## Under-Graduate Programme with MATHEMATICS; 6th Semester

**MATHEMATICS** **MINOR COURSE**

**MMT626N: Vector Spaces** **Credits: 4 ( 3-TH + 1-TUT)**

**Theory: 3 Credits (45 Hours)** **Tutorial: 1 Credits (15 Hours)**

**Objective:** To help the students in finding real life applications using operators and vector spaces. This course will introduce a student, the basics of linear algebra and some of its application.

**Expected Outcomes:** The student will use this knowledge wherever he/she goes after undergraduate program. It has applications in computer science, finance mathematics, industrial mathematics, and bio-mathematics.

### Theory: 3 Credits

**Unit- I**

Review of algebra of vectors, Vector spaces, Subspaces, criteria for a subset to be subspace, algebra of subspaces, quotient spaces, linear dependence and independence of vectors, Maximal Linearly independent subsets, bases and dimension of vector spaces. Existence, invariance and extension theorems (statements only). Linear transformations, null space and range, rank and nullity of a linear transformation, Sylvester's theorem.

**Unit – II**

Matrix representation of a linear transformation, algebra of linear transformations, Composition of Linear Transformations and matrix Multiplication, change of coordinate matrix. Similarity, invertibility of linear transformations. Isomorphic vector spaces. Linear functional, Dual of a vector space, Dual basis.

**Unit – III**

The dual (transpose) map $T^* : W^* \to V^*$ associated with a linear map $T : V \to W$ and its basic properties. Relationship between the null space and range of a linear map and those of its dual. Matrix representation of the dual map with respect to dual bases.

Invariant subspaces and Cayley-Hamilton theorem (Operator form), eigenvalues and eigenspaces, diagonalizability.

### Tutorials: 1 Credits

**Unit – IV**

1. Exercise numbers 1 to 8 and 11, 13, 14 on Page no. 41-42 of the recommended book no.1.
2. Exercise numbers 1 to 6 and 14, 15, 16, 26 on Page no. 57-58 of the recommended book no.1.
3. Exercise numbers 1 to 10 and 11, 13, 14 on Page no. 74,75 of the recommended book no.1.
4. Exercise numbers 1 to 4 on Page no. 85 of the recommended book no.1.
5. Exercise numbers 1 to 5 on Page no. 257-258 and exercise no. 2 on Page no. 278 of the recommended book no.1.

**Recommended Book**


1. Linear Algebra, Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Pearson, 5th Edition.
2. K. Hoffman and R. Kunze, Linear Algebra, Pearson Education, 2018.
3. D. C Lay, S.R. Lay and J.J. AcDonald, Linear Algebra and Its Applications, Pearson, 5th Edition, 2023.
4. Sheldon Axler, Linear Algebra Done Right, Springer, 2nd edition.
5. S. Lipschutz & M. Lipson, Linear Algebra, Schaum's outline series, Tata McGraw-Hill, 4th Edition 2009.
6. Robert A. Beezer, A first course in linear algebra, Congruent Press; 3rd edition, 2012.
7. John B. Fraleigh and Raymond, Linear Algebra, Addison Wesley Pub. Com. 3rd Edition, 1995