1. ~~**Vector and Scalar Quantities** - Look for explanations that differentiate between these two types of quantities, emphasizing how vectors have both magnitude and direction, while scalars only have magnitude.~~
2. ~~**Rectangular Coordinates** - Search for tutorials explaining how vectors can be represented using x and y components in a Cartesian coordinate system.~~
3. **Polar Coordinates** - Find resources that demonstrate how vectors can be represented using magnitude and angle, often expressed as r and θ.
4. ~~**Engineering (i,j,k) Notation** - This notation represents vectors using unit vectors along the x, y, and z axes respectively. Search for tutorials explaining this notatibon and its application in representing vectors.~~
5. ~~**Physical Diagrams and Verbal Descriptions** - Seek explanations that illustrate vectors using diagrams and verbal descriptions to understand their direction and magnitude.~~
6. ~~**Position Vectors** - Look for explanations that delve into how position vectors denote the position of a point in a coordinate system relative to an origin.~~
7. **Resultant of Two Vectors** - Search for tutorials that demonstrate how to find the resultant vector when two vectors act together, both graphically and mathematically.
8. **Relative Velocity in 2-Dimensions** - Focus on resources explaining how to compute relative velocities when dealing with motions in two dimensions.

TYPES OF QUANTITIES

Scalar Quantities	Vector Quantities
A physical quantity that only uses a value with a unit	A physical quantity that uses a value with a unit and direction
It has no direction	It has a direction
Mass – length – time – density – temperature	Displacement – velocity - acceleration
Mass = 50 kg	Displacement = 50 m, east

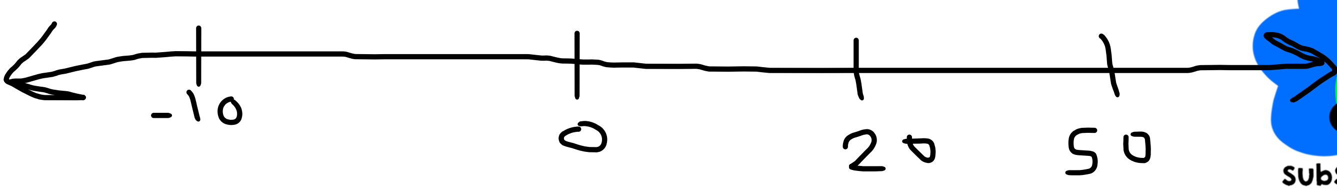
In venctors

If you see a value between two abs like this ||x||
this value is the magnitude of a vector

Coordinate systems

One-dimensional coordinate system

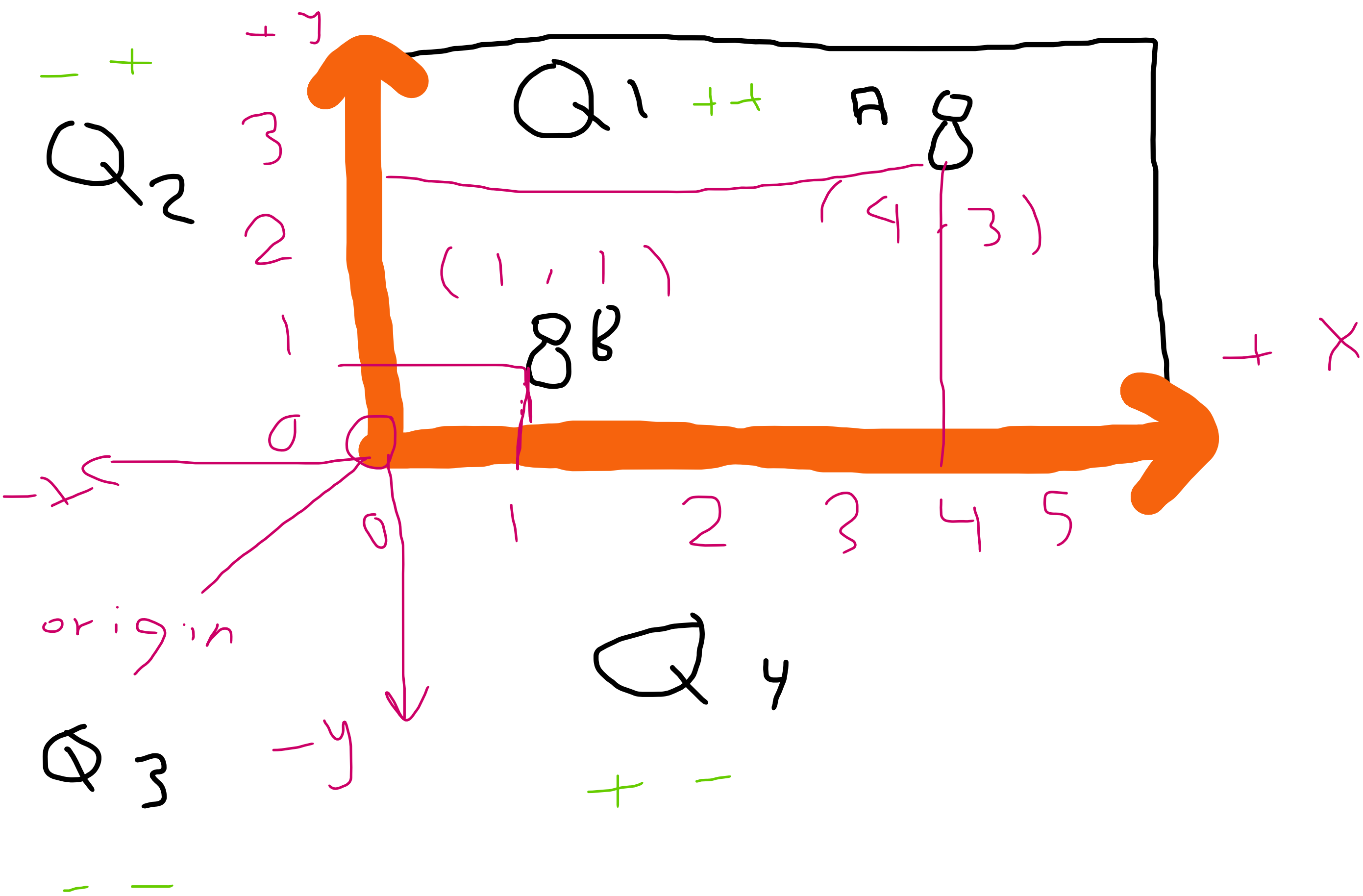
It means moving in a line, we have talked about it in the previous 3 Los, it has a single axis which we call x you can designate it with a number



Rectangular Coordinate system

It's a system that has two axes, X & Y, you cant tell where something is just with a number, you would need a vector of (x, y)

Imagine a soccer field or a 2D top-down game



It can be called

- X-y plane
- Coordinate plane
- Cartesian Coordinate system

Polar Coordinate system

It's an alternative way to describe points in 2D, unlike the rectangular coordinate system which uses perpendicular axes (x,y), it uses a different system involving

> **Radial distance (r)** represents the distance from origin point to the point in question, it is always positive and it equals the magnitude of the vector from origin to the point
>
> **Angle (Θ)** is measured counterclockwise from a reference direction often the positive x axis in the rectangular system, if you got it in radian, convert it into degree, and if you saw π then multiply by 180

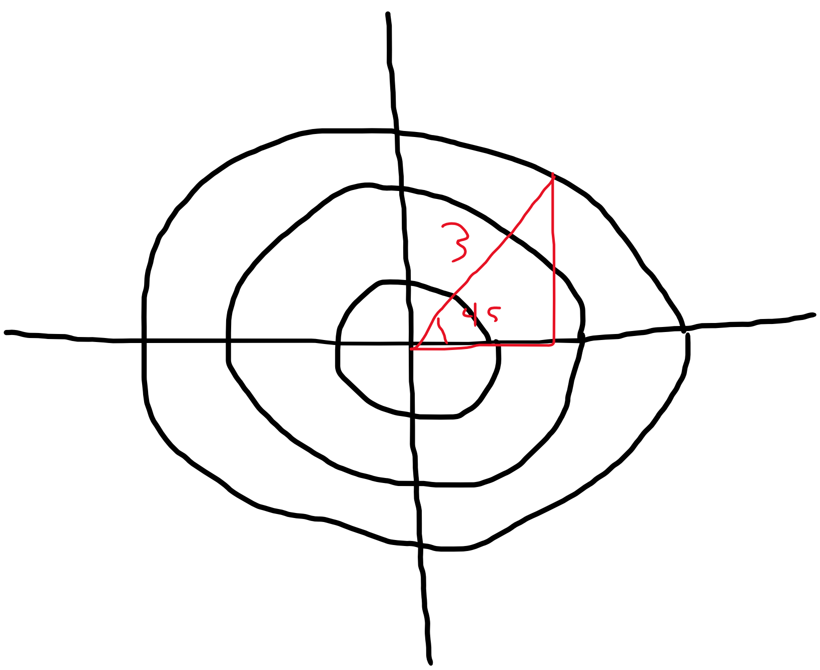
How to convert polar coordinates to cartesian

- $x = r * \cos(\Theta)$
- $y = r * \sin(\Theta)$

How to convert cartesian coordinates to polar

- $r = \sqrt{x^2 + y^2}$
- $\theta = \arctan(y/x)$ or $\tan^{-1}(y/x)$

so let's say we have the polar point of (3 , 45°)



Well, what if r is negative

So let’s say we have two points in polar coordinations (r, ϴ)

A - (-2, 60)

B - (2, 60)

To convert a negative R into a positive r, just add 180 on the angle

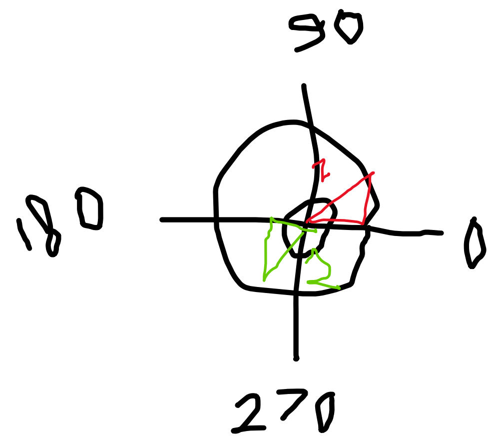
So instead of A (-2, 60) there is A (2, 240)

And now do your conversions easily

And if you want R positive to turn to negative, just check if the angle is > 180

You can subtract by 180 and make r negative

If ϴ was negative, just get it’s positive equivalent or add 360



1. (r, θ) $\quad -2\pi$
2. $(r, -\theta)$
3. $(-r, \theta)$ $\quad \pm\pi$
4. $(-r, -\theta)$ $\quad -2\pi$

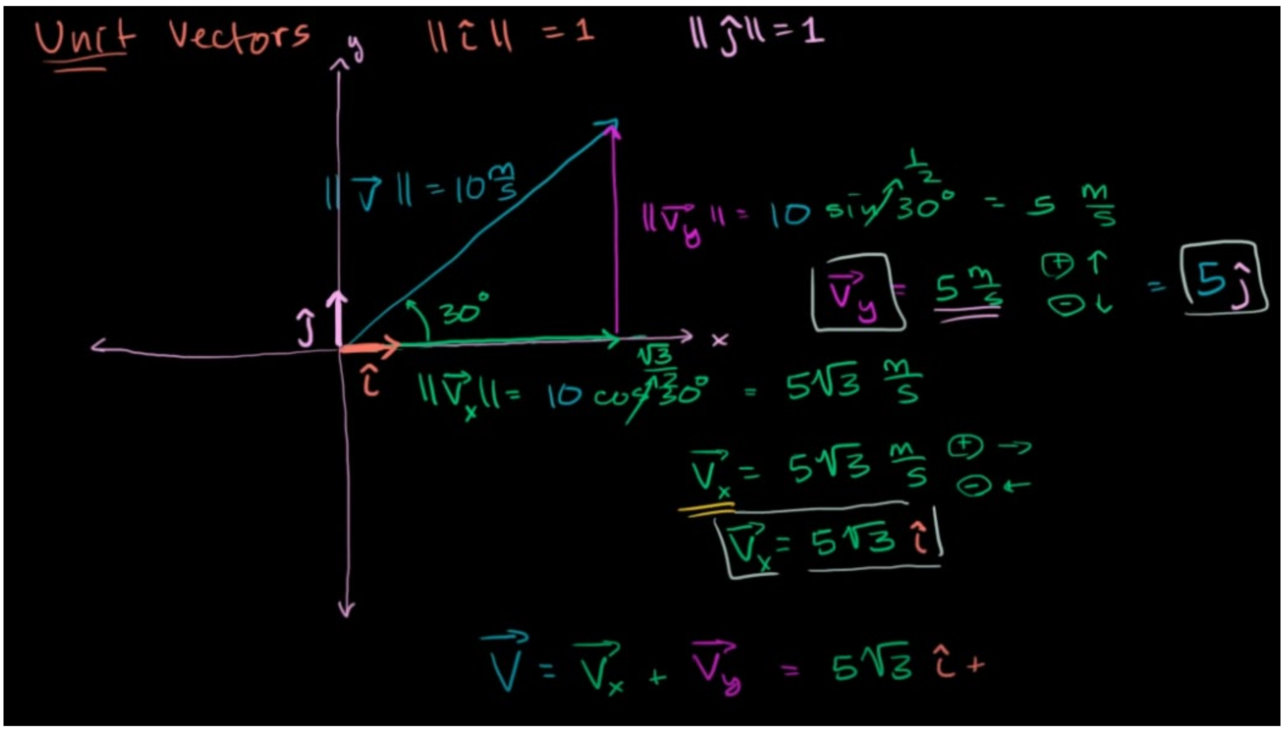
The ijk notation or **engineering notation** or **vector notation** is a way to represent vectors using unit vectors along the different axes

i –> represents the unit vector along the x axis (1, 0, 0)

j –> represents the unit vector along the y axis (0, 1, 0)

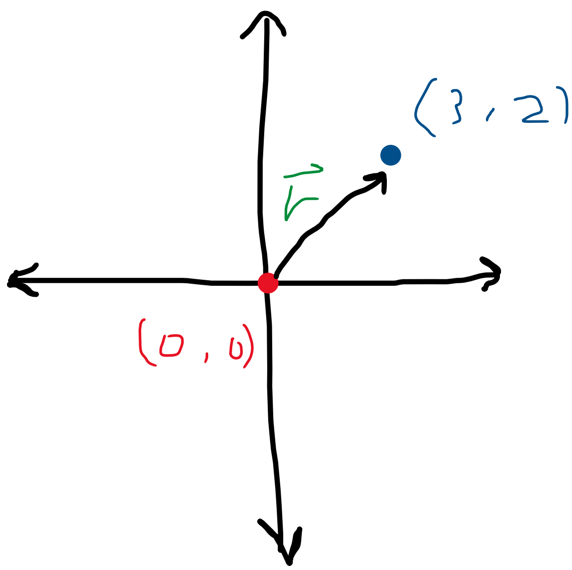
k –> represents the unit vector along the z axis (0, 0, 1)

imagine a vector V (1, 1, 1)
then V = i + j + k = (1,0,0) + (0,1,0) + (0,0,1) = (1,1,1)
when multiple i by something, we are changing the x value, same with j, k



Position Vectors

It’s a vector that starts from the origin point and points to a point in space, it is represented by $\vec{r}$



$$\vec{r} = (x_1 - x_2,\ y_1 - x_2) \quad \text{OR}$$

$$(x_1 - x_2)i + (y_1 - y_2)j$$

So $\vec{r}$ in this scenario is (3-0)i + (2-0)j = (3, 0) + (0, 2) = (3, 2)

So the magnitude or $|\vec{r}|$ is $\sqrt{x^2 + y^2} = \sqrt{13}$

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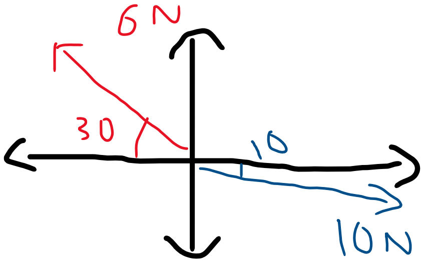
How to find the resultant of two vectors?

If the vector is in polar



1-determine the x,y vector of each

$(-3\sqrt{3}, 3)$ $(9.8, -1.7)$

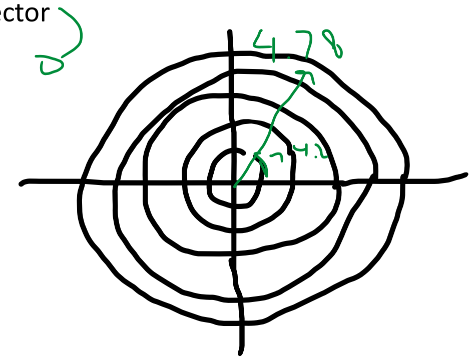
2-now add the two vectors

$(4.6, 1.3)$

3-get the result

$(4.78, 74.2^{\circ})$

4-turn it into a polar vector



If the vector is in cartesian

1-add the two vectors

2-get the result

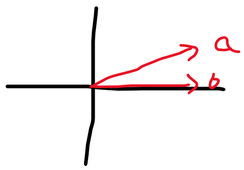
MULTIPYING TWO VECTORS ($\boldsymbol{a} \cdot \boldsymbol{b}$)

You have two ways, the **dot product** and the **cross product**

THE DOT PRODUCT

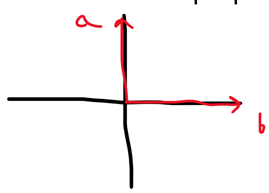
It explains how much the two vectors align, when it's

- **positive ->** the vectors point in similar directions



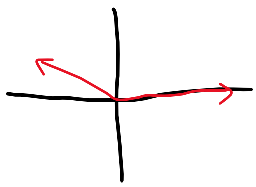
$a \cdot b > 0$

- **zero ->** the vectors are perpendicular



$a \cdot b = 0$

- **negative ->** the vectors point in opposite directions



$a \cdot b < 0$

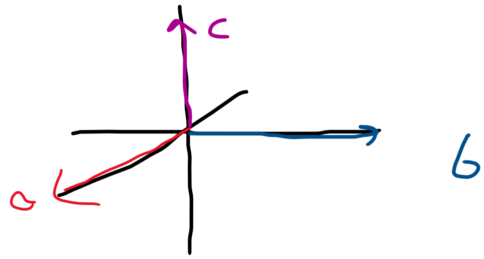
let's Imagine that you have vector **a (a_1 , a_2 , a_3)** and vector **b (b_1 , b_2 , b_3)**

then **($\boldsymbol{a} \cdot \boldsymbol{b}$)** = ($a_1$ * b_1) + (a_2 * b_2) + (a_3 * b_3)

if it's a 2 axis vector, just remove a_3 and b_3

THE CROSS PRODUCT

It's gives a new vector that Is **perpendicular** to the plane formed by the original two vectors



$$\mathbf{A} = \langle a_1, a_2, a_3 \rangle$$
$$\mathbf{B} = \langle b_1, b_2, b_3 \rangle$$

The cross product $\mathbf{C} = \mathbf{A} \times \mathbf{B}$ is a new vector with components:

$$c_1 = (a_2 \cdot b_3) - (a_3 \cdot b_2)$$
$$c_2 = (a_3 \cdot b_1) - (a_1 \cdot b_3)$$
$$c_3 = (a_1 \cdot b_2) - (a_2 \cdot b_1)$$

So, the resulting vector $\mathbf{C}$ is given by:

$\mathbf{C} = \langle c_1, c_2, c_3 \rangle$

If x -> cross multiplicate y and z

If y -> cross multiplicate x and z

If z -> cross multiplicate x and y

RELATIVE VELOCITY IN 2D

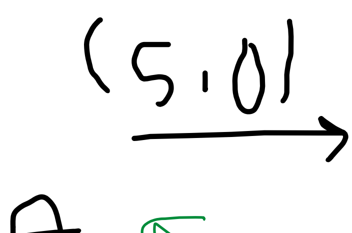
If the velocities are in cartesian

1-new X = object X – observer X

2-new Y = object Y – observer Y

3-and you have the new vector which is the relative velocity

So let's say we have an observer moving at (5,0)m/s



And an object moving at (0,6)m/s

The relative velocity is

(0-5, 6-0) = (-5,6)m/s

If it gave you the polar vectors

1-turn each polar into its respective vector coordination

2-do the calculations like “vectors”

3-turn the result into polar

4-you have the relative velocity in polar