WELCOME TO

# TECH I.S.

## Linear Algebra

# Introduction to Linear Algebra

**Linear Algebra is the branch of mathematics that helps us study linear equations using Vectors and Matrices.**

# Vectors

Vector is a one-dimensional array of ordered real-valued scalars:

$$\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}$$

Vectors in column form
(Default form):

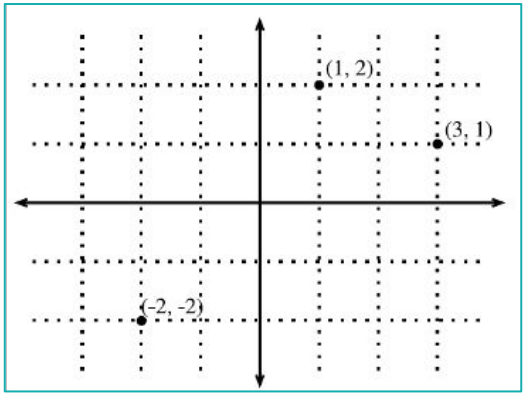
$$\mathbf{x} = \begin{bmatrix} 1 \\ 7 \\ 0 \\ 1 \end{bmatrix}$$

Vectors in row form:

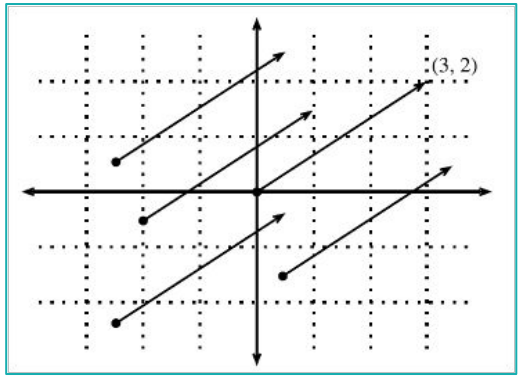
$$\mathbf{x} = [1 \quad 7 \quad 0 \quad 1]^T$$

# Geometry of Vectors

In 2D, we can visualize the data points w.r.t an origin and also w.r.t to direction.




Vector as Point in space




Vector as Direction in space

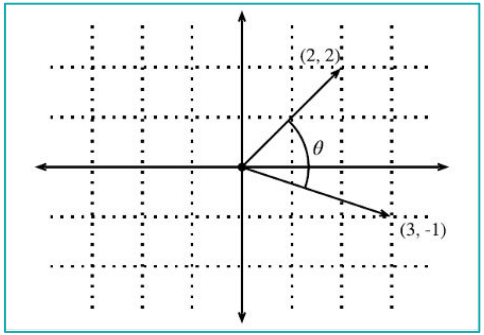
# Dot Product of Vectors

**Dot product of two vectors is given by:**

$$\mathbf{u} \cdot \mathbf{v} = \|\mathbf{u}\|\|\mathbf{v}\| cos(\theta)$$

**Geometrically it means :**

**Determining the contribution that one vector puts on the other vector and vice versa.**



# Use Case: Dot Product of Vectors

Vectors *a* & *b* are called Orthogonal if the angle between them is *right angle, i.e.* $\theta=90°$ , *useful in independent Linear equations.*

$$\mathbf{a} \cdot \mathbf{b} = |\mathbf{a}||\mathbf{b}| \cos(\pi/2) = 0$$

In ML, Cosine similarity is employed as a measure of closeness of two vectors/data points.

$$\cos\theta = \frac{\mathbf{u} \cdot \mathbf{v}}{\|\mathbf{u}\|\|\mathbf{v}\|}$$

# Norm of a Vector

**The norm of Vector measures the size of the vector.**

**Denoted by $\ell_p$**

**Euclidean Distance:**
***$\ell_2$ norm***

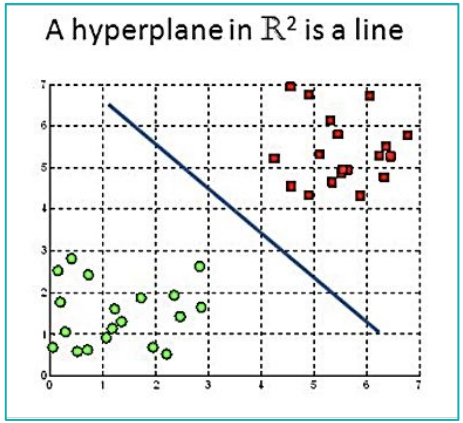
$$\|\overline{v1} - \overline{v2}\|_2 = \left( |f_{1,2} - f_{1,1}|^2 + |f_{2,2} - f_{2,1}|^2 \right)^{1/2}$$

**Manhattan Distance:**
***$\ell_1$ norm***

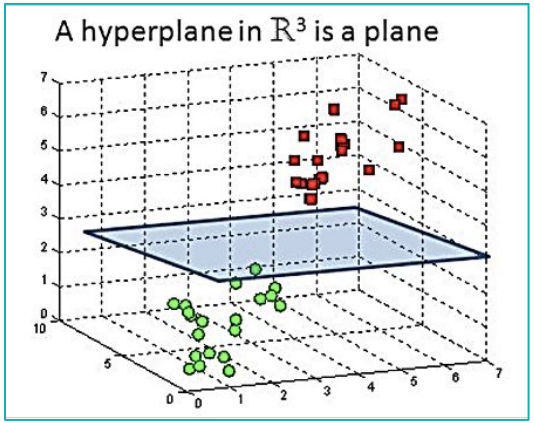
$$\|\overline{v2} - \overline{v1}\|_1 = |f_{1,2} - f_{1,1}| + |f_{2,2} - f_{2,1}|$$

# Hyperplane

**Hyperplane is a generalization of a concept of plane in high-dimensional space.**




**In 2D space, a hyperplane is a straight line.**




**In 3D space, a hyperplane is a straight plane.**

# Much obliged.

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