Agenda

13 October 2025 20:39

{7 sessions}

{First 2 sessions - Pure Math ⇒ fundamentals, derivations, formulae etc. Raw Math.}

⇓

[3rd Session to 7th session → Apply that to an ML use case]

{i) Basic Trignometry}

(Reading for you)

{ii) Basic Calculus

Derivatives of Basic Fns $x, x^2, \log x$}

Intro

20 August 2025 17:34

Predict whether a person has heart disease or not

[Cholestrol, BP, age, weight, blood sugar, lifestyle factors]

{Historical data} => past 5 years.

features / Independent variables

{target / Dependent variable / label}

x_1 SleepHoursPerDay	x_2 AlcoholDrinksPerDay	x_3 Age	x_4 BMI	y HeartDiseaseFlag
8.0	0	28	22.4	0
6.5	2	45	27.8	1
7.2	1	35	24.5	0
5.0	4	52	29.1	1
7.8	0	31	23.0	0
6.0	3	49	30.2	1
8.5	0	26	21.9	0
5.5	5	60	32.4	1
7.0	1	40	25.6	0
6.2	2	55	28.7	1

Data => $\boxed{\text{ML Model}}$ => {Equation or some logic}

(x_1, x_2, x_3, x_4, y)

$$y = ax_1 + bx_2^2 \cdots\cdots$$

$$y = x_1 + x_2$$

1 patient

$y = x_1 + x_2$

1 patient

Sleep, Alcohol, Age, BMI $\Rightarrow$

$x_1 + x_2 \Rightarrow \underline{\underline{y}}$

sleep alcohol.

$\boxed{\text{All Math and fundamentals to Understand how this process happens}}$

Co-ordinate Geometry

16 August 2025 12:40

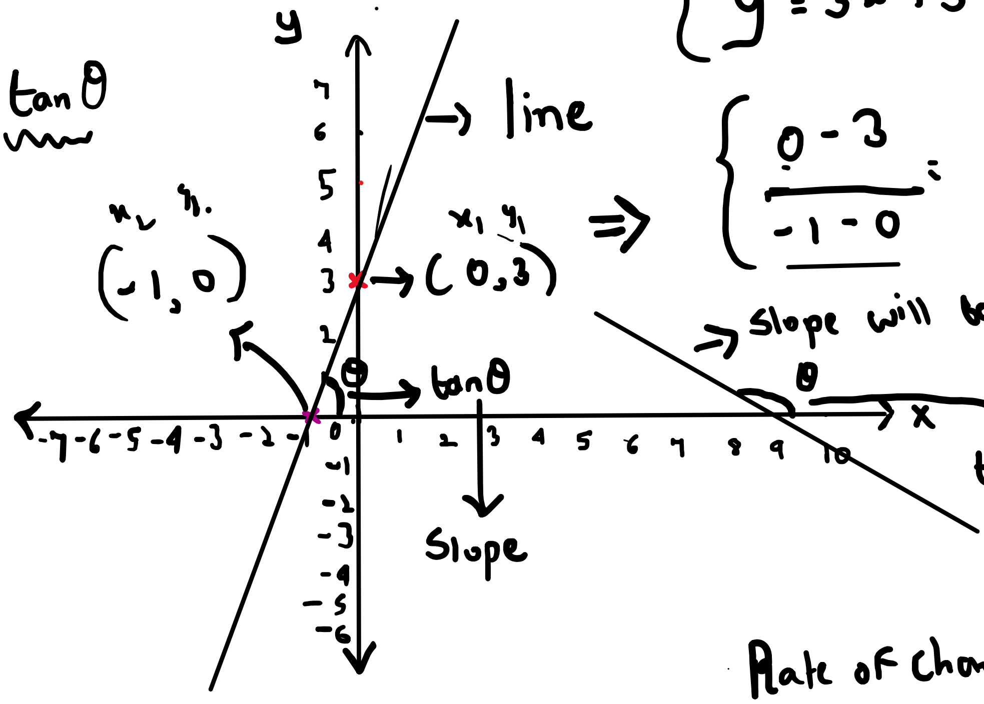
c $\quad x = 0 \quad y = 3$

$x = -1 \quad y = 0$

$$\left[\, y = 3x + 3 \,\right]$$

$$\left\{\, y = 3x + 3 \,\right\}$$ equation of the line

tan θ



$$\Rightarrow \left\{ \frac{0-3}{-1-0} = \frac{-3}{-1} = 3 \right\}$$

→ slope will be negative.

tan θ will give slope

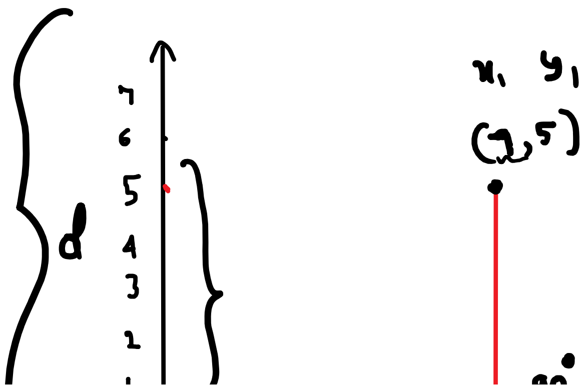
$$\frac{\text{Rate of change of } y}{\text{Rate of change of } x}$$

$$\left[\, y = mx + c \,\right]$$ m ⇒ slope

c ⇒ y intercept

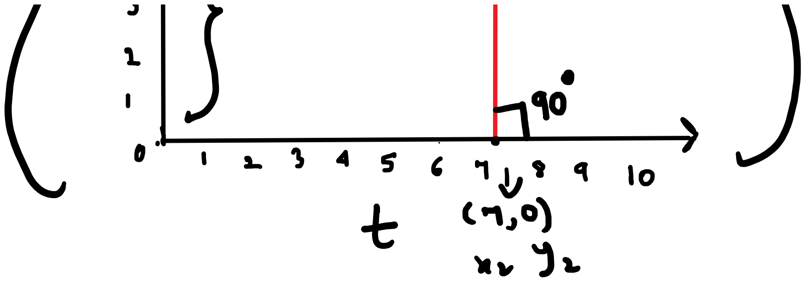
$$\begin{bmatrix} (x_1, x_2) \\ (y_1, y_2) \end{bmatrix}$$

$$\left[\ \text{slope} = \frac{y_2 - y_1}{x_2 - x_1} \right.$$



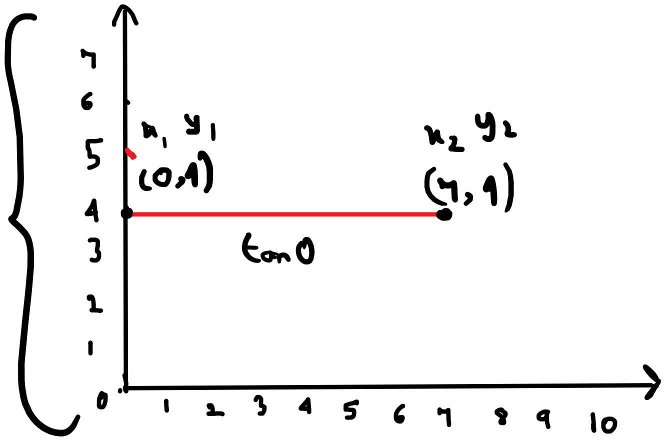
$$\text{slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{0 - 5}{7 - 7}$$

$$\Rightarrow \left[= \frac{-5}{0} = \infty \right]$$ perp



Slope = $\frac{\text{Change in } d}{\text{Change in } t}$ ← speed or velocity

velocity = $\left\{\frac{5\text{ km}}{0}\right\} = \infty$



$$\left[\frac{4-4}{7-0} = \frac{0}{7} = 0\right]$$ → velocity or speed

parallel

line is moving forward.

Object is not moving

$\left(\tan = \frac{P}{B}\right)$

line

[Problem with $y = mx + c$ form?]

[equation of line]

$\Rightarrow \boxed{y = \infty x + c}$ y intercept.

Slope is ∞

x ×

y ×

We need a different form.

$$\{[\{Ax + By + C = 0\}]\}$$

same line in different form. $\{m = \}$ y-int = }

$\left\{\left\{y = \left(\frac{1}{3}\right)x + \frac{7}{1}\right\}\right\}$ ⇒ Lets convert into $Ax + By + C = 0$ form

$y = mx + c$

$y = \frac{x + 21}{3} \Rightarrow 3y = x + 7 \Rightarrow [x - 3y + 21 = 0]$

Slope = 1/3
y-int = 7

$$\begin{cases} A = 1 \\ B = -3 \\ C = 21 \end{cases}$$

new formula for slope = $\left(-a/b\right)$

[new formula for y-intercept = $-c/b$]

if B = 0

$[Ax + C = 0]$ ✓ $[3x + 5 = 0]$ [infinity]

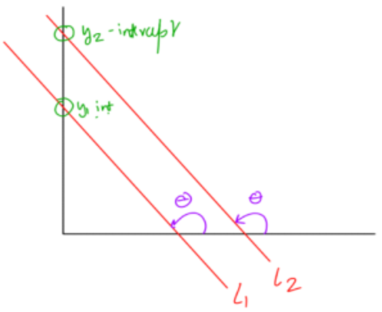
Slope = $-\frac{A}{B}$

y-intercept = $-\frac{C}{B}$

//

{parallel lines have the same slope!

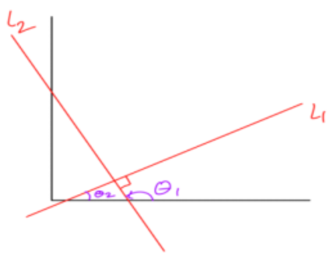
$m_1 = m_2$}



$m_1 \times m_2 = -1$

[Perpendicular Lines]

$$\left\{ \boxed{m_1 * m_2 = -1} \right\}$$



$\{m_1^? = -\frac{1}{m_2}$ | $l_1 \Rightarrow$ if y inc by 3u for 1u in x

line a and b are ⊥ slope of line a = 3

Slope of line b ? => -1/3

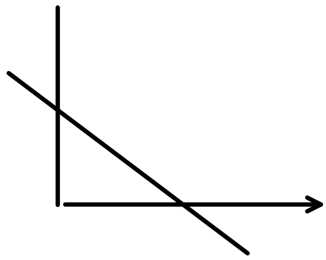
{$w_1, w_2 \Rightarrow$ Weights
$w_0 \Rightarrow$ Bias}

$\{ \underline{A}x + \underline{B}y + \underline{C} = 0 \Rightarrow [\underbrace{w_1}_{w_1} x + \underbrace{w_2}_{} y] + \underbrace{w_0}_{c_1} = 0 \}$

$$\{ \underline{A}x + \underline{B}y + \underline{C} = 0 \Rightarrow [\underbrace{W_1}_{w} x + \underbrace{W_2}_{} y] + \underbrace{W_0}_{w} = 0 \}$$

In ML $\Rightarrow$ $\left.\begin{array}{l} A = W_1 \\ B = W_2 \\ C = W_0 \end{array}\right\}$ { We call them Weights in ML }

$$\{ \underline{\text{slope}} = \left[-W_1 / W_2 \right] \quad [\underline{y_{int}} = -W_0 / W_2] \}$$

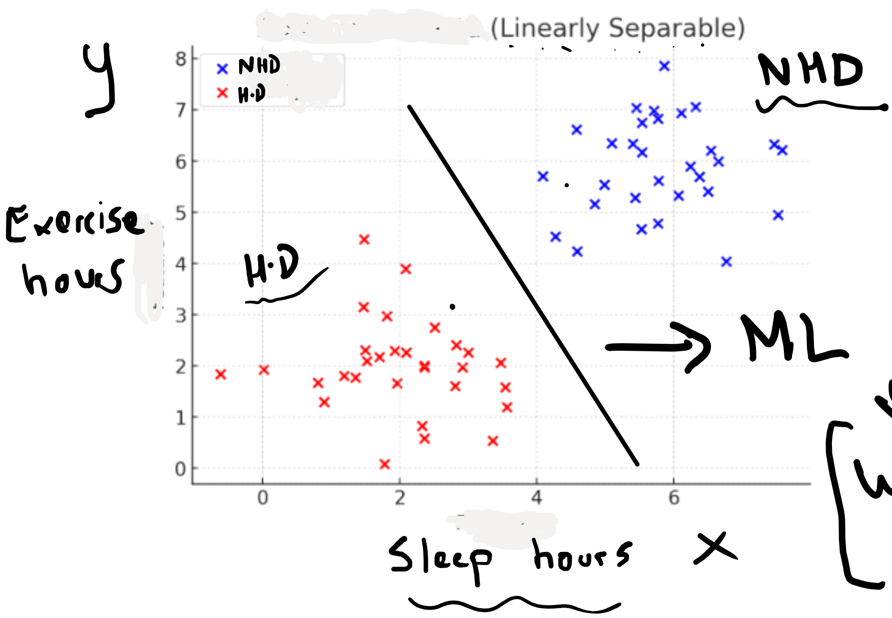


$$[W_1 x_1 + W_2 y + W_0 = 0 \Rightarrow 2D \rightarrow \text{Line}]$$

$$[W_1 x_1 + W_2 x_2 + W_3 y + W_0 = 0 \Rightarrow 3D \rightarrow \text{Plane}]$$

$$W_1 x_1 + W_2 x_2 + W_3 x_3 + W_4 y + W_0 = 0 \Rightarrow 4D \text{ or More } [\text{Hyperplane}]$$

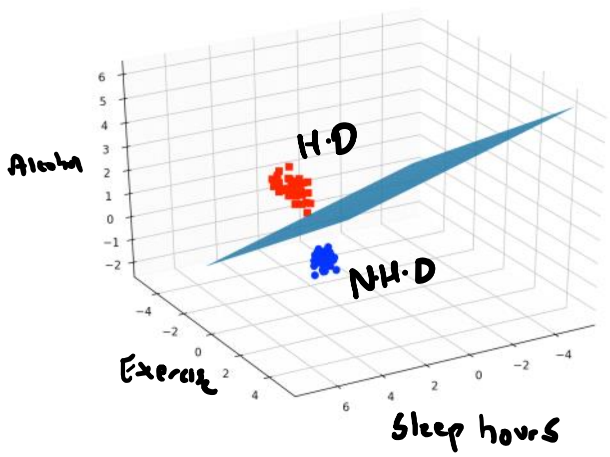
Why is all of the above important?



$\rightarrow$ ML model

$\Downarrow$

$$[W_1 x_1 + W_2 x_2 + W_0 = 0]$$



$$W_1x + W_2y + W_3z + W_0 = 0$$

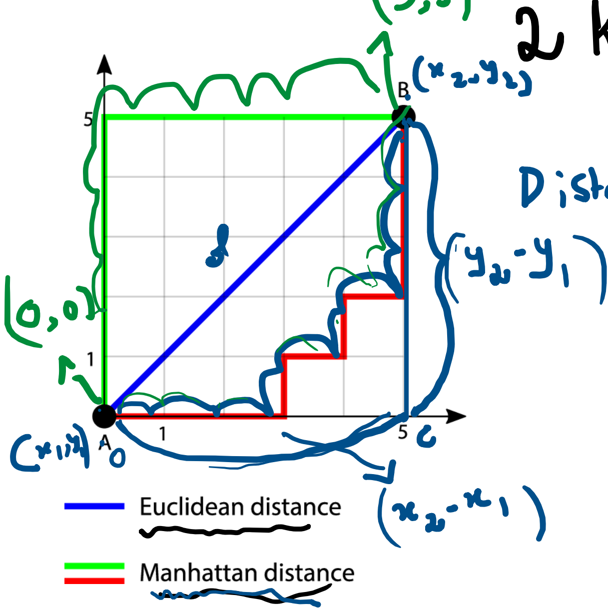
4 variables ?

x, y, z $\times$

$$\left\{ W_1x_1 + W_2x_2 + W_3x_3 \cdots\cdots + W_0 = 0 \right\}$$

Types of distance

12 October 2025 21:36



2 kinds of distances.

Distance b/w A and B

Pythagoras Theorem

$$(y_2 - y_1)^2 + (x_2 - x_1)^2 = d^2$$

Euclidean distance

Straight line distance

$$= \sqrt{(y_2 - y_1)^2 + (x_2 - x_1)^2}$$

Manhattan distance? $\Rightarrow |x_2 - x_1| + |y_2 - y_1|$

$$|5 - 0| + |5 - 0| = 10$$

[Some models use Euclidean dist]

[Some models use Manhattan distance]

Vectors

18 August 2025 19:44

What is a Vector?

Anything with Magnitude and direction

$\begin{bmatrix}4\\3\end{bmatrix} \Rightarrow \sqrt{4^2+3^2} = 5$

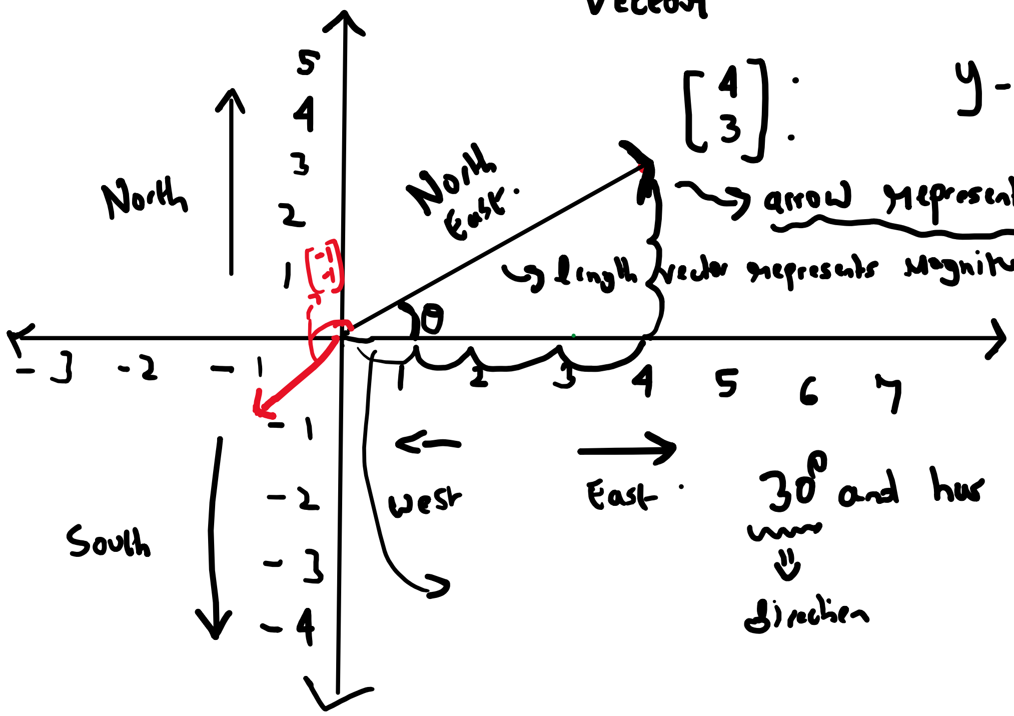
$\begin{bmatrix}x_1\\x_2\end{bmatrix} \Rightarrow \sqrt{x_1^2+x_2^2}$

Vector

X-Axis ⇒

y-Axis ⇒

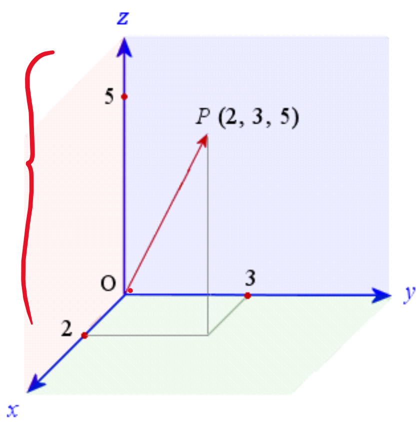
$\begin{bmatrix}4\\3\end{bmatrix}$



→ arrow represents the direction

→ length vector represents magnitude.

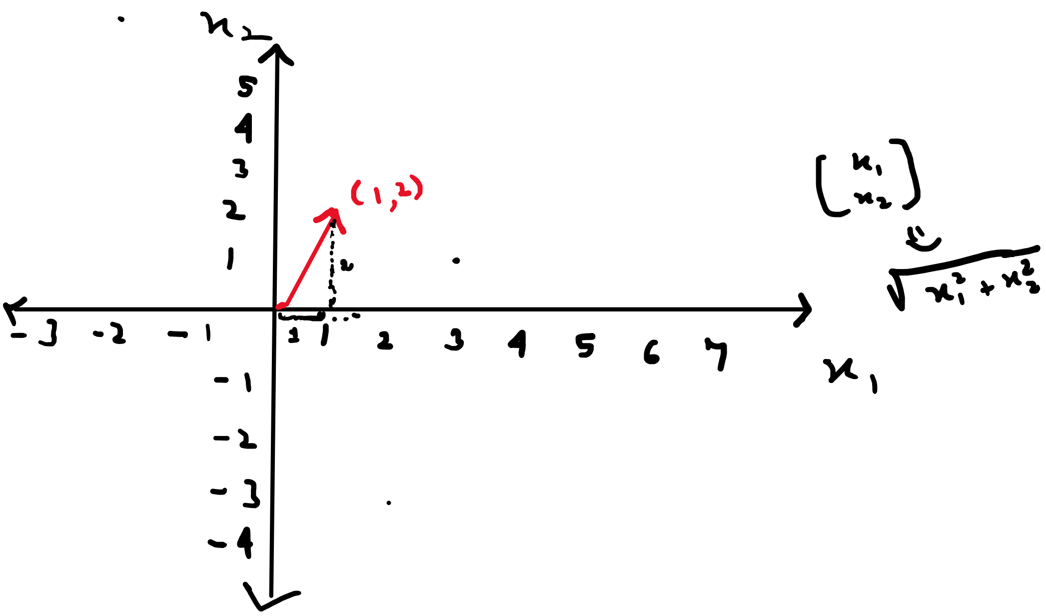
$\underbrace{30^\circ}_{\text{direction}}$ and has magnitude of $\underbrace{5}_{\text{Magnitude}}$



→ Vector in 3 dimensions

In Multiple dimensions $\rightarrow \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ \vdots \\ x_n \end{bmatrix} = \vec{x}$

Magnitude of a vector



Magnitude of $\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \sqrt{x_1^2 + x_2^2}$

Magnitude of $\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \sqrt{x_1^2 + x_2^2 + x_3^2}$

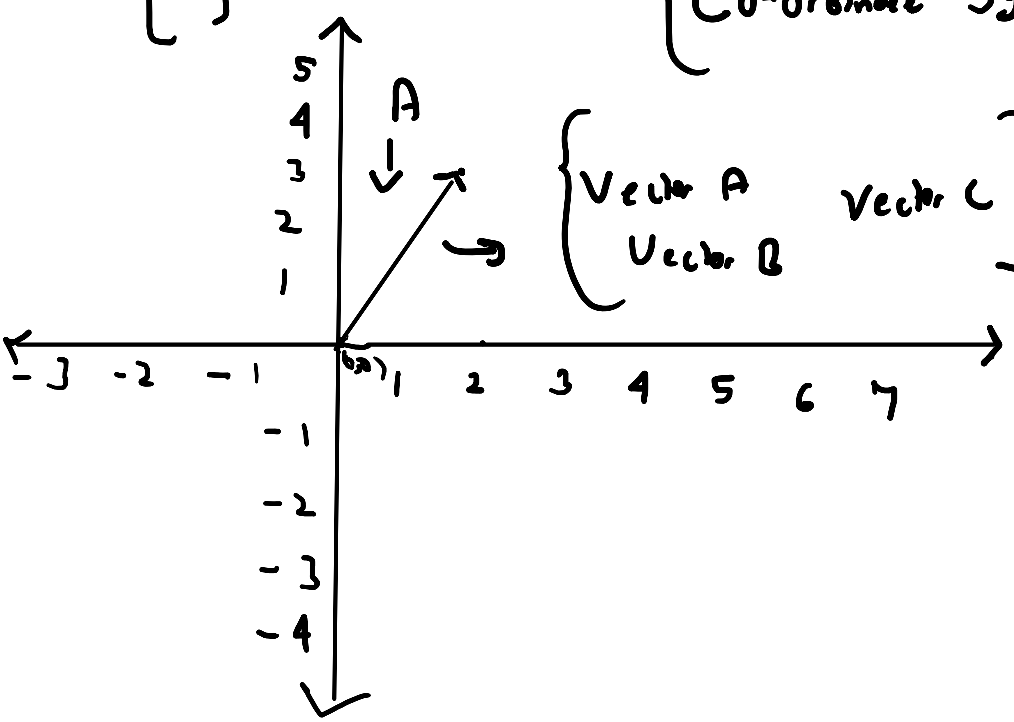
Magnitude of $\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} = \sqrt{x_1^2 + x_2^2 \cdots\cdots x_n^2}$

Does a vector have to start from the origin?

$$\left\{\begin{bmatrix}2\\3\end{bmatrix}\right\} \sqrt{2^2+3^2} = \sqrt{4+9} = \left\{\frac{\sqrt{13}}{\underline{60^\circ}}\right\}$$

[ ]

[Co-ordinate System]



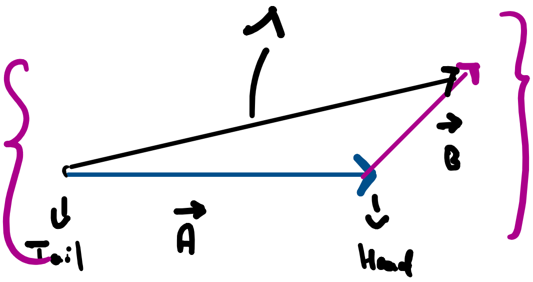
$\rightarrow$ {Vector A Vector B Vector C}

Vector Addition/Subtraction

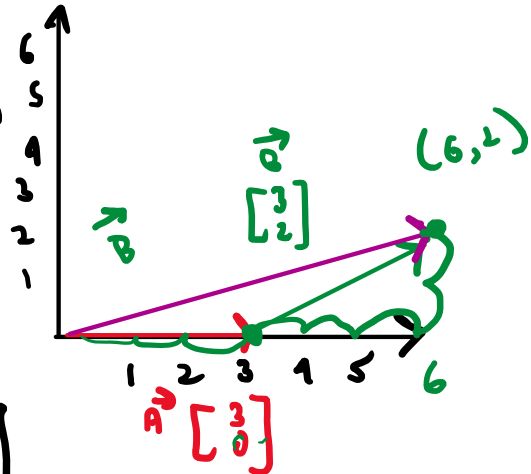
21 August 2025 20:48

$$\vec{A} + \vec{B} = \vec{C}$$

$$\begin{bmatrix}3\\0\end{bmatrix}+\begin{bmatrix}3\\2\end{bmatrix}=\begin{bmatrix}6\\2\end{bmatrix} \checkmark$$



Vector addition

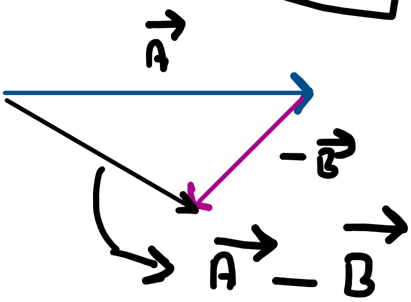


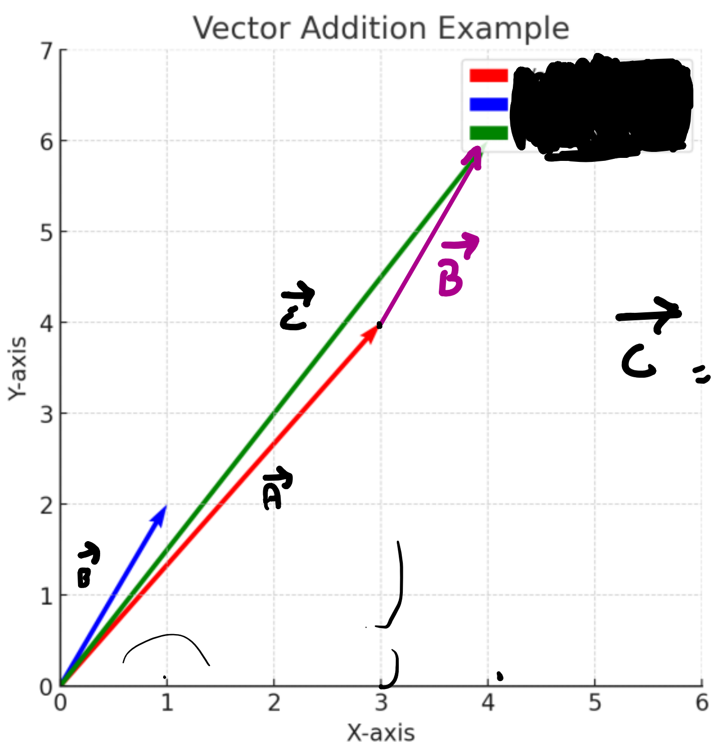
$\boxed{-\vec{B}}$

Vector Subtraction

$\Downarrow$

Addition in opposite direction





$$\vec{C} = \vec{A} + \vec{B}$$

$$\begin{bmatrix}3\\4\end{bmatrix}+\begin{bmatrix}1\\2\end{bmatrix}=\begin{bmatrix}4\\6\end{bmatrix}$$

A **vector is defined only by its magnitude and direction**, not by its absolute position in space.

Example:

Take $\vec{v} = (3, 4)$.

- If you draw it from the origin, it points to $(3, 4)$.
- But if you draw the *same arrow* starting from point $(10, 10)$, it will point to $(13, 14)$.

Adding vectors = combining movements

Think of a vector as "go this far, in this direction."

For example:

$\vec{A} = (3, 2)$ means:

- Move **3 units right** (x-direction),
- Move **2 units up** (y-direction).

2. Adding vectors = combining movements

If you then apply $\vec{B} = (1, 4)$, it means:

- From where you are, move **1 unit right** and **4 units up**.

So doing $\vec{A} + \vec{B}$ is like chaining the moves:

1. Start at origin.
2. Follow $\vec{A}$.
3. From there, follow $\vec{B}$.
4. Where you land is the new vector $(4, 6)$.

Dot Product

12 October 2025 21:52

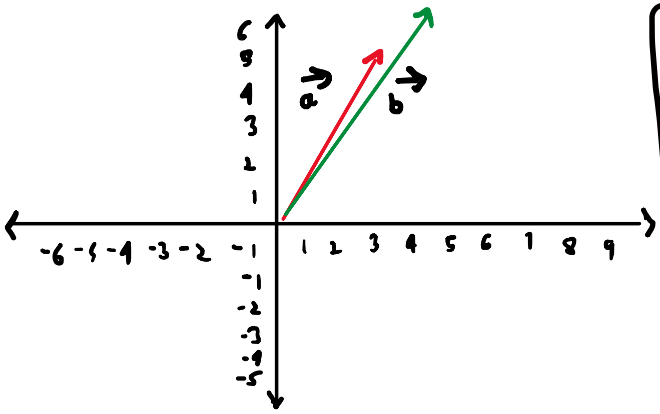
$\vec{a}$ $\begin{bmatrix}3\\5\end{bmatrix}$ $\vec{b}$ $\begin{bmatrix}4\\6\end{bmatrix}$

$\vec{a}$

$[3\ \ 5]\begin{bmatrix}4\\6\end{bmatrix} = 12+30$

$= \underline{42}$

Dot product

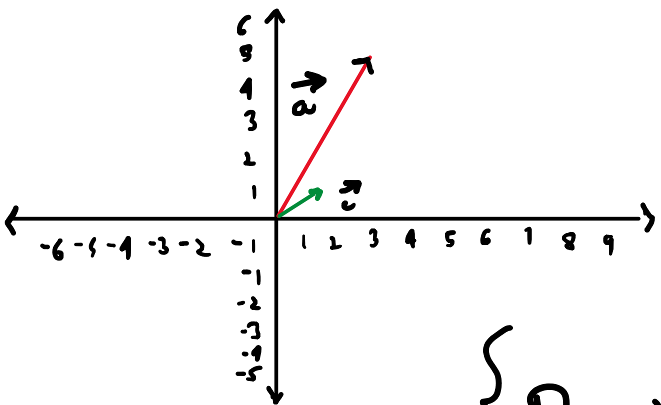


$[42]$

$\begin{bmatrix}9+25\\=34\end{bmatrix}$

$\vec{a}$ $\begin{bmatrix}3\\5\end{bmatrix}$ $\vec{c}$ $\begin{bmatrix}1\\1\end{bmatrix}$

$[3\ \ 5]\begin{bmatrix}1\\1\end{bmatrix} = 3+5 = 8$



$[8]$

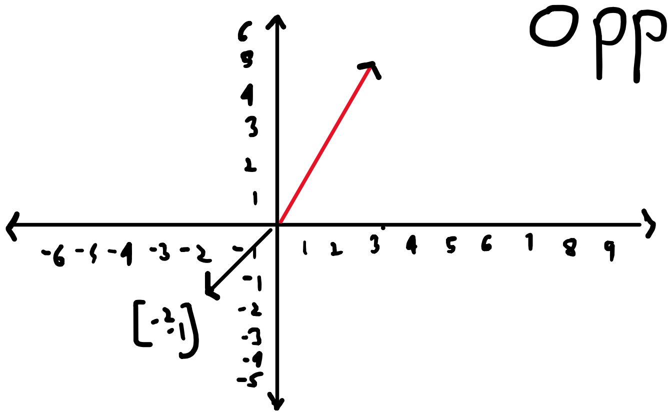
{Directional similarity}

(Higher the dot product of two vectors, higher the chance they will be similar in direction)

$\vec{a}$ $\begin{bmatrix}3\\5\end{bmatrix}$ $\vec{d}$ $\begin{bmatrix}-2\\-1\end{bmatrix}$ $= [3\ \ 5]\begin{bmatrix}-2\\-1\end{bmatrix} = \underline{-11}$

opposite directions

Opposite directions.



[is negative]

[Vectors are pointing in opposite directions]

$A = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \quad B = \begin{bmatrix} 1 \\ \sqrt{3} \end{bmatrix}$

$$\mathbf{a} \cdot \mathbf{b} = \|\mathbf{a}\| \, \|\mathbf{b}\| \cos\theta$$

$$1 = 1 \times 2 \times \cos\theta$$

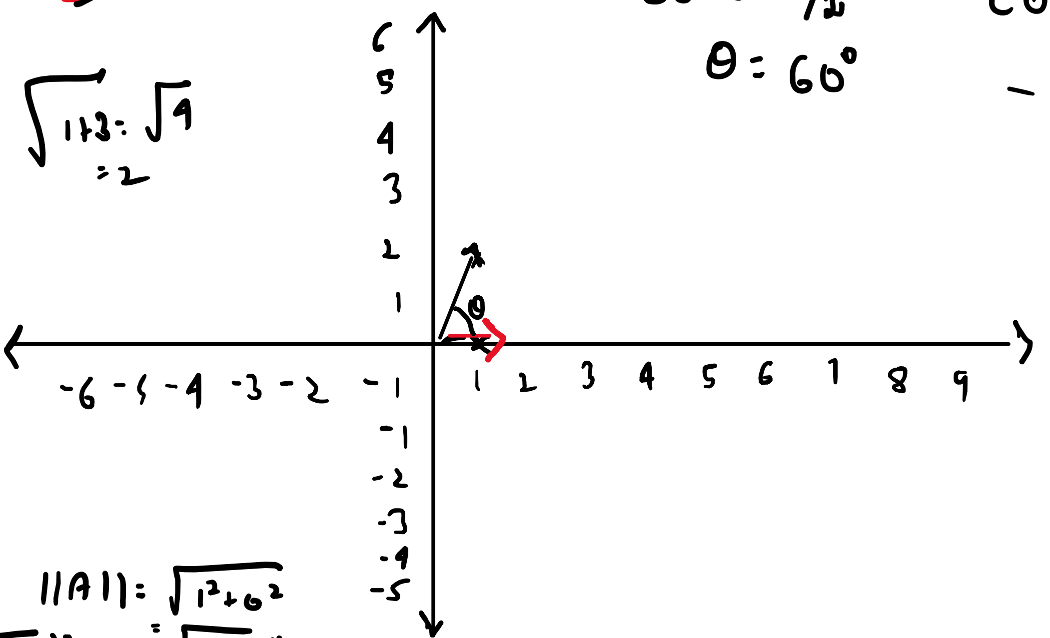
$$1 = 2\cos\theta$$

$$\cos\theta = 1/2$$

$$\theta = 60^\circ$$

$\cos 120^\circ$

$$\sqrt{1^2 + (\sqrt{3})^2} = \sqrt{1+3} = \sqrt{4} = 2$$



$[1, 0] \quad [-1, \sqrt{3}] \quad \|A\| = \sqrt{1^2 + 0^2} = \sqrt{1} = 1$

$\sqrt{(-1)^2 + (\sqrt{3})^2} = \sqrt{1+3} = \sqrt{4} = 2$

$\vec{A} = [1, 0], \quad \vec{C} = [-1, \sqrt{3}]$

$\{a \cdot b < 0\} \Rightarrow$ Obtuse or More than 90°

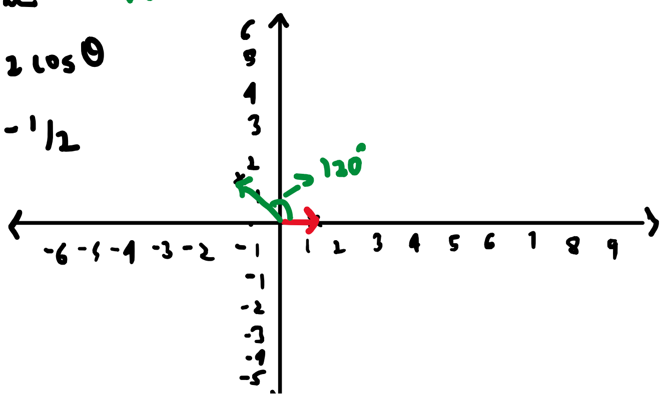
$\|A\|$

$-1 = 1 \times 2 \times \cos\theta$

$= -1 = 2\cos\theta$

$\cos\theta = -1/2$

$\theta = 120^\circ$



-2
-3
-4
-5

[np.dot(a,b)]

{Trigonometric Identities}

[$\sin\theta$, $\cos\theta$, $\tan\theta$]