Semester: 1				
Programme: Data Science				
Course: Real Analysis and Linear Algebra 1				
Paper code: C1DS250121T			**Credits: 4**	
Hours/week: 4				
Category: Core/MDC/SEC/VAC: Core				
Theory / Practical / Composite: Theory				
No of Module: 2				
Course Outcome:				
1. **Remember** the fundamental definitions and properties related to sets, logic, real number systems, special classes of matrices, and vector operations.				
2. **Understand** the principles of matrix operations and determinants to interpret and manipulate structured data in tabular forms, including the geometric interpretation of vector operations.				
3. **Apply** set theory, propositional logic, and the Gram-Schmidt orthogonalization process to model data structures and construct orthonormal vectors.				
4. **Analyse** matrix rank and subspace relationships, such as the Rank-Nullity Theorem, to identify dimensionality and dependencies within multidimensional datasets.				
5. **Evaluate** the convergence of sequences and series of real numbers using standard mathematical tests and assess the solvability of linear systems based on matrix rank and nullity.				
6. **Create** mathematical representations of data tables and multidimensional structures by synthesizing concepts of basis, dimension, and vector spaces over the field of real numbers.				
Prerequisites: ***Basic knowledge about any prior course***				
SYLLABUS				
Module/Unit	**Content**	**Hours Or Number of Classes**	**CO Mapping**	**Cognitive Level**
Module I / Unit 1	Sets, Logic, and Relations Sets, operations on sets, Cartesian product, power set, Propositional logic, predicates, quantifiers, Equivalence relations, partial orders, injective, surjective, and bijective functions, Cardinality & Infinite Sets-Cardinality of finite and infinite sets, Comparison of cardinalities, Cantor-Schroeder-Bernstein theorem (statement only).	**10**	**CO1, CO3**	**K1, K3**
Module I / Unit 2	Real Number System Real number system: Basic ideas, Archimedean Property, completeness.	**4**	**CO1**	**K1**
Module I / Unit 3	Sequences and Series of Real Numbers Sequences: Definition, convergence, bounded and monotone sequences, Cauchy	**12**	**CO5**	**K5**

	sequences. Series: Definition, absolute and conditional convergence. Tests of convergence (statement and applications): Comparison, Limit Comparison, Ratio, Root, Rabbe's, Cauchy Condensation, Logarithmic, Integral tests, Abel's and Dirichlet's tests.			
Module II/ Unit 1	**Algebra of Matrices and Determinants:** Matrix representation of data tables and its relevance in data science. A review of matrix operations- addition, multiplication, transposition. Introduction to special classes of matrices- symmetric, skew-symmetric, orthogonal, and idempotent matrices. Concepts of trace, rank, and partitioning of matrices. Determinants: Definition, interpretation, and key properties. Determinant of product of matrices, effect of elementary row transformations on the determinant. Singular and non-singular matrices and their properties. Inverse of a matrix and related properties. Adjoint and cofactor.	**6**	**CO1, CO2, CO6**	**K1, K2, K6**
Module II / Unit 2	**Ideas of Vectors:** Definition of a vector. Vector addition and scalar multiplication. Scalar product. Linear combination of vectors and the geometric interpretation of vector operations. Linear independence and dependence of a set of vectors. Orthogonal and orthonormal vectors. Gram-Schmidt orthogonalization process**.**	**6**	**CO1, CO2, CO3**	**K1, K2, K3**
Module II / Unit 3	**Vector Space :** Vector spaces over the field of real numbers. Subspaces. Sum and intersection of subspaces. Span of a set of vectors. Basis and dimension. Projection. Orthogonal subspaces. Ortho-complement of a subspace. Row space and column space of a matrix. Null space and nullity of a matrix; connections with solvability of linear systems.	**10**	**CO4, CO5, CO6**	**K4, K5, K6**
Module II / Unit 4	**Matrix Rank and Its Applications:** Definition of rank of a matrix, row rank, and column rank; equivalence of row rank and column rank. Standard theorems involving rank, including the Rank-Nullity Theorem. Rank of the sum and product of matrices.	**4**	**CO4, CO5**	**K4, K5**
Text Books				
1. Bertle R. G., Sherbert D. R. (2011): Introduction to Real Analysis, 4th Edition, Wiley & Sons Inc. 2. Goldberg R. R. (2020): Methods of Real Analysis, Oxford & IBH Publishing Co Pvt Ltd.				

3. Khuri A. (2003): Advanced Calculus with Applications in Statistics, 2nd Edition, Wiley Interscience.
4. Rudin W. (2017): Principles of Mathematical Analysis, 3rd Edition, McGraw Hill Publication.
5. Rosen, K. H. (2019): Discrete Mathematics and Its Applications, 8th Edition, McGraw-Hill.
6. Kolman, B., Busby, R., Ross, S. C. (2013): Discrete Mathematical Structures, 6th Edition, Pearson.
7. Hadley, G. (2002): Linear Algebra. Narosa Publishing House (Reprint).
8. Mapa, S. K. (2016): Higher Algebra: Abstract and Linear. Levant Books.
9. Narayan, S. (2004): A Textbook of Matrices. S. Chand & Co. Ltd.
10. Searle, S. R. (1982): Matrix Algebra Useful for Statistics. John Wiley & Sons. 11. Lay, D. C., Lay, S. R., & McDonald, J. J. (2015): Linear Algebra and Its Applications (5th Edition). Pearson.

Evaluation	CIA: 30 Semester exam: 70 Total: 100	
Paper Structure for Theory Semester Exam Module :	Module-I (35 marks)	Module-II (35 marks)
	To answer Short: 4 out of 6 (5 marks) Long: 1 out of 2 (15 marks)	To answer Short: 4 out of 6 (5 marks) Long: 1 out of 2 (15 marks)

Course outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive levels
CO1	**Remember** the fundamental definitions and properties related to sets, logic, real number systems, special classes of matrices, and vector operations.	K1
CO2	**Understand** the principles of matrix operations and determinants to interpret and manipulate structured data in tabular forms, including the geometric interpretation of vector operations**.**	K2
CO3	**Apply** set theory, propositional logic, and the Gram-Schmidt orthogonalization process to model data structures and construct orthonormal vectors.	K3
CO4	**Analyse** matrix rank and subspace relationships, such as the Rank-Nullity Theorem, to identify dimensionality and dependencies within multidimensional datasets.	K4
CO5	**Evaluate** the convergence of sequences and series of real numbers using standard mathematical tests and assess the solvability of linear systems based on matrix rank and nullity.	K5
CO6	**Create** mathematical representations of data tables and multidimensional structures by synthesizing concepts of basis, dimension, and vector spaces over the field of real numbers.	K6