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Department of Mathematics
National Institute of Technology Srinagar

NO:NITS/MATH/25/300
Date: 19-05-2025

Dean Academic Affairs
NIT Srinagar

Kindly find DPGC minutes held on 28 April 2025 at 3:00PM in the Department of Mathematics for your necessary action.

19/05/2025

Dr. Zamrooda Jabeen
Head
Department of Mathematics

Department of Mathematics
National Institute of Technology Srinagar

NO: NITS/MATH/25/300
Dated: 28/04/2025

Minutes of the Meeting

A meeting of the Departmental Postgraduate Committee (DPGC) was held on April 28, 2025, at 3:00 PM in the conference room of the Department of Mathematics. The following members were present:

Dr. Zamrooda Jabeen - Chairperson, DPGC
Prof. Abdul Liman - Convenor, DPGC
Prof. Kowsar Majid - Member (Sister Department)
Dr. Mehraj Ahmad Lone - Member
Dr. Rameez Raja - Member
Dr. Owais Ahmad - M. Sc. Coordinator
Dr. Atendra Kumar - Member
Ms. Nida Zehra - M. Sc Student (Member)

The following was discussed and resolved:

1. **Modifications in the Research Title of Mr. Annayat Ali.** The application of Mr. Annayat Ali, bearing Enrollment No. 2020PHSMTH005, for the modification of his Ph.D. research title was reviewed and deliberated upon in detail. Considering the ongoing research progress of the candidate, the Committee unanimously recommended the proposed change in the research title from **"On Ramanujan Hypergraphs and Other Combinatorial Structures"** to **"Combinatorial Invariants of Graphs Derived from Algebraic Structures"** and he will continue to work under the supervision of **Dr. Rameez Raja**.

2. **Ph.D. Admission of Mr. Suhail Ahmad Shah under INSPIRE Fellowship:** The Committee unanimously recommended the admission of **Mr. Suhail Ahmad Shah** to the Ph.D. program under the supervision of **Dr. Mushtaq Ahmad Bhat**, supported by the INSPIRE fellowship.

3. **Ph.D. Admission Cancellation of Mr. Shabir Ahmad Parry:** The Committee unanimously recommended the cancellation of Ph.D. admission of **Mr. Shabir Ahmad Parry**, who was enrolled under the supervision of **Dr. Idrees Qasim**.

4. **M.Sc. Mathematics (New Scheme and Syllabus)**: The Committee unanimously recommended for the adoption of the **revised scheme and syllabus for M.Sc. Mathematics**, effective from **Autumn 2025**. The Committee reviewed the proposed modifications presented by the faculty and endorsed the final version. The revised scheme and syllabus is enclosed herewith **(Annexure-I)**.

5. **Research Proposals of Ph.D. Research Scholars:** The list of scholars along with their research proposals for approval is enclosed herewith **(Annexure-II)**.

Nida Zehra (member)

Dr. Atendra Kumar
Member

5.5.2025

Dr. Owais Ahmad
M. Sc. Coordinator

Dr. Rameez Raja
Member

Dr. Mehraj Ahmad Lone
Member

Prof. Kowsar Majid
Member Sister Department

15/5/25

Prof. Abdul Liman
Convenor DPGC

Dr. Zamrooda Jabeen
Chairperson DPGC

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DEPARTMENT OF MATHEMATICS

NATIONAL INSTITUTE OF TECHNOLOGY SRINAGAR

SRINAGAR, J&K, INDIA-190006.

M.Sc. Mathematics

Revised Curriculum and Syllabi

(w.e.f. Autumn-2025)

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FIRST YEAR (SEMESTER I)						
S.No.	Course Code	Course Name	L	T	P	C
		CORE COURSES				
1.	MM- 101	Real Analysis	2	1	0	3
2.	MM- 102	Abstract Algebra	2	1	0	3
3	MM-103	Topology	2	1	0	3
4	MM- 104	Discrete Mathematics	2	1	0	3
5	MM- 105	Number Theory	2	1	0	3
		ELECTIVES (STUDENTS HAVE TO CHOOSE ANY ONE OUT OF THREE ELECTIVES)				
1.	MM-106	Probability and Statistics	2	1	0	3
2.	MM-107	Integral Equations and Calculus of Variations	2	1	0	3
3.	MM-108	C Programming	2	1	0	3
		Total Hrs./ Credits				18

L stands for *Lecture*; T stands for *Tutorial*; P stands for *Practical;* C stands for *Total credit.*

FIRST YEAR (SEMESTER II)						
S.No.	Course Code	Course Name	L	T	P	C
		CORE COURSES				
1.	MM- 201	Complex Analysis	2	1	0	3
2.	MM- 202	Linear Algebra	2	1	0	3
3.	MM-203	Ordinary Differential Equations	2	1	0	3
4.	MM- 204	Python Language	2	1	0	3
5.	MM- 205	Numerical Techniques using MATLAB	2	1	0	3
		ELECTIVES (STUDENTS HAVE TO CHOOSE ANY ONE OUT OF THREE ELECTIVES)				
1.	MM-206	Operations Research	2	1	0	3
2.	MM-207	Multivariable Calculus	2	1	0	3
3.	MM-208	Integral Transforms and their Applications	2	1	0	3
		LAB COURSES				
1.	MM-209	Python Language Lab	0	0	3	1.5
2.	MM-210	Numerical Techniques using MATLAB Lab	0	0	3	1.5
		Total Hrs./ Credits				21

SECOND YEAR (SEMESTER III)						
S.No.	Course Code	Course Name	L	T	P	C
		CORE COURSES				
1.	MM- 301	Functional Analysis	2	1	0	3
2.	MM-302	Measure Theory and Integration	2	1	0	3
3.	MM-303	Differential Geometry	2	1	0	3
4.	MM-304	Partial Differential Equations	2	1	0	3
		ELECTIVES (STUDENTS HAVE TO CHOOSE ANY TWO OUT OF SEVEN ELECTIVES)				
1.	MM-305	Advanced Complex Analysis	2	1	0	3
2.	MM-306	Advanced Graph Theory	2	1	0	3
3.	MM-307	Algebraic Combinatorics	2	1	0	3
4.	MM-308	Fourier Transforms and its Applications	2	1	0	3
5.	MM-309	Machine Learning using Python	2	1	0	3
6.	MM-310	Computational Fluid Dynamics	2	1	0	3
7.	MM-311	Module Theory	2	1	0	3
		Total Hrs./ Credits				18

SECOND YEAR (SEMESTER IV)						
S.No.	Course Code	Course Name	L	T	P	C
		CORE COURSES				
1.	MM- 401	Project Seminar	0	0	0	1
2.	MM-402	Project Work/Dissertation	0	0	0	8
		ELECTIVES (STUDENTS HAVE TO CHOOSE ANY THREE OUT OF NINE ELECTIVES)				
1.	MM-403	Polynomial Theory	2	1	0	3
2.	MM-404	Wavelet Analysis	2	1	0	3
3.	MM-405	Summability Theory	2	1	0	3
4.	MM-406	Optimization Techniques	2	1	0	3
5.	MM-407	Differentiable Manifolds	2	1	0	3
6.	MM-408	Coding Theory	2	1	0	3
7.	MM-409	Fundamentals of Data Science	2	1	0	3
8.	MM-410	Algebraic Geometry: Ideals, Varieties and Dimensions	2	1	0	3
9	MM-411	Advanced Functional Analysis	2	1	0	3
		Total Hrs./ Credits				18

CREDIT POINTS SUMMARY

SEMESTER	SEMESTER I	SEMESTER II	SEMESTER III	SEMESTER IV	TOTAL
CREDITS	18	21	18	18	75

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (First Sem.)	Real Analysis	MM-101	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Riemann Integral, Definition of upper and lower Riemann integrals, Necessary and sufficient conditions for Rieman integrability, Definition and existence of the Riemann-Stieltjes integral, upper and lower sums, integrals. Refinement of the partition. Necessary and sufficient conditions for Riemann-Stieltjes integrability. Some properties of the Riemann-Stieltjes integrals. The integral as a limit of a sum. R-S integrability of continuous and monotonic functions, reduction of the R-S integral of the Riemann integral. First and second Mean value theorems. Change of variables.	14
Module 2	Improper integrals: integration of the unbounded functions with a finite limit of integration. Comparison of tests for convergence of improper integrals. Cauchy's test for convergence. Absolute convergence. An infinite range of integration of the bounded functions. Convergence of integrals of unbounded functions with infinite limits of integration. Integration as a product of functions. Abel's and Dirchlet's test for convergence.Arithmetic Mean- Geometric mean inequality, Cauchy-Schwarz inequality, Chebyshev's inequality, Holder's and Minkowski inequality, convex and concave functions, Jensen's inequality, Bernoulli's inequality, some applications involving inequalities.	14
Module 3	Uniform convergence of sequence and series of functions" pointwise convergence, uniform convergence on an interval, Cauchy's criterion for uniform convergence, Mn-test for uniform convergence of sequences, Weirestrass's M-test, Abels's and Dirchlet's test for uniform convergence of series. Uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation, Weirestrass Approximation Theorem.	14

Text Books :

1. W. Rudin, Principles of Mathematical Analysis, Third Edition, Mc-GrawHill, 1976.
2. R. Goldberg, Methods of Real Analysis, John Wiley & Sons, 1976.
3. T. M. Apostol, Mathematical Analysis, Narosa Publishing House, 2004.

Reference Books:

1. S. C. Malik, Mathematical Analysis, Wiley Eastern Limited Urvashi, Press, 1983, Meerut.
2. B. J. Venkatachala, Inequalities- An approach Through Problems, Hindustan Book Agency (India), 2009.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (First Sem.)	Abstract Algebra	MM-102	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Review of groups, Group homomorphism, Normal subgroups, Lagrange's theorem, Quotient groups, Cauchy's theorem, Symmetric groups, Dihedral groups, Semidirect product, Group action, orbits and stabilizers, Cayley's theorem, Class equations Sylow's Theorems and their applications, Free groups.	14
Module 2	Introduction to rings, Ideals, Isomorphism theorems, Prime and maximal ideals, local rings, Localization, Radical ideals, Nil radical, Jacobson radical, Integral domains, field of fractions, Euclidean Domains, Principal Ideal Domains, Unique factorization domains, Gauss lemma, Eisenstein's irreducibility criterion.	14
Module 3	Field Extensions, Finite and Algebraic Extensions. Splitting Fields, Separable and inseparable extensions. Characterization of finite fields, polynomials over finite fields, Cyclotomic polynomials and Extensions.	14

Text Books:

1. I. N. Herstein, Topics in Algebra, Wiley India Pvt. Ltd., 2nd Edition, 2006.
2. M. Artin, Algebra, Pearson, 2nd Edition, 2011.

Reference Books:

1. D. S. Dummit and R. M. Foote, Abstract Algebra, Wiley, 3rd Edition, 2004.
2. J. B. Fraleigh, A First Course in Abstract Algebra, Pearson, 7th Edition, 2002

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year(First Sem.)	Topology	MM-103	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Metric Spaces: Definitions and examples, open and closed sets, convergence and completeness, continuous mappings, spaces of continuous functions. Topological Spaces: Definition and examples, elementary concepts, open bases and open subbases, weak topologies.	16
Module 2	Compactness: Definition and examples, compact spaces, product of spaces, Tychnoff's theorem and locally compact spaces, compactness for metric spaces, Ascolis theorem. Seperation: Definition and examples, T1 spaces and Hausdroff spaces, completely regular spaces and normal spaces, Urysohn's lemma and Tietze theorem, Urysohn's imbedding theorem, Stone-Cech compatification.	16
Module 3	Connectedness: Definitions and examples, connected spaces and properties, the component of space, locally connected spaces, totally disconnected spaces.	10

Text Books :

1. G.F. Simmons, Toplology and modern analysis, McGraw Hill Book company, 2014.
2. J. Munkres, Topology, Pearson Publication, 2nd Edition, 2021.

Reference Books:

1. J. L. Kelley, General Topology, Third Edition, Springer, 2012.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (First Sem.)	Discrete Mathematics	MM-104	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Partially ordered sets and Combinatorics: Partially ordered set, Digraph associated to a poset, Hasse Diagram, Extremal elements of a poset, Isomorphism, Lattices, Basic properties of lattices, Distributive, complemented and modular lattices, Solving linear homogeneous and nonhomogeneous recurrence relations, Generating functions.	14
Module 2	Graphs: Basic definitions, Isomorphism, Some basic graphs, Konigsberg seven bridge problem, Bipartite graphs and their characterization, Eulerian graphs and their characterization, Hamiltonian graphs and Dirac's theorem, Degree sequences, Havel-Hakimi criterion, Wang Kleitman criterion, Connectivity and Planar graphs.	14
Module 3	Trees and their properties, Cayley's theorem, Adjacency matrix of a graph, powers of adjacency matrix and counting walks, Incidence matrix, Laplacian matrix and its basic properties like rank and positive semi-definiteness, Spanning tress and matrix tree theorem. Applications of matrix tree theorem. Directed graphs, Eulerian and Hamiltonian digraphs, Tournaments, Redei's Theorem and Camion's Theorem.	14

Text Books:

1. N. Biggs, Algebraic Graph Theory, 2nd Edition, Cambridge University Press (1993).
2. S. Pirzada, An Introduction to Graph Theory, The Orient Blackswan (2012).

Reference Books

1. K. Rosen, Discrete Mathematics and its Applications, 8th Edition McGraw Hill (2021).
2. D. West, Introduction to Graph Theory, 2nd Edition, Pearson Education (2015).

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (First Sem.)	Number Theory	MM-105	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Prime numbers, Euclid's first theorem, factorization in primes, Fundamental Theorem of Arithmetic, Linear Diophantine Equations; Necessary and Sufficient condition for solvability of linear Diophantine equations. Infinitude of primes, discussion of the Prime Number Theorem, infinitude of primes in specific arithmetic progressions, Dirichlet's theorem (without proof).	14
Module 2	Arithmetic functions, Mobius inversion formula. Structure of units modulo n Euler's phi function. Congruences, theorems of Fermat and Euler, Wilson's theorem, linear congruences, quadratic residues, law of quadratic reciprocity.	14
Module 3	Chinese remainder theorem, polynomial congruences. Binary quadratic forms, equivalence and reduction, Fermat's two square theorem, Langrage's four square theorem. Continued fractions, rational approximations, Liouville's theorem, transcendental numbers, transcendence of e and pi.	14

Text Books:

1. I. Niven and H. S. Zuckerman, An Introduction to the Theory of Numbers, 5th Edition, Wiley Eastern, 2000.

2. A. Baker, A Concise Introduction to the Theory of Numbers, Cambridge University Press, 1984.

Reference Books:

1. G. E. Andrews, Number Theory, Hindustan Publishing Corporation, New Delhi, 1992

2. W. W. Adams and L. J. Goldstein, Introduction to the Theory of Numbers. 3rd Edition, Wiley Eastern, 1972.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (First Sem.)	Probability and Statistics	MM-106	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Random variables, change of variables, probability distributions of random variables, Moments, moment generating function, characteristics function, standard discrete and continuous distributions, two dimensional random variables, conditional expectation, Chebyshev's inequality, Law's of large numbers, convergence in probability. Sampling, Types of sampling, parameters and statistic, tests of significance, procedure for testing of hypothesis, tests of significance large samples, sampling of attributes, sampling of variables, sampling distributions of Chi, F and Z.	14
Module 2	Unbiased estimates and efficient estimates, estimates and interval estimates, reliability, confidence interval estimates of population parameters, confidence interval for mean, confidence interval for proposition, confidence interval for the variance of a normal distribution, confidence interval for variance ratios, maximum likelihood estimation, methods of minimum variance, method of moments and least squares	14
Module 3	Statistical hypothesis, null hypothesis, tests of hypothesis and significance, critical region, level of significance, Type I and Type II errors, power of test, analysis of variance, one way and two way classification.	14

Text Books :

1. Mood, A.M, Graybill F.A and Boes D.C. Introduction to the Theory of Statistics. McGraw Hill, New Delhi, 2008.

Reference Books:

1. James, G., Witten, D., Hastie, T. and R. Tibshirani. An Introduction to Statistical Learning: with Applications in R. Springer, 2013.
2. Hogg, R., Tanis, E. and Zimmerman, D. Probability and Statistical Inference. Pearson Education India, 2019.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (First Sem.)	Integral Equations and Calculus of Variations	MM-107	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Linear Integral equations, Some basic identities, Initial value problems reduced to Volterra integral equations, Methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, Iterated kernels and Neumann series for Volterra equations. Resolvent kernel as a series. Laplace transform method for a difference kernel. Solution of a Volterra integral equation of the first kind.	15
Module 2	Boundary value problems reduced to Fredholm integral equations, Methods of successive approximation and successive substitution to solve Fredholm equations of second kind, Iterated kernels and Neumann series for Fredholm equations. Resolvent kernel as a sum of series. Fredholm resolvent kernel as a ratio of two series. Fredholm equations with separable kernels.	15
Module 3	Motivating problems of calculus of variations, Shortest distance, Minimum surface of resolution, Brachistochrone problem, Isoperimetric problem, Geodesic. Fundamental lemma of calculus of variations, Euler equation for one dependant function and its generalization to 'n' dependant functions and to higher order derivatives. Conditional extremum under geometric constraints and under integral constraints.	12

Text Books :

1. Jerri, A.J., Introduction to Integral Equations with Applications, A Wiley-Interscience Publication, 1999.

Reference Books:

1. Kanwal, R.P., Linear Integral Equations, Theory and Techniques, Academic Press, New York, 2017.

2. Gelfand, J.M., Fomin, S.V., Calculus of Variations, Prentice Hall, New Jersey, 1963.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (First Sem.)	C Programming	MM-108	2-0-2-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Programming and Programming Languages, Flowchart, The C Programming Language, Identifiers, Symbolic Constants, Declarations, Arithmetic Operations, Relational and Logical Operations, If-Else, Conditional Expression, Switch, While Loops, Do-While Loops.	14
Module 2	For Loops, Break and Continue, Goto, Function Prototypes, Call by reference, Call by arguments, recursive function, inline function. What is a Pointer? Pointer Syntax, Pointers and Arrays, Pointer Arithmetic, Return Values and Pointer, Pointers to Pointers, Function Pointers, Dynamic Memory allocation.	14
Module 3	Array Initialization, Character Arrays and Strings, Strings and the Standard Library, Arrays of Pointers, Multi-dimensional Arrays. Formatted IO: printf, scanf, string formatting; File IO: Opening and Closing Files, Standard IO, Sequential File Operations.	14

Text Books:

1. V. Rajaraman, COMPUTER PROGRAMMING IN C, PHI Learning (2004).
2. E. Balagurusamy, Programming In Ansi C, 3rd edition, Tata McGraw-Hill Publication, New Delhi, 2004.
3. Brian W. Kernighan, The C Programming Language (Ansi C Version), PHI; 2 edition (1990).

References Books:

1. D.M. Ritchie, S.C. Johnson, M.E. Lesk, B.W. Kernighan, The C programming language. Bell Sys. Tech. J. 1978.
2. Oualline S. Practical C programming, O'Reilly Media, Inc., 1997.
3. S.G. Kochan, Programming in C, Pearson education, 2015.

Atendra G

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (Second Sem.)	Complex Analysis	MM-201	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	A review of functions of a complex variable, Limits, Continuity, Differentiability, Cauchy-Riemann Equations and their applications, Analytic function, Harmonic function, The functions like e^z, $\sin z$, $\cos z$ and the complex logarithm. Contour integral, Cauchy's theorem, Cauchy- Goursat's theorem, Cauchy's integral formula, Higher order derivatives, Morera's theorem, Cauchy's inequality, Liouville's theorem and its applications.	17
Module 2	Power Series, Radius of convergence of a power series, Cauchy's-Hadamard formula for finding radius of convergence, Taylor theorem, Taylor's series, Expansion of analytic functions in a power series, Laurent's series, Singular Points, Isolated singularities, Poles and essential singular points, Behavior of functions at infinity. Residues: Cauchy's residue theorem and its applications, Calculation of residues, Evaluation of definite integrals by the method of residues.	15
Module 3	Bilinear transformations- Properties and Classification, Fixed Points, Cross ratios, Inverse points and Critical points. Mappings of: Upper half plan on to unit disc, Unit disc onto unit disc, left half plan on to unit disc, Circle onto circle.	10

Text Books:

1. L. Ahlfors, Complex analysis, Third edition, McGraw Hill Publication, Third edition, 2017.
2. Brown and Churchill, Complex Variables and Applications, eighth edition, Mc Graw Hill, 8th edition, 2017.
3. S. Ponnusamy, Foundations of Complex analysis, second edition, Narosa publication, Edition, 2022.
4. J.B. Conway, Functions of a complex variable-I, Springer-Verlag New York Heidelberg Berlin, 2nd edition, 1978.

Reference Books:

1. E.C. Titchmarsh, Theory of functions, Second edition, Oxford Science Publication, 2nd Edition, 1976.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (Second Sem.)	Linear Algebra	MM-202	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Detail:

Module No.	Contents	Hours
Module 1	Vector spaces, Elementary Properties in Vector Spaces. Subspaces, Spanning Sets, Linear Independence, Dependence, Basis for a vector space, Dimensions of Sums of Subspaces, Linear Transformations, The Null Space and the Range Space of a Linear Transformation, The Rank-Nullity-Dimension Theorem. Isomorphisms Between Vector Spaces, Equality of the Row-rank and the Column-rank, The Matrix of a Linear Transformation, Matrix for the Composition and the Inverse. Similarity Transformation.	15
Module 2	Eigenvalues and Eigenvectors of Linear Operators, Diagonalization of Linear Operators, The Minimal Polynomial, The Cayley-Hamilton Theorem, Invariant Subspaces, Triangulability, Diagonalization in Terms of the Minimal Polynomial, Independent Subspaces and Projection Operators, Direct Sum Decompositions and Projection Operators, The Primary Decomposition Theorem and Jordan Decomposition.	13
Module 3	Inner Product Spaces, Norms on Vector spaces. The Gram-Schmidt Procedure, Bessel's Inequality, Parseval's Identity, Orthogonal Complementary Subspaces, Orthogonal Projections, Projection Theorem. Linear Functionals, The Adjoint Operator, Properties of the Adjoint Operation. Inner Product Space Isomorphism, Unitary Operators, Self-Adjoint Operators, Normal Operators.	14

Text Books:

1. S. Axler, Linear Algebra Done Right, Springer, 3rd Edition, 2015.

2. Hoffman and Ray Kunze, Linear Algebra, Prentice-Hall (Pearson), 2nd Edition, 1971.

Reference Books:

1. S. H. Friedberg, Arnold J. Insel, and Lawrence E. Spence, Linear Algebra, Pearson, 4th Edition, 2003.
2. G. Strang, Linear Algebra and Its Applications, Cengage Learning, 4th Edition, 2006.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (First Sem.)	Ordinary Differential Equations	MM-203	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Linear equations with constant coefficients second order homogeneous equations - Initial value problems - Linear dependence and independence- Wronskian and a formula for Wronskian-Non-homogeneous equation of order two - Homogeneous and non-homogeneous equation of order n – Initial value problems- Annihilator method to solve the non-homogeneous equation- Algebra of constant coefficient operators.	14
Module 2	Initial value problems -Existence and uniqueness theorems – Solutions to solve a nonhomogeneous equation – Wronskian and linear dependence – reduction of the order of a homogeneous equation – homogeneous equation with analytic coefficients- Legendre equation. Euler equation – Second order equations with regular singular points –Exceptional cases – Bessel Function.	14
Module 3	Sturm-Liouville Problems, Eigenvalue Problems, Orthogonality of Characteristic Functions, The Expansion of functions in a series of orthonormal Functions. Existence and uniqueness of solutions to first order equations: Equation with variable separated – Exact equation – method of successive approximations – the Lipschitz condition – the convergence of the successive approximations and the existence theorem.	14

Text Books:

1. E.A. Coddington, An introduction to ordinary differential equations (3rd Printing) Prentice- Hall of India Ltd., New Delhi, 1987.
2. S. L. Ross, Differential Equations, 3rd Edition, Wiley India, 2004.

Reference Books:

1. G. F Simmons, Differential equations with applications and historical notes, Tata McGraw Hill, New Delhi, 1974.
2. Williams E. Boyce and Richard C. DI Prima, Elementary differential equations and boundary value problems, John Wiley and Sons, New York, 1967.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (Second Sem.)	Python Language	MM-204	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26	24	50

Course Details:

Module No.	Contents	Hours
Module 1	Data and types: int, float, boolean, string, list; variables, expressions, statements, simultaneous assignment, precedence of operators; comments; in-built modules and functions; Conditional: boolean values and operators, conditional (if), alternative (if-else), case analysis (if-elif-else).	15
Module 2	Iteration: while, for, break, continue, pass; functions: function definition, function call, flow of execution, parameters and arguments, return values, local and global scope, Strings: string slices, immutability, string functions and methods, string module.	13
Module 3	Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters, nested lists, list comprehension; Tuples: tuple assignment, tuple as return value, tuple operations. Dictionaries: operations and methods, looping and dictionaries, reverse lookup, dictionaries and lists; Files: Text files, reading and writing files, format operator, file names and paths.	14

Text Books:

1. Yashavant Kanetkar and Aditya Kanetkar, Let's Python, BPB, Third edition, 2021.
2. Zed Shaw, Learn Python the Hard Way, , Pearson Addison-wesley, First edition, 2017.

Reference Books:

1. Allen B. Downey, Think Python, O'Reilly, Second Edition, 2015.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Second Sem.)	Numerical Techniques using MATLAB	MM-205	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Approximate Numbers and Significant Digits, Propagation of errors, Different types of errors, Backward error analysis, Sensitivity and conditioning, Stability and accuracy. Nonlinear equations, Bisection method, Newton's method and its variants, Fixed point iterations, Convergence analysis.	14
Module 2	Finite differences, Polynomial interpolation, Hermite interpolation, Spline interpolation. Numerical integration, Trapezoidal and Simpson's rules, Newton-Cotes formula, Gaussian quadrature, Richardson extrapolation.	14
Module 3	Initial Value Problem (IVP): Taylor series method, Euler and modified Euler methods, Runge-Kutta methods, Multistep methods, Predictor-Corrector method. Boundary Value Problem (BVP): Solution of Boundary Value Problems by Finite Difference Method, Collocation method, MATLAB.	14

Text Books:

1. K. E. Atkinson, An Introduction to Numerical Analysis, 2nd Edition, John Wiley, 2008.
2. D. Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing, 3rd Edn., AMS, 2002.
3. A. Ralston, P. Rabinowitz, A first course in numerical analysis. Courier Corporation; 2001.

References Books:

1. S. D. Conte and Carl de Boor, Elementary Numerical Analysis - An Algorithmic Approach, 3rd Edn., McGraw Hill, 1980.
2. M.K. Jain, S.R. Iyengar, R.K. Jain, Numerical methods: problems and solutions. New Age International, 2007.
3. K. Atkinson, W. Han, Theoretical numerical analysis. Berlin: Springer; 2005.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (Second Sem.)	Operations Research	MM-206	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Historical Development; Art of Modeling Objective function; Constraints and Constraint surface; Formulation of design problems as mathematical programming problems; Classification of optimization problems.	14
Module 2	Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations; Graphical method for two variable optimization problem; Examples; Formulation of LPP, simplex method: Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems; Duality in LP; Primal-dual relations; Dual Simplex method; Sensitivity or post optimality analysis.	14
Module 3	Elementary queuing and inventory models. Steady-state solutions of Markovian queuing models: M/M/1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited waiting space, M/G/1.	14

Text Books:

1. G. Hadlay, Linear Programming, First Edition, 1962.
2. A M Natarajan, P Balasubramani, A Tamilarasi, Operations Research, Fourth Edition , Pearson Education Inc, 2006.
3. Hamidi A. Taha, Operations Research -An Introductory, Eight Edition , Macmillan, 2005.

Reference Books:

1. S. I. Gass, Linear Programming, Fifth Edition Mc-Graw Hill, 1985 .
2. W. Chuchman, Introduction to Operations Research, John Wiley and Sons, New York, 1957.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (Ssecond Sem.)	Multivariable calculus	MM-207	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	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. 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 $\mathbb{R}^n$	20
Module 2	Vector fields and scalar fields. The gradient field. The divergence of a vector field. The curl of a vector field. Combined operations. Irrotational fields and Solenoidal fields. Double integrals, triple integrals and multiple integrals in general. Change of variables in integrals. Arc length and surface area.	10
Module 3	Line integrals in the plane. Integrals with respect to arc length. Basic properties of line integrals. Line integrals as integrals of vectors. Green's Theorem. Independence of path, Simply connected domains, Extension of results to multiply connected domains. Line Integrals in space. Surfaces in space, orientability. Surface integrals. The divergence theorem, Stokes's theorem. Integrals independent of path.	12

Text Books:

1. David Widder: Advanced Calculus, Prentice Hall of India, 1999
2. Wilfred Kaplan: Advanced Calculus.,Adisson-Wasley Publishing Company,1973.
3. T. M. Apostol, Mathematical Analysis, 2nd Edition, Narosa Pub., New Delhi, 2002.

Reference Books:

1. E.Swokowski: Calculus with Analytical Geometry, Prindle, Weber & Schmidt, 1994.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (Second Sem.)	Integral Transforms and Their Applications	MM-208	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Laplace transform, Condition for the existence of Laplace transform, Properties of Laplace transform, Inverse Laplace transform, Convolution theorem and properties of Convolution, Heaviside's expansion theorem.	12
Module 2	Solutions of Ordinary Differential Equations by Laplace Transform, Partial Differential Equations, Solutions of Integral Equations, Evaluation of Definite Integrals, Applications of the Joint Laplace and Fourier Transform.	16
Module 3	Definition of Hilbert transform and examples, Basic properties of Hilbert transform, Applications of Hilbert transforms, Definition of Stieltjes transform and examples, Basic operational properties of Stieltjes transform, Inversion theorems for Stieltjes transform, Applications of Stieltjes transform.	14

Text Books:

1. Davies Brian, Integral Transforms and Their Applications. Third Edition, Springer-Verlag New York, 1999.

Reference Books:

1. Ditkin, V. A., and Prudnikov, A. P, Integral transforms and Operational Calculus, Pergamon Press, Oxford, 1965.

2. Churchill, R. V. Operational Mathematics, McGraw-Hill Book Company, Third Edition New York, 1972.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
First Year (Second Sem.)	Python Language (Lab)	MM-209	0-0-3-1.5
Evaluation Policy	**Continuous Assessment**		**End-Term**
	40		60

Course Details:

Module No.	Contents	Hours
Module 1	SIMPLE PROGRAMS: I/O, Basic Arithmetic On data types, CONDITIONS AND LOOPS: working with Comparison Operators, Single Loop and Nested Loop Programs, LIST PROGRAMS: Working with Lists in Python, Usage of In-built list functions, STRING PROGRAMS: Working with Strings in Python, Usage of In-built String Functions,	10
Module 2	MATH PROGRAMS I: Using python to solve basic Math Problems (User-Defined Functions to be used) (a) Write a program in python to find quotient and reminder after division. (b)FIND GCD of two number. (c)FIND Area and Perimeter of A given Polygon (Triangle or Rectangle or Square) (d) WRITE a function to determine the number of solutions of a given quadratic equation.(e)Write a function to Check if a given Number is a prime. (f) Using the Function defined in (e), compute all the prime numbers in the range 'a' to 'b' taken from user. Store them in a list.	16
Module 3	MATH PROGRAMS II: Using python along with 'NumPy' library to solve math Problems (Such as Matrix Operations) MATH PROBLEMS III: Using python along with 'Matplotlib' to display Graphs and visualize data.	16

Text Books:

1. Yashavant Kanetkar and Aditya Kanetkar, Let's Python, BPB, 3rd edition, 2021.
2. Zed Shaw, Learn Python the Hard Way, , Pearson Addison-wesley, First edition, 2017.

Reference Books:

1. Allen B. Downey, Think Python, O'Reilly, 2nd edition, 2015.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Third Sem.)	Numerical Techniques using MATLAB (LAB)	MM-210	0-0-3-1.5
Evaluation Policy	**Continuous Assessment**		**End-Term**
	60 Marks		40Marks

Course Details:

Module No.	Contents	Hours
Module 1	Introduction to MATLAB Programming, Building codes for solving Non-Linear equations using Bisection method, Newton's method with MATLAB functions fzero and fsolve.	14
Module 2	MATLAB functions for interpolation and evaluation of integration using Trapezoidal and Simpson's rules.	14
Module 3	MATLAB functions for solving ODE-Initial value problem and ODE-Boundary value problem, stiff and non-stiff ODEs, practical problems.	14

Text Books:

1. Alam, S.N. and Alam, S.S., Understanding Matlab: A Textbook for Beginners. IK International Publishing House, 2013.
2. Etter, D.M., Kuncicky, D.C. and Hull, D.W. Introduction to MATLAB (Vol. 4). Hoboken, NJ, USA: Prentice Hall, 2002.
3. Chapman, S.J., MATLAB programming for engineers. Brooks/Cole Publishing Co., 2001.

References Books:

1. Kattan, P. Matlab for beginners (Vol. 1). Petra books, 2022.
2. Turk, I. Practical MATLAB. Berkeley, CA, USA: Apress, 2019.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Third Sem.)	Functional Analysis	MM-301	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Normed linear spaces, Banach spaces, classical examples: C([0,1]), l_p, c, c_0,c_{00},L_p[0,1]: continuity and boundedness of linear operators, quotient spaces, finite dimensional norme spaces, Riesz lemma, non-compactness of unit ball, seperability with examples.	14
Module 2	Hahn Banach extension theorem, open mapping theorem, closed graph theorem, uniform boundedness principle	14
Module 3	Inner product spaces, Hilbert spaces, Projection theorem, Orthonormal basis, Bessel inequality, Parseval equality, dual , duals of classical spaces c_0, l_p, L_p[0,1]: Riesz representation theorem, adjoint of an operator, double dual, weak and weak* convergence.	14

Text Books :

1. J. B. Conway, A course in functional analysis, Second Edition., Springer, Berlin, 1990.
2. M. T. Nair, Functional Analysis, PHI-Learning, New Delhi, 2014.

Reference Books:

1. C. Goffman and G. Pedrick, A first course in functional Analysis, Prentice Hall, 1974.
2. P.D. Lax, Functional Analysis, Wiley intersience, 2002.
3. B. V. Limaye, Functional Analysis, New Age International, 1996.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Third Sem.)	Measure Theory and Integration	MM-302	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Measure Theory: Definition of outer measure and its basic properties, outer measure of an interval as its length, countable additivity of an outer measure, Borel measurable sets and Lebesgue measurability of Borel sets, Non- measurable sets.	12
Module 2	Measurable functions and their characterization. Algebra of measurable functions, Convergence a.e., convergence in measure and almost uniform convergence, their relationship on sets of finite measure, Egroff's theorem.	10
Module 3	Riemann integral and its deficiency, Lebesgue integral of bounded function, comparison of Riemann and Lebesgue integrals, properties of Lebesgue integral for bounded measurable function. The Lebesgue integral for unbounded functions, integral of non-negative measurable functions, Fatou's lemma and monotone convergence theorem, Lebesgue dominated convergence theorem, general Lebesgue integral, improper integral. L^p Spaces, Properties of L^p spaces, Convergence in mean, Holder's inequality, Minkowski's inequality.	20

Text Books:

1. H.L. Royden, Real Analysis, Third Edition, Pearson, 2008
2. S.C. Malik and Savita Arora, Mathematical Analysis ,3rd Edition, New Age International (P) Ltd., New Delhi, 2008.
3. G. De Barra, Measure Theory and Integration, Narosa Publishing House, New Delhi, 2011.

Reference Books:

1. R.R. Goldberg, Methods of Real Analysis, John Wiley & Sons, 1976.
2. T.M. Apostol, Mathematical Analysis, Narosa Publishing House,2007.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Third Sem.)	Differential Geometry	MM-303	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Differentiable curves, regular points, parameterization and reparameterization of curves, unit speed curves, arc-length is independent of parameterization, plane curves, curvature of plane curves, osculating circle. Space curves, Serret-Frenet frame, fundamental theorem of space curves. Characterization of helices and curves on sphere in terms of their curvature and torsion, evolutes and involutes of space curves, Isoperimetric inequality, Four vertex theorem.	12
Module 2	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, first fundamental form, line element, invariance of a line element under change of coordinates, angle between two curves, condition of orthogonally of coordinate curves, area of bounded region, invariance of area under change of coordinates.	12
Module 3	Normal curvature, principal curvatures and principle directions, classification of points with prescribed principal curvatures, Euler's formula, Gauss map and its differential, second fundamental form, normal curvature in terms of second fundamental form. Meunier theorem, Gaussian and mean curvature, Weingarten equation, 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, Christoffel symbols, expressing Christoffel symbols in terms of metric coefficients and their derivative, Theorema egrerium. Gauss equations and Manardi Codazzi equations for surfaces, fundamental theorem for regular surface. geodesic curvature, geodesic curvature is intrinsic, equations of geodesic, geodesic on sphere, geodesic as distance minimizing curves, Gauss-Bonnet theorem(statement only)	18

Text Books:

1. M.P. Do Carmo, Differential geometry of curves and surfaces, Dover Publications, 2nd Ed., 2016.
2. A. Pressley, Elementary Differential Geometry, Springer Publication, 2nd Ed., 2010.
3. K. Tapp, Differential geometry of curves and surfaces, Springer Publication, 2016.

Reference books:

1. S. Montiel and A. Ross, Curves and surfaces, AMS publication, 2nd Edition, 2009.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year(Third Sem.)	Partial Differential Equations	MM-304	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hour
Module 1	Formation and classification of first-order PDEs, Linear and Quasilinear first-order PDEs, Cauchy's problem for first-order PDEs, The Cauchy Kowalevski Theorem, Integral surfaces passing through a given curve, Nonlinear first-order PDEs, The method of characteristics, Compatible systems, Charpit's method, Jacobi's method for nonlinear PDEs	12
Module 2	Classification, Canonical forms, Well-posed problems, Superposition principle, – Separation of variables, Solution to the Laplace and Poisson Equation- Dirichlet and Neumann Problem for a rectangle, The Dirichlet and Neumann Problem for a circle, Solution to the Laplace equation for Cylindrical and Spherical Coordinates. Occurrence of the Diffusion Equation- Elementary Solutions of the Diffusion Equation- Separation of Variables Method- Solution to diffusion equation in spherical and cylindrical Equation- Maximum Principles and Consequences.	15
Module 3	Occurrence of the Wave Equation- Derivation of one-dimensional wave equation- D' Alembert Solution, Vibrating String - Variables Separable Solution, Forced Vibrations- Solutions to the Non-Homogeneous equations- Duhamel's Principles.The Delta function – Green's function – Method of Green's function – Dirichlet Problem for the Laplace and Helmholtz operators – Method of images and eigen functions – Higher dimensional problem – Neumann Problem.	15

Text Books:

1. I. N. Sneddon, Elements of Partial Differential Equations, Tata McGraw Hill, 2022.

Reference books:

1. D. Bleecker and G. Csordas, Basic Partial Differential Equations, Van Nostrand Reinhold, New York, 1992.
2. Lawrence C. Evans, Partial Differential Equations (Graduate Studies in Mathematics), 2010.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Third Sem.)	Advanced Complex Analysis	MM-305	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Maximum Modulus Principle, Schwarz Lemma and its generalization, Meromorphic function, Argument Principle, Rouche's theorem with application, Inverse function Theorem, Poisson integral formula for a circle and half plane, Poisson Jenson formula, Carleman's theorem, Hadamard three-circle theorem and the theorem of Borel and Caratheodory.	14
Module 2	Principle of analytic continuation, uniqueness of direct analytical continuations and uniqueness of analytic continuation along a curve. Power series method of analytic continuation, Functions with natural boundaries and related examples. Shewartz reflection principle, functions with positive real part.	14
Module 3	Space of analytic functions, Hurwitz's theorem, Montel's theorem, Riemann Mapping theorem (Statement only), Weierstrass factorization theorem, Gamma function and its properties. Riemann Zeta function, Reimann's functional equation. Harmonic functions on a disc, Harnack's inequality and theorem, Dirichlet's problem.	14

Text Books:

1. Complex Analysis, Third Edition, L. Ahlfors, Springer, 1988.
2. Theory of Functions, E.C. Titchmarsh, Oxford University Press, 1972.

Reference Books:

1. J.B Conway, Functions of a complex variable , Springer-Verlag New York Heidelberg Berlin, 1979.
2. Richard Silverman, Complex Analysis, Dover publications, 2001.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Third Sem.)	Advanced Graph Theory	MM-306	3-0-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Graph Coloring and Matching Theory: Motivation, Vertex coloring, Chromatic number, Mycielski's theorem, Greedy Coloring Algorithm, Brooks theorem, Edge coloring, Basic definitions, Vizing's theorem, Matching, Maximum matching, Berge's criterion, Hall's theorem, Perfect matching and Tutte's characterization.	15
Module 2	Domination in Graphs: Dominating sets in graphs, Minimal dominating sets and their characterization, Domination number, Computing the domination number of basic graphs, Several upper and lower bounds on domination number in terms of various graph invariants.	07
Module 3	Algebraic Graph Theory: Non negative matrices, Irreducible matrix, Primitive matrix, index of imprimitivity, Perron Frobenius theory, Characteristic polynomial of a graph, Coefficient theorem, Eigenvalues of complete graph, Complete bipartite graph, Cycle, Path, Spectral characterization of bipartite graphs, Eigenvalues of regular graphs and their line graphs, Characterization of regular graphs, Strongly regular graphs and their characterization, Graphs associated to algebraic structures like Paley graphs, Zero divisor graphs.	20

Text Books:

1. D. Anderson, T. Asir, A. Badawi, T. Chelvam, Graphs from Rings, 1st Edition, Springer Nature Switzerland AG 2022.
2. N. Biggs, Algebraic Graph Theory, Third Edition, Cambridge University Press, 1993.

Reference Books:

1. S. Pirzada, An Introduction to Graph Theory, The Orient Blackswan, 2012.
2. T. Hayness, S. Hedetniemi, P. Slater and M. Dekker, Fundamental of Domination in Graphs, 1st Edition, CRC Press, 1998.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Third Sem.)	Algebraic Combinatorics	MM-307	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Sperner property of posets, algebraic characterization of strong Sperner property, unimodality of q-binomial coefficients. Young lattice and counting tableaux, RSK correspondence.	14
Module 2	Polytopes and convexity, Circulant Hadmard matrices, Wedderburn's Theorem and some consequences.	14
Module 3	Representations of symmetric groups, combinatorial invariants in algebraic structures, algebraic methods in combinatorics,	14

Text Books:

1. R. P. Stanley, Algebraic Combinatorics: Walks, Trees, Tableaux, and More, Springer, 2013.

2. A. Prasad, Representation theory (a combinatorial view point), Cambridge University Press, 2015.

Reference Books:

1. Bruce E. Sagan, The Symmetric Group: Representations, Combinatorial Algorithms, and Symmetric Functions, 2nd Edition, Springer, 2001.

2. R. P. Stanly. Enumerative Combinatorics, vol. 2, Cambridge University Press, 1999.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Third Sem.)	Fourier Transform and its Applications	MM-308	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Fourier transform in $L^1(\mathbb{R})$ and $L^2(\mathbb{R})$, Properties of Fourier transform, Riemann Lebesgue lemma. Fourier sine and cosine, Convolution and its properties, Correlation and its properties, Parseval's Identity for Fourier transform, Poisson Summation Formula, Shannon Sampling Theorem, Heisenberg's uncertainty principle.	20
Module 2	Application of Fourier Transforms for solving ordinary differential equations, partial differential equations, Integral equations, Evaluation of definite integrals using Fourier transform.	14
Module 3	Application of Fourier transforms in mathematical statistics, Multiple Fourier transforms and their Applications.	8

Text Books :

1. Davies, Brian, Integral Transforms and Their Applications, Third Edition, Springer-Verlag New York,1992.

2. Lokenath Debnath, Dambaru Bhatta, Integral Transforms and Their Applications. Second Edition, Chapman & Hall/CRC (Taylor & Francis), 2018.

Reference Books:

1. Baidyanath Patra, An Introduction to Integral Transforms, CPC Press, Taylor & Francis Group.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Third Sem.)	Machine Learning using Python	MM-309	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Data Analysis and visualization using • Numpy • Panda • Matplotlib • Scipy etc	15
Module 2	Introduction to machine learning. • Supervised machine learning • Unsupervised machine learning • Study of various machine learning algorithms including Classification, Regression, • KNN, • K Means	16
Module 3	Logistic Regression, • Support Vector Machines (SVM), • Decision Tree, • Naïve Bayes, • Ensemble Methods, Random Forest etc • Mini Project/Prediction	11

Text Books:

1. Andreas C Muller, Sarah Guido, Introduction to Machine Learning with python, O'Reilly, 2016.
2. John Paul Meuller, Beginning Programming with Python Dummies, Wiley, 2018.

Reference Books:

1. Sheetal Taneja and Naveen Kumar, Python Programming- A modular Approach (with Graphics, database, Mobile and Web Applications, First Edition, Pearson, 2017.
2. Stephen Marshland, Machine Learning an algorithmic Perspective, Second Edition, Chapman & Hall Book, 2014.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Fourth Sem.)	Computational Fluid Dynamics	MM-310	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Introduction: Historical Perspective, Comparisons of experimental, Theoretical and Numerical approaches, Different numerical approaches, Eulerian and Lagrangian descriptions of fluid motion, Kinematics of fluid motion, Some analytical solutions of the Navier-Stoke's equations and their physical interpretation, Well-posed problems.	14
Module 2	Governing Equations and Numerical Solution: Classification of PDEs, Physical Classification, Mathematical Classification, Navier-Stokes System of equations, Derivation of Finite Difference Equations, Accuracy of Finite Difference solutions. Elliptic Equations, Parabolic Equations, Hyperbolic Equation, Stability, Convergence and Consistency of the Solution.	14
Module 3	Application of Finite Difference Methods to the Equations of Fluid Mechanics: Numerical Methods for Inviscid Flow Equations, Numerical Methods for Boundary-Layer Type Equations, Finite Volume Methods, SIMPLE algorithm, TECPLOT software.	14

Text Books:

1. D. A. Anderson, J. C. Tannehill, and R. H. Pletcher, Computational Fluid Mechanics and Heat Transfer, 2nd ed, Taylor & Francis, 1997.
2. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere, 2000.
3. T. J. Chung, Computational Fluid Dynamics, 2nd ed. Cambridge University Press, 2010.

Reference Books:

1. P. Niyogi, S. K. Chakrabartty, M. K. Laha, Introduction to Computational Fluid Dynamics, Pearson Publications, 2011.
2. G. K. Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press, 1993.
3. A. R. Patterson, A First Course in Fluid Dynamics, Cambridge University Press, 1992.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Third Sem.)	Module Theory	MM-311	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Detail:

Module No.	Contents	Hours
Module 1	Modules: basic definitions and examples, submodules, quotient modules and module homomorphisms, isomorphisms theorem on modules, generation of modules and direct sums, simple modules, Schur's lemma and its applications, annihilators, torsion elements, torsion and torsion free modules. Finitely generated modules, Nakayama lemma.	15
Module 2	Free modules, rank and related results, Exact, short exact and split exact sequences. Four and Five lemma. Tensor product of Modules with basic properties and applications, projective, injective and flat modules.	14
Module 3	Rings and modules of fractions and localization, Chain conditions, Noetherian and Artinian rings, primary decomposition in Noetherian rings and Artinian rings and structure theorem on Artinian rings, modules over PID. Modules of finite length and primary Decomposition.	13

Text Books:

1. Serge Lang, Algebra, 3rd Edition, Springer, 2002
2. M.F. Atiyah and I.G. MacDonald, Introduction to Commutative Algebra, 1st Edition, Addison-Wesley, 1969

Reference Books

1. Thomas W. Hungerford, Algebra, 1st Edition, Springer, 1974
2. David S. Dummit and Richard M. Foote, Abstract Algebra, 3rd Edition, Wiley, 2004

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Fourth Sem.)	Polynomial Theory	MM-403	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Introduction, The fundamental theorem of algebra, (Revisited) Symmetric polynomials, The Continuity theorem, Orthogonal Polynomials, General Properties, The Classical Orthogonal Polynomials, Harmonic and Sub Harmonic functions, Tools from Matrix Analysis.	14
Module 2	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.	14
Module 3	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, Lp analogous of Markov's inequality.Coefficient Estimates, Polynomials on the unit circles. Coefficients of real trigonometric polynomials, Polynomials on the unit interval.	14

Text Books:

1. Q.I. Rahman and G. Schmeisser, Analytic theory of Polynomials, , Science publication, 1989.
2. Morris Marden , Geometry of polynomials, American Mathematical Society, 2000.

Reference Books:

1. G.V. Milovanovic, D.S. Mitrinovic and Rassias. M. Topics in polynomials: extremal properties, problems, inequalities, zeros, World Scientific Publishing Co Pte Ltd, 1994.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Fourth Sem.)	Wavelet Analysis	MM-404	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details::

Module No.	Contents	Hours
Module 1	Fourier series, Fourier Transforms, inversion formula, Paresval identity and Plancherel Theorem, Continous-time convolution and delta function, Heisenberg uncertinity principle, Poisson's summable formula, Shannon sampling theorem, Discrete Fourier transform, fast Fourier	14
Module 2	Time-frequency localization, definition and examples of wavelets, Dyadic wavelets, wavelet series, orthonormal wavelet bases, continuous and discrete wavelet transform, frames.	14
Module 3	Multiresolution analysis, orthonormal systems and Riesz systems, scaling equation and structure constants, from scaling function to MRA and orthonormal wavelet, biorthonormal wavelets.	14

Text Books:

1. D. F. Walnut, An introduction to Wavelet analysis, Birkhauser, Boston, 2002.
2. E. Hernandez and G. Weiss, A first course on wavelet analysis, CRC Press.
3. P. Wojtasczyk, A mathematical introduction to wavelets, London Math. Society student text, Cambridge university Press, 1997.

Reference Books:

1. M. Frazier, An introduction to wavelets through linear algebra, Springer-Verlag new york Inc. 2014.

2. G. Bachman, L. Narici and E. Beckestein, Fourier and wavelet analysis, Springer, 2000.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Fourth Sem.)	Summability Theory	MM-405	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details::

Module No.	Contents	Hours
Module 1	Special methods of summation: Norlund means, Regularity and consistency of Norlund means, Inclusion, Equivalence, Euler means, Regularity of (E, I) method, Abelian means, Regularity of (A, λ) method, A-method and its regularity, A theorem of inclusion for Abelian means, Complex methods, Summability of 1-1+1-1-... by special Abelian methods, A theorem of consistency, Methods ineffective for the series 1-1+1-..., Riesz's Typical means.	14
Module 2	Arithmetic means: Holder's means, Simple theorems concerning Holders Summabilitty, Cesaro means, Simple theorems concerning Cesaro summability, Cesaro and Abel summability, Cesaro means and Norlund means, Equivalence theorem, Riesz's arithmetic means, uniformly distributed sequence, Tauberian Theorem for Cesaro summability	14
Module 3	The method of Euler and Borel: The (E, q) method, simple properties of (E, q) method, Borel's method's, The formal relation between Euler's and Borel's methods, Normal, absolute and regular summability, Abelian Theorems for Borel's summability.	14

Text Books:

1. A. Zygmund, Trigonometric Series Vol. 1 &2, Cambridge University Press, 1959.

2. G. H. Divergent Series, Oxford Clarendon Press, Cambridge university press, 1947.

Reference Books:

1. M. Mursaleen, F. Basar, Topics in Modern Summability Theory, CRC Taylor & Francis Group New York 2022.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Fourth Sem.)	Optimization Techniques	MM-406	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Stationary points, functions of single and two variables, global optimum, convexity and concavity of functions of one and two variables, optimization of functions of one and multiple variables, Gradient vectors, optimization of functions of multiple variables subject to equality constraints, Lagrangain function, optimization of function of multiple variable subject to equality constraints, Hessian matrix formulation, Eigen values, Khun-Tucker conditions, examples.	14
Module 2	Introduction to non-linear programming, one dimensional minimization methods, unrestricted search with examples, basic optimization methods and their convergence analysis, random search method, univariate method, pattern search method with examples, Hookes and Jeeves method, simplex method, reflection, expansion, contraction, NLP, constraint optimization techniques, cutting plane method with examples	14
Module 3	Basic steps in PERT/CPM techniques, network diagram representation, Fulkerson's i-j rule for drawing network, crashing, illustrative examples.	14

Text Books :

1.G. Hadlay, Linear Programming, First Edition, Narosa, 1962.

2.T Hamidi, Operations Research -An Introductory, Eigth Edition, Macmillan, 2005.

3. S. S. Rao, Engineering Optimization: theory and practice, New Age International Pvt. Ltd, New Delhi, 2000.

Recommended Books:

1. S.I. Gass , Linear Programming, 5th Edition Mc-Graw Hill, 1985 .

2. W. Chuchman, Introduction to Operations Research, John Wiley and Sons, New York, 1957.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Fourth Sem.)	Differentiable Manifolds	MM-407	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Review of Multivariable calculus, Manifolds, Topological manifolds, coordinate charts, atlases, Differentiable manifolds, Definition and examples, Smooth maps between two smooth manifolds, Tangent vector and tangent space at a point on a manifold, Differential of a smooth map.	14
Module 2	Immersions, Submersions and submanifolds and their examples, Vector fields, Lie bracket, Lie algebra of vector fields, Jacobian of a smooth map, Integral curves on manifolds, Covectors and Cotangent space, Pullback of 1-form, One parameter group of transformation, exponential map.	14
Module 3	Differential forms, exterior product, exterior derivative, affine connections, Parallellism, geodesic covariant differential of tensors, torsion and curvature of a connection, structure equations of Cartan, Bianchi's identities.	14

Text Books:

1. M. P. Do Carmo, Riemannian Geometry, Brikhauser, 2013.
2. J. M. Lee, Introduction to topological manifolds, Springer, 2011.
3. J. M. Lee, Introduction to smooth manifolds, Springer, 2013.

Reference Books:

1. W. M. Boothby, An introduction to differentiable Manifolds and Riemannian Geometry, Academic Press, Revised Edition, 2003.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Fourth Sem.)	Coding Theory	MM-408	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Basic Concepts: Idea behind the use of codes, block codes and linear codes, repetition codes, nearest neighbor decoding, syndrome decoding, requisite basic ideas in probability, Shannon's theorem (without proof). Tanner Graphs, Low-Density Parity-Check (LDPC) Codes, Group Codes, Graph-based codes	14
Module 2	Good linear and non- linear codes: Binary Hamming codes, dual of a code, constructing codes by various operations, simplex codes, Hadamard matrices and codes constructed from Hadamard and conference matrices, Plotkin bound and various other bounds, Gilbert-Varshamov bound. Reed-Muller and related codes: First order Reed-Muller codes, RM code of order r, Decoding and Encoding using the algebra of finite field with characteristic two. Perfect codes: Weight enumerators, Kratchouwk polynomials, Lloyd's theorem, Binary and ternary Golay codes, and connections with Steiner systems.	14
Module 3	Cyclic codes: The generator and the check polynomial, zeros of a cyclic code, the idempotent generators, BCH codes, Reed-Solomon codes, Quadratic residue codes, and generalized RM codes. Codes over rings : Quaternary codes over rings, binary codes de rived from such codes, cyclic codes over rings.	14

Text Books:

1. J. H. van Lint, Introduction to Coding Theory, Springer, 1999.
2. W. C. Huffman and V. Pless, Fundamentals of Error Correcting Codes, Cambridge University Press, 2003.

Reference Books:

1. S. Ling and C. Xing, Coding Theory: A First Course, Cambridge University Press, 2004.
2. T. Richardson and R. Urbanke. Modern Coding Theory. Cambridge University press, 2008.

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Year (Semester)	Course Title	Course Code	L-T-P-Credits
Second Year (Fourth Sem.)	Advanced Functional Analysis	MM-411	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Course Details:

Module No.	Contents	Hours
Module 1	Orthogonal Projections and Bilinear forms: Orthogonal complements, orthogonal projections, Projection theorem, Projection on convex sets, Sesquilinear forms, Bilinear forms and their basic properties, Lax Miligram lemma.	12
Module 2	Spectral Theory of Continuous Linear Operators: Eigen values and eigen vectors, Resolvent operators, Spectrum, Spectral properties of bounded linear operators, Compact linear operators on normed spaces, Finite dimensional domain or range, Sequence of compact linear operators, Weak convergence, Spectral theory of compact linear operators.	14
Module 3	Geometry of Banach Spaces and Differential Calculus on Normed Spaces: Smooth Banach spaces, Modulus of smoothness, Duality mapping and its properties, Gateaux derivative, Gradient of function, Frechet derivative, Chain rule, Mean value theorem, Properties of Gateaux and Frechet derivatives, Implicit function theorem, Taylor's formula, Inverse function theorem.	16

Text Books :

1. C. Chidume, Geometric properties of Banach spaces and Nonlinear iterations, Lecture notes in Mathematics, Vol. 1965, Springer-Verley London Limited, 2009.
2. E. Kreyazig, Introductory Functional Analysis with Applications, John Wiley and Sons, New York, 1989.
3. A.H. Siddiqui, Applied Functional Analysis, CRC Press, 2003.

Reference Books:

1. M.C. Joshi and R.K. Bose, Some Topics in Nonlinear Functional Analysis, Wiley Eastern Limited, New Delhi, 1985.