WHEN WILL THE DOT PRODUCT BE ZERO?

The Dot product can be zero,

→ If the angle between the two vectors is 90° i.e., if one or both of the vectors is zero vector.

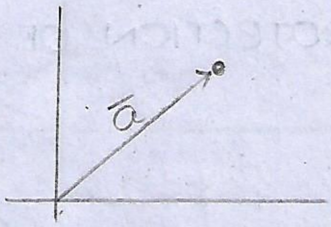
→ If the points are on the opposite axis.

UNIT VECTOR:

A unit vector is a vector of length 1 and sometimes called as direction vector.

→ It is denoted as $\hat{a}$

$$\Rightarrow \hat{a} = \frac{\vec{a}}{\|\vec{a}\|}$$

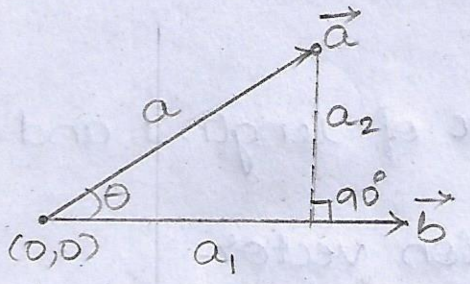


PROJECTION OF A VECTOR:

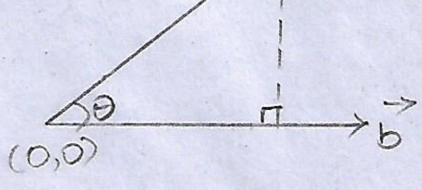
The vector projection is the vector produced when one vector is resolved into two component vectors i.e.,

One is $\parallel$el to the other vector and one is $\perp$r to the other vector.

→ The parallel vector is the vector projection.



PROJECTION OF ONE VECTOR ON ANOTHER VECTOR:



Projection of $\vec{a}$ on $\vec{b}$ is represented as $Proj_{\vec{b}}\vec{a}$

$\Rightarrow \cos\theta = \frac{Adj}{Hyp} = \frac{d}{\|\vec{a}\|}$

$\text{Proj}_{\vec{b}}\,\vec{a}$ is denoted as d.

$\Rightarrow d = \|\vec{a}\| \cdot \cos\theta_{a,b} \rightarrow$ MAGNITUDE

$\rightarrow \text{Proj}_{\vec{b}}\,\vec{a}$ = MAGNITUDE X DIRECTION

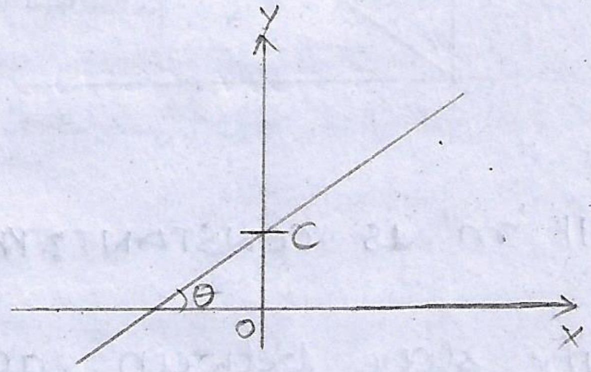
$= d \times \dfrac{\vec{b}}{\|\vec{b}\|}$

$= \{\|\vec{a}\| \cdot \cos\theta\} \cdot \dfrac{\vec{b}}{\|\vec{b}\|}$

LINE EQUATION :

A equation between two variables, that gives a straight line when plotted.

$\Rightarrow Y = mx + C$



where

m = slope of line eqⁿ.

C = intercept of Y.

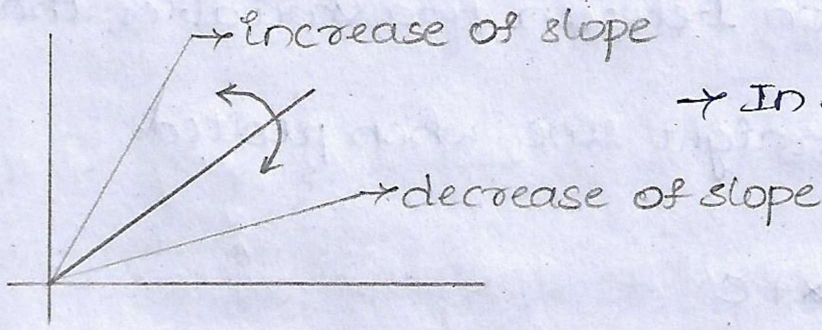
θ = angle between the line and x-axis

θ → Tangent angle.

WHAT HAPPENS WHEN WE CHANGE SLOPE OF LINE?

When a line shifts in such a way that it maintains the same steepness (almost a vertical slope) as the original line, but moves up or down; or to the right or left.

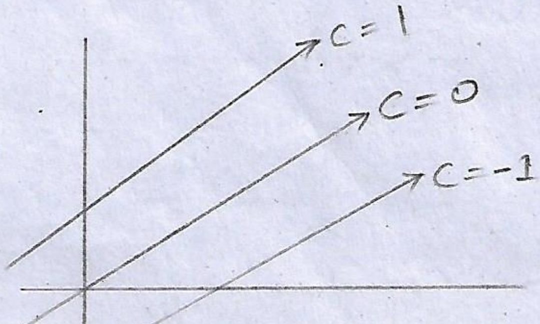
→ the y-intercept changes while the slope remaind the same.

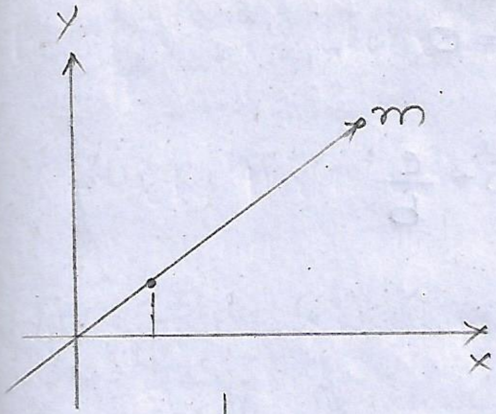


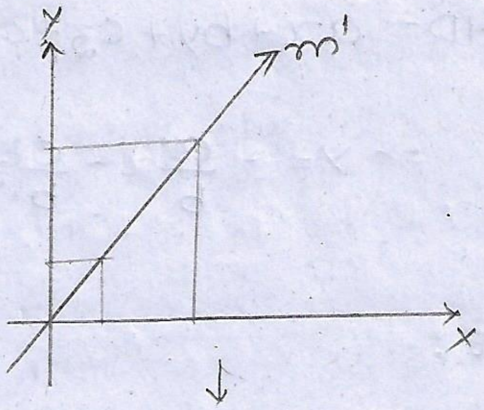
→ In this case, 'c' is constant.

IF 'm' is CONSTANT: THE

The slope between each pair of points is same for any given line.







As $x\uparrow$, $y\uparrow$ $\downarrow$ This property is used in linear Regression.

As $x\uparrow$, $y\uparrow$ rapidly

In the above graphs, the intercept is same i.e., constant (= 0) and the slope is changed.

We know the line eq^n for 2D is $y = mx + c$.

The general form of line eq^n is

$$ax + by + c = 0 \Rightarrow y = -\frac{a}{b}x - \frac{c}{b}$$

Intercept $= -c/b$, slope $= -a/b$.

$\rightarrow$ 3D $-$ $ax + by + cz + d = 0$

$$\Rightarrow y = \underbrace{-\frac{a}{b}}_{\text{Slope with 'x' axis}}x - \underbrace{\frac{c}{b}}_{\text{Slope with 'z' axis}}z - \frac{d}{b}$$

$\frac{d}{b}$ $\rightarrow$ intercept with 'y' axis

$\rightarrow$ 4D - $ax + by + cz + dw + e = 0$

$$\Rightarrow y = -\frac{a}{b}x - \frac{c}{b}z - \frac{d}{b}w - \frac{e}{b}$$

NOTE:

If 'n' dimensions hyperplanes are present, then we get 'n-1' slopes and will have excatly one intercept.

HYPERPLANE:

It is a subspace whose dimension is one less than that of its ambient space.

$\hookrightarrow$ If there are more number of dimensions (d) then $x_1, x_2, \ldots\ldots, x_d$; then the

coefficients $\rightarrow w_1, w_2, \ldots\ldots w_d$

$\Rightarrow$ 2D $\rightarrow$ $w_1x_1 + w_2x_2 + w_0 = 0$

where w_0 is the final term and it is constant.

$\Rightarrow$ 3D - $w_1x_1 + w_2x_2 + w_3x_3 + w_0 = 0$.

$\Rightarrow$ 4D - $w_1x_1 + w_2x_2 + w_3x_3 + w_4x_4 + w_0 = 0$

For the above equations, the dot product is written as

$$w = \begin{bmatrix} w_0 \\ w_1 \\ w_2 \end{bmatrix}, \quad x = \begin{bmatrix} 1 \\ x_1 \\ x_2 \end{bmatrix}$$

$$\Rightarrow w_1x_1 + w_2x_2 + w_0 = 0 \rightarrow [w_1 \ w_2]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + w_0 = 0$$

$$\pi_2 \Rightarrow w^T \cdot x = 0.$$

where π - represents hyper plane

2 represents the dimensions.

$$w = \begin{bmatrix} w_0 \\ w_1 \\ w_2 \\ w_3 \end{bmatrix}, \quad x = \begin{bmatrix} 1 \\ x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

$$\Rightarrow w_1x_1 + w_2x_2 + w_3x_3 + w_0 = 0.$$

$$\Rightarrow [w_0 \ w_1 \ w_2 \ w_3]\begin{bmatrix} 1 \\ x_1 \\ x_2 \\ x_3 \end{bmatrix} = 0$$

$$\pi_3 \Rightarrow w^T \cdot x = 0$$