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# Introduction to Matrix

A **matrix** represents a collection of numbers arranged in order of rows and columns. It is necessary to enclose the elements of a matrix in parentheses or brackets.

A matrix with 9 elements is shown below:

1	2	3
4	5	6
7	8	9

The above Matrix M has 3 rows and 3 columns. Each element of matrix [M] can be referred to by its row and column number. For example,  $M_{23} = 6$

**Order of a Matrix :** The order of a matrix is defined in terms of its number of rows and columns.

Order of a matrix = No. of rows  $\times$  No. of columns

Therefore, Matrix  $[M]$  is a matrix of order  $3 \times 3$ .

## Transpose of a Matrix

The transpose  $[M]^T$  of an  $m \times n$  matrix  $[M]$  is the  $n \times m$  matrix obtained by interchanging the rows and columns of  $[M]$ .

Transpose of a matrix  $A$  is defined as:

```
if  $A = [a_{ij}]_{m \times n}$ :  
    then  $A^T = [b_{ij}]_{n \times m}$  where  $b_{ij} = a_{ji}$ 
```

For Example, transpose of matrix  $M$ ,  $M^T$  will be:

```
M   = 1 2 3  
      4 5 6  
      7 8 9
```

```
MT = 1 4 7  
      2 5 8  
      3 6 9
```



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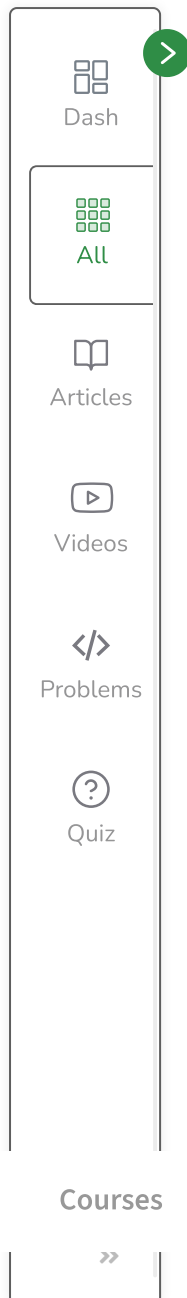


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## Properties of transpose of a matrix:

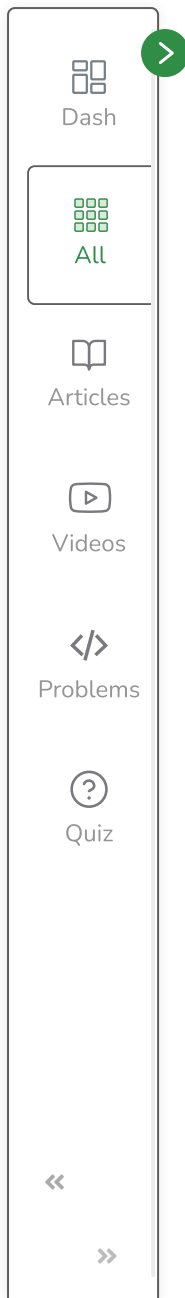
- $(A^T)^T = A$
- $(A+B)^T = A^T + B^T$
- $(AB)^T = B^T A^T$

## Properties of Matrix addition and multiplication:

1.  $A+B = B+A$  (Commutative)
2.  $(A+B)+C = A+ (B+C)$  (Associative)
3.  $AB \neq BA$  (Not Commutative)
4.  $(AB) C = A (BC)$  (Associative)
5.  $A (B+C) = AB+AC$  (Distributive)

## Terminologies

- **square matrix:** A square matrix has as many rows as it has columns. i.e. no of rows = no of columns.



- **Symmetric matrix:** A square matrix is said to be symmetric if the transpose of original matrix is equal to its original matrix. i.e.  $(A^T) = A$ .
- **Skew-symmetric:** A skew-symmetric (or antisymmetric or antimetric[1]) matrix is a square matrix whose transpose equals its negative. i.e.  $(A^T) = -A$ .
- **Diagonal Matrix:** A diagonal matrix is a matrix in which the entries outside the main diagonal are all zero. The term usually refers to square matrices.
- **Identity Matrix:** A square matrix in which all the elements of the principal diagonal are ones and all other elements are zeros. Identity matrix is denoted as  $I$ .
- **Orthogonal Matrix:** A matrix is said to be orthogonal if  $AA^T = A^T A = I$ .
- **Idempotent Matrix:** A matrix is said to be idempotent if  $A^2 = A$ .
- **Involuntary Matrix:** A matrix is said to be Involuntary if  $A^2 = I$ .
- **Singular Matrix:** A square matrix is said to be singular matrix if its determinant is zero i.e.  $|A|=0$
- **Nonsingular Matrix:** A square matrix is said to be non-singular matrix if its determinant is non-zero.

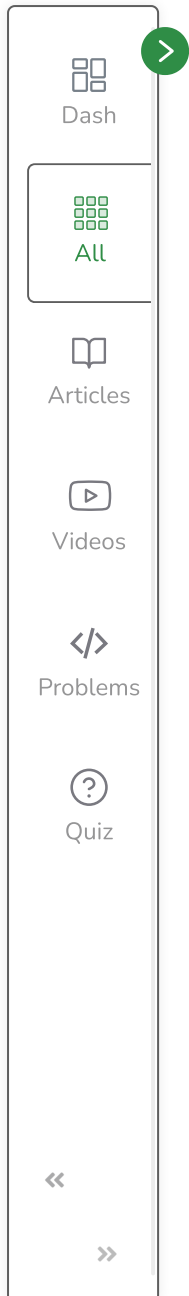


**Note:** Every Square Matrix can uniquely be expressed as the sum of a symmetric matrix and skew symmetric matrix.  $A = \frac{1}{2}(A + A^T) + \frac{1}{2}(A - A^T)$ .

**Trace of a matrix:** trace of a matrix is denoted as  $\text{tr}(A)$  which is used only for square matrix and equals the sum of the diagonal elements of the matrix. For example:

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

$$\text{tr}(A) = 1+5+9 = 15$$

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