
4. I. N. Herstein, 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: MM 15102CR	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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.

CREDIT-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.

CREDIT-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.

CREDIT-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: MM 15103CR	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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.

CREDIT-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 \mathbb{R} .

CREDIT-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.

CREDIT-IV

Heine-Borel theorem, Tychonoff'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 ($i = 1, 2, 3, 3\frac{1}{2}, 4$) and their permanence properties, connectedness, local connectedness, their relationship and basic properties, connected sets in \mathbb{R} ,

Urysohn's lemma, Urysohn's metrization theorem, Tietze'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 MATRICES

Course No. MM 15104DCE	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

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 $P^{-1}AP = P^TAP$ 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 $|A| \leq a_{11} a_{22} \dots a_{nn}$.

UNIT IV

Gram matrices: the Gram matrix BB^T 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 $|B| \leq \prod_{i=1}^n [\sum_{k=1}^n b_{ik}^2]$, 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 $0 \leq \lambda \leq 1$,

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. MM 15105DCE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

Division algorithm, 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, sequence of primes, Euclid's second theorem, infinitude of primes of the form $4n+3$ and of the form $6n+5$, congruences, complete residue system (CRS), reduced residue system (RRS) and their properties, Fermat and Euler's theorems with applications, Euler's ϕ -function, $\phi(mn) = \phi(m)\phi(n)$ where $(m, n) = 1$, Wilson's theorem and its application to the solution the congruence of $x^2 \equiv -1 \pmod{p}$.

CREDIT-II

Solutions of linear congruence's, Chinese Remainder theorem, congruences of higher degree $F(x) \equiv 0 \pmod{m}$, where $F(x)$ is a polynomial, congruences with prime power, congruences with prime modulus and related results, Lagrange's theorem, factor theorem and its generalization, polynomial congruences $F(x_1, x_2, \dots, x_n) \equiv 0 \pmod{p}$ in several variables, equivalence of polynomials, Chevalley's theorem, Warning's theorem, quadratic forms over a field of characteristic $\neq 2$, equivalence of quadratic forms, Witt's theorem, representation of Field Elements, Hermite's theorem.

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 Apostol, 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.

ADVANCED CALCULUS

Course No. MM 15106DCE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

Functions of several variables in \mathbb{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.

CREDIT-II

Sufficient conditions for differentiability and for the equality of mixed partials, Taylor's theorem for functions from \mathbb{R}^n and \mathbb{R} , inverse and implicit function theorem in \mathbb{R}^n , extremum problems for functions on \mathbb{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.

PROBABILITY THEORY

Course No. MM 15107DCE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

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.

INTRODUCTION TO REAL ANALYSIS

Course No. MM 15108GE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

Review of real numbers, countable and uncountable sets, countability of rationals and uncountability of reals, bounded and unbounded sets, lub and glb of a set, sequences and their limits, bounded and monotonic sequences, convergent and divergent sequences, limit inferior and limit superior, infinite series and their convergence and divergence, tests of convergence of positive term series.

CREDIT-II

Continuity, differentiability and integrability of real functions, properties of continuous functions in a closed interval, derivatives and integrals of some special functions, continuity, differentiation and integration of sum, difference, product and quotient of functions, Rolle's theorem and its applications, Mean value theorem, expression of a function as a series.

NUMERICAL METHODS

Course No. MM 15109GE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-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.

CREDIT-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. MM 151100E	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-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.

CREDIT-II

Indefinite integral, techniques of integration, definite integral, area of a bounded region, applications of integration, velocity and net change, region between curves, volume by slicing, volume by shells, length of curves, physical applications.

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, Integral Calculus, Kapoor Publications.
4. R.K.Jain and S.R.K. Lyengar, Advanced Engineering Mathematics, Narosa.

INTRODUCTION TO NUMBERS

Course No. MM 15111OE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

Number system, basic binary operations, ordering of integers, well ordering principle, principle of mathematical induction, radix representations, divisibility, greatest common divisor (gcd), least common multiple (lcm) and their properties, pigeonhole principle.

CREDIT-I

Prime and composite numbers, relatively prime numbers, infinitude of prime numbers, primes of different forms, perfect numbers, fundamental theorem of arithmetic, congruence's and their properties.

Recommended Books:

1. W.J.Leveque, Topics in Number Theory, Addison Wesley Publishing Company.
2. Ivan Niven & H.S.Zuckerman, An introduction to the Theory of Numbers, Wiley Eastern Ltd.
3. G.H.Hardy & E.M.Wright, An introduction to the Theory of Numbers, Oxford University Press 1954.
4. H.N.Wright, First Course in Theory of Numbers, John Wiley & Sons, New York 1939.

SEMESTER-II

DISCRETE MATHEMATICS

Course No: MM 15201CR	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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.

CREDIT-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.

CREDIT-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.

CREDIT-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.

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.

REAL ANALYSIS - II

Course No: MM 15202CR	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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.

CREDIT-II

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

CREDIT-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.

CREDIT-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 15203CR	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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.

CREDIT-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, Rouché's theorem and its applications.

CREDIT-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.

CREDIT-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.

THEORY OF NUMBERS -II

Course No: MM 15204DCE	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-I

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

CREDIT-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.

CREDIT-III

Number theoretic functions, some simple properties of $\tau(n), \sigma(n), \phi(n)$ and $\mu(n)$. 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 $\tau(n), \sigma(n), \phi(n)$, Farey fractions, rational approximation.

CREDIT-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.

FOURIER ANALYSIS

Course No: MM 15205DCE	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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.

CREDIT-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.

CREDIT-III

The Fourier Transforms

Definition and examples of Fourier transforms in $L^1(\mathbb{R})$, basic properties of Fourier transforms, Fourier transforms in $L^2(\mathbb{R})$, Convolution theorem, Plancherel's and Parseval's formulae, Poisson summation formula, Shannon-Whittaker sampling theorem, Discrete and fast Fourier transforms with examples.

CREDIT-IV

Applications of Fourier Transforms

Application of Fourier transforms to the central limit theorem in mathematical statistics, solution of ordinary differential equations and integral equations using Fourier transforms, applications of Fourier transforms to Dirichlet's problem in the half-plane, Neumann's problem in the half-plane and Cauchy's problem for the diffusion equation.

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.

OPERATION RESERACH

Course No: MM 15206DCE	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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.

CREDIT-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.

CREDIT-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.

CREDIT-IV

Game theory: Two person zero sum games, games with pure strategies, games with mixed strategies, Min. Max. principle, dominance rule, finding solution of 2×2 , $2 \times m$, $2 \times n$ 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.

NUMERICAL ANALYSIS

Course No. MM 15207DCE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

Examples from ODE where analytical solution are difficult or impossible, examples from PDE where analytical solution are difficult or impossible, numerical solution of ordinary differential equations, initial value problems- Picard's and Taylor series methods – Euler's Method- Higher order Taylor methods, Modified Euler's method- Runge-Kutta methods of second and fourth order.

CREDIT-II

Boundary- value problems –finite difference method, forward, backward and central difference methods, second order finite difference and cubic spline methods. numerical solution of Partial differential equations, difference methods for elliptic partial differential equations – difference schemes for Laplace and Poisson's equations, difference methods for parabolic equations in one-dimensional system.

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.
3. D.V. Griffiths and I.M. Smith, Numerical Methods for Engineers, Blackwell Scientific Publications (1991).

BIO-MATHEMATICAL MODELLING

Course No. MM 15208DCE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-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.

CREDIT-II

Mathematical models in ecology and epidemiology: models for interacting populations, types of interactions, Lotka-Volterra 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 15209DCE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-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.

CREDIT-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 Recommended:

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.

COMPLEX VARIABLES

Course No. MM 15210GE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

Review of complex numbers, De-Moivre's theorem and its 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.

CREDIT-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 Laurent's theorems (statements only), classification of singularities, zeros of analytic functions, argument principle, Rouché's theorem and its applications.

Books Recommended:

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

RIEMANN INTEGRATION

Course No. MM 15211GE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

Bounded functions, partition of an interval, upper and lower Riemann sums, refinement of a partition, behavior of upper and lower sums under a refinement, upper and lower Riemann integrals, definition and existence of R-integral, necessary and sufficient condition for R-integrability of a bounded function, R- integrability of sum, difference, product and quotient of two functions.

CREDIT-II

R- integrability of continuous and monotonic functions, R- integrability of functions having a finite number of discontinuities, If f is R- integrable over $[a,b]$, then so is $|f|$ and $\left| \int_a^b f(x)dx \right| \leq \int_a^b |f(x)| dx$, indefinite integral of an R-integrable function and its properties, fundamental theorem of integral calculus, mean value theorems for integrals.

Books Recommended:

1. S.C.Malik, Mathematical Analysis.
2. S.M.Shah & Saxena, Real Analysis.
3. W.Rudin, Principles of Mathematical Analysis.

BASIC GRAPH THEORY

Course No. MM 15212GE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

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, EDT, degree sequences and their characterizations, degree sets.

CREDIT-II

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, Vertex connectivity, edge connectivity, Whitney's theorem, Planar graphs, Kuratowski's two graphs, Euler's formula, Incidence matrix $A(G)$, cycle matrix $B(G)$, fundamental cycle matrix B_f , cut-set matrix $C(G)$, adjacency matrix, matrix tree theorem, types of digraphs.

Books Recommended:

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, OrientBlackswan, 2012
6. W. T. Tutte, Graph Theory, Cambridge University Press
7. D. B. West, Introduction to Graph Theory, Prentice Hall

MATRIX ALGEBRA

Course No. MM 152130E	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-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.

CREDIT- 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

- 5 Franz E. Hohn, Elementary Matrix Algebra, American Publishing company Pvt.ltd.
- 6 Shanti Narayan, A Text Book of Matrices, S. Chand and company Ltd.
- 7 Rajendra Bhatia , Matrix Analysis Springer.
- 8 A.Aziz, N.A.Rather and B.A.Zargar, Elementary Matrix Algebra , KBD.

ELEMENTARY DIFFERENTIAL EQUATIONS

Course No. MM 15214OE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

Introduction: order and degree of a differential equation, formation and solution of a differential equation, variable separable method, homogeneous and Bernoulli's differential equations, exact differential equations, integrating factors, linear differential equations with constant coefficients, particular integrals.

CREDIT-I

Applications of first order differential equations, growth and decay, dynamics of tumor growth, radioactivity and carbon dating, Newton's law of cooling, second order differential equations, diffusion equation including Laplace, Heat and wave equations.

Recommended Books:

1. Zafar Ahsan, Differential Equations and Their Applications, second edition, PHI, New Delhi.
2. H.T.H. Piaggio, Differential Equation, PHI New Delhi.
3. K.S.Rawat, Differential Equations, Sarup and Sons, New Delhi.

SEMESTER-III

ORDINARY DIFFERENTIAL EQUATIONS

Course No: MM 15301CR	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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.

CREDIT-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 $Pdx + Qdy + Rdz = 0$.

CREDIT-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.

CREDIT-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.
5. D. Somasundaram, Ordinary Differential Equations, Narosa Publishers, New Delhi.

COMPLEX ANALYSIS-II

Course No: MM 15302CR	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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 $\arg(z)$, $\text{Log } z$ and z^n , Blaschke's theorem.

CREDIT-II

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

CREDIT-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.

CREDIT-IV

Functions with positive real part, Borel's theorem, univalent functions, area theorem, Bieberbach's conjecture (statement only) and Koebe's $\frac{1}{4}$ 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. Titchmarsh, 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. Markushevich, Theory of Functions of a Complex Variable.

FUNCTIONAL ANALYSIS-I

Course No: MM 15303CR	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

BANACH SPACE:

CREDIT-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_0 , l_p ($p \geq 1$), $C[a, b]$.

CREDIT-II

Uniform boundedness, principle and weak boundedness, dimension of an ∞ -dimensional Banach space, conjugate of a continuous linear operator and its properties, Banach-Steinhaus theorem, open mapping and closed graph theorems, counterexamples to Banach-Steinhaus, 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_0 , $C[0, 1]$, l_p , $p \geq 1$), reflexive Banach Spaces, closed subspace and the dual of a reflexive Banach space, examples of reflexive and non-reflexive Banach spaces.

CREDIT-III

HILBERT SPACE:

Hilbert spaces: definition and examples, Cauchy's Schwartz inequality, parallelogram 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.

CREDIT-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.

ADVANCED GRAPH THEORY

Course No: MM 15304DCE	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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

CREDIT-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 implies 1-factor theorem, Erdos- Gallai theorem follows from f-factor theorem, degree factors, k -factor theorem, factorization of K_n .

CREDIT-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.

CREDIT-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 15305DCE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

Semiring, algebra and σ -algebra of sets, Borel sets, measures on semirings, 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

Improper Riemann integral as a Lebesgue integral, calculation of some improper Riemann integrable functions, Riemann Lebesgue lemma, product measures and iterated integrals, examples of non-integrable functions whose iterated integrals exist, Fubini theorem.

Recommended Books:

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

References:

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

MATHEMATICAL BIOLOGY

Course No: MM 15306DCE	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-I

Diffusion in biology: Fick's law of diffusion, Fick's perfusion law, membrane transport, diffusion through a slab, convective transport, transcapillary 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.

CREDIT-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, Poiseuille's flow and its applications, the pulse wave.

CREDIT-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.

CREDIT-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 15307DCE	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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 $L^2(\mathbb{R})$.

CREDIT-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.

CREDIT-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.

CREDIT-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).

LINEAR ALGEBRA

Course No: MM 15308DCE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

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

CREDIT-II

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

Books Recommended:

1. Robert 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.

ELEMENTARY LINEAR ALGEBRA

Course No: MM 15309GE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

Linear spaces, Euclidean space, unitary space, orthonormal basis, Gram-Schmidt orthogonalization process, linear transformation infinite dimensional spaces, matrix of linear, rank and nullity, annihilator of a subset of a vector space, eigen vectors, spaces spanned by eigen vectors, similar and congruent matrices.

CREDIT-II

Characteristic polynomial, minimal polynomial, diagonalization, diagonalization of symmetric and Hermitian matrices, Cayley-Hamilton theorem, reduction of a matrix to normal form, Jordan canonical form, quadratic form, reduction to normal form, Sylvester's law of inertia, simultaneous reduction of two quadratic forms, applications to geometry and mechanics.

Books Recommended:

1. P. M. Cohn, Basic algebra.
2. S. Lang, Algebra.
3. S. Lang, Linear Algebra.
4. Hoffman & Kunze, Linear Algebra, Prentice Hall.
5. Rao and Bhimsankaran, Linear Algebra.
6. S. Kumareson, Linear Algebra.

LATTICES AND BOOLEAN ALGEBRA

Course No: MM 15310GE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

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).

INTRODUCTION TO MATHEMATICAL MODELLING

Course No: MM 15311OE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-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.

CREDIT-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 Gershenfeld : 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.

COMPLEX INTEGRATION

Course No: MM 15312OE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

Curves in the complex plane, properties of complex line integrals, Cauchy's integral theorem (without proof) and its applications, Cauchy's integral formulae, consequences of simply connectivity, Morera's theorem, Taylor's theorem, zeros of analytic functions, Laurent's theorem and classification of singularities.

CREDIT-I

Calculus of residues, residue at a finite point, residue of infinity, Cauchy's residue theorem, evaluation of integrals of the type $\int_0^{2\pi} R(\cos \theta, \sin \theta) d\theta$,

$\int_{-\infty}^{\infty} f(x) dx$, $\int_{-\infty}^{\infty} f(x) \cos mx dx$ and of the functions having singularities on the real axis.

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.
7. A.I. Markushevish, Theory of Functions of a Complex Variable.

SEMESTER-IV

PARTIAL DIFFERENTIAL EQUATIONS

Course No: MM 15401CR	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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.

CREDIT-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.

CREDIT-III

Derivation of Laplace and heat equations, boundary value problems, Dirichlet'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.

CREDIT-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

DIFFERENTIAL GEOMETRY

Course No: MM 15402CR	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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.

CREDIT-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.

CREDIT-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 $K(p) = (eg-f^2)/EG-F^2$, 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.

CREDIT-IV

Christoffel symbols, expressing Christoffel symbols in terms of metric coefficients and their derivative, Theorema egregium (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 15403CR	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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.

CREDIT-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.

CREDIT-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.

CREDIT-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, \mathbb{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 Algebra.
3. Surjeet Singh and Qazi Zameer-ud-din, Modern Algebra, Vikas Publishers Pvt. Limited.

ANALYTIC THEORY OF POLYNOMIALS

Course No: MM 15404DCE	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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.

CREDIT-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 Jensen's theorem, extensions of Jensen's theorem.

CREDIT-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, L^p analogous of Markov's inequality.

CREDIT-IV

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

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 15405DCE	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-I

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

CREDIT-II

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

CREDIT-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.

CREDIT-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 Graybill, 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 15406DCE	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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, complementability of dual of a Banach space in its bidual, uncomplementability of c_0 in l_∞ .

CREDIT-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, Banach's closed range theorem, injective and surjective bounded linear mappings between Banach spaces.

CREDIT-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 $L_p[a,b]$, extreme points, Krein-Milman theorem and its simple consequences.

CREDIT-IV

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

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 Baggett, Functional Analysis, A Primer (Chapman and Hall, 1991).

References:

1. B. Bollobas, 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 15407DCE	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-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

CREDIT-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

CREDIT-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 .

CREDIT-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.

Recommended Books:

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.

References:

1. I. Eklund 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 15408DCE	Max. Marks:	100
Duration of Examination: 2:30 Hrs.	External Exam:	80
No. of Credits: 04	Internal Assessment:	20

CREDIT-I

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

CREDIT-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.

CREDIT-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.

CREDIT-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.

LATEX AND MATLAB

Course No: MM 15409DCE	Max. Marks:	50
Duration of Examination: 2:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

LateX

Purpose and nature of LateX, LateX workflow, LateX philosophy and user interface, advantages over word processors, basic text formatting, equation formatting, introduction to TeX programming, insertion and deletion of mathematical formulae in LateX, formation of graphics in LateX, creating power point of LateX file.

CREDIT-II

MATLAB

Introduction to MATLAB, basic features, array and array operations: simple array, array construction and orientation, array mathematics, standard arrays, manipulation and sorting, multidimensional arrays: array construction, array mathematics and manipulation, relational and logical operations, control flow, functions, matrix algebra: sets of linear equations, matrix functions, special matrices, data analysis and statistical functions, polynomials: roots, multiplications, addition, division, derivatives and integral evaluation.

Recommended Books:

1. Helmut and Partik W.Daly, Guide to LateX.
2. M.Goossens, F.Mittelbach, S.Rahtz, D.Roegel and H.Voss, The Latext Graphics Companion, 2nd Edition.
3. Duane Hanselman, Mastering MATLAB, Bruce Little field.
4. Stormy Attaway, MATLAB, A Practical Approach.

PROJECT

Course No: MM 15410DCE	Max. Marks:	50
Duration of Examination: 2:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

LAPLACE TRANSFORMATIONS

Course No: MM 15411GE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

Laplace transform-definition, Laplace transform of some elementary functions, piecewise continuity, functions of exponential order, sufficient conditions for existence of Laplace transform, linearity property, first and second translation (shifting property), Laplace transform of derivatives, Laplace transform of integrals, periodic functions, initial and final value theorems and their generalizations, methods of finding Laplace transform, differential equations, evaluation of integrals, the Gamma function, Bessel functions, the error function, sine and cosine integrals, exponential integral, unit step function, Dirac delta function, null functions, Laplace transform of special functions.

CREDIT-II

Definition and uniqueness of inverse Laplace transform, Lerch's theorem, some inverse Laplace transform, some properties of 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, the beta function, evaluation of integrals, ordinary differential equations with constant coefficients and with variable coefficients, simultaneous ordinary differential equations,

Recommended Books:

1. Murrey R. Spiegel, Laplace Transforms, Schaum's outline series.

FOURIER TRANSFORMATIONS

Course No: MM 15412GE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

Credit I

Introduction, periodic functions, Fourier series, Dirichlet's conditions, determination of Fourier coefficients, even and odd functions and their Fourier expansion, change of interval, half range series, simple applications of the transform to one dimensional problems, Harmonic analysis.

Credit II

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, applications of Fourier transform in partial differential equations with special reference to heat and wave equation.

Recommended Books:

1. I. N. Sneddon: The use of Integral Transforms, McGraw-Hill, Singapore 1972.
2. R. R. Goldberg, Fourier Transforms, Cambridge University Press, 1961.
3. D. Brain, Integral Transforms and their applications, Springer, 2002
4. L. Debnath and F. A. Shah, Wavelet Transforms and their applications, Springer, 2015.

APPLIED GROUP THEORY

Course No: MM 154130E	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT I

Basic concepts of relations and functions, binary operation, types and properties of functions, groups, sub-groups, normal subgroups, Cyclic groups and their properties; Homomorphism and Isomorphism, permutation groups, cosets and Lagrange and Cayley's theorems (statements only), Quotient groups and the homomorphism theorem, action of groups on sets, applications of groups through geometric patterns.

CREDIT II

Alternating groups and their properties, symmetry groups in Euclidean space, motivation, isometries of n-space, the finite subgroups, representation theory, linear representations of groups, decomposing displacements, some compact lie groups and their representations, some examples of Lie groups, representation theory of compact Lie groups.

Recommended Books:

1. G. Birkhoff and T. C. Bartee, Modern Applied Algebra, Mc-Graw Hill.
2. Arjeh Cohen, Rosane Ushirobira and Jan Draisma, Group theory for Maths, Physics and Chemistry Students.
3. J. A. Gallian, Contemporary Modern Algebra.
4. Surjeet Singh and Qazi Zameer-ud-Din, Modern Algebra.
5. P. M. Cohn, Lie Groups.

MODULES AND VECTOR SPACES

Course No: MM 15414OE	Max. Marks:	50
Duration of Examination: 1:30 Hrs.	External Exam:	40
No. of Credits: 02	Internal Assessment:	10

CREDIT-I

Modules, sub modules, quotient modules, homomorphism and isomorphism theorems, cyclic modules, Schur's lemma, free modules, ascending chain combination and maximum condition, descending chain condition and minimum condition.

CREDIT-I

Vector spaces, subspaces, criterion for a subspace, sum, union and intersection of subspaces, quotient space, homomorphism and isomorphism, kernel of a homomorphism, fundamental theorem of homomorphism, linear space, linear dependence and linear independence, basis and dimension, dimensions of quotient space and sum of subspaces.

Recommended Books:

1. Surjeet Singh and Qazi Zameerudin, Modern Algebra, Eight Edition, Vikas Publishing House Pvt. Ltd. (2006).
2. P. B. Bhattacharya, S.K.Jain and J.R.Nagpal, Basic Abstract Algebra, Cambridge University Press (1995).
3. M. Artin, Algebra, Prentice Hall, Eaglewood Cliffs N.J. (1991).
4. P. M. Cohn, Algebra, Vols,1 &2, John Willey, New York, 1974,1977.