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

Position and displacement

What's the difference?

Position is the **location** of something in a given moment of time **relative** to another thing called **the reference frame**

Displacement is the difference between an object's position from one time to another, it's the **change in position**

So let's say I was in the kitchen and I'm now in the living room, my position relative to the kitchen changed, that's what I call **Displacement**

It can be calculated using

[**Displacement = final position – initial position**]

[$\Delta x = xf - x0$]

it’s a **vector quantity** so we say it like Displacement = [50 m, east]

Time and Elapsed Time

Time is basically the **progression of events** from the past to the present to the future, it’s defined in physics as a fundamental quantity, it’s measured most accurately using an atomic clock

Elapsed Time is the amount of time that passes from the start of an event to the end of it, or it’s the **Difference** between two times

Velocity

Velocity is the speed and direction of an object’s motion, something like velocity = 60 km/h east

It has three types

- **Average velocity** is the total displacement divided by the total time the displacement took
  You calculate it using [$avg\ velocity = \frac{total\ displacement}{total\ time}$]
- **Instantaneous Velocity** is the velocity at a specific point in time, it’s like taking a photo of a moving object and getting it’s velocity at this specific snapshot
- **Negative velocity** is the same velocity but in the opposite direction to the same velocity but in positive

Speed

It’s the rate at which an object covers distance, or “how fast the object is going”

It’s calculated using a distance by time ratio

$$speed = \frac{distance}{time}$$

Speed is a scalar quantity so it does not tell us anything other than how fast is the object, no direction or whatever, that’s why there is no such thing as negative speed, because it has no direction

Acceleration

It’s the rate at which an object changes it velocity, it caused by changing speed (up or down) or changing directions (like moving in a circle)

It’s a vector quantity that is represented by the unit of distance divided by time squard m/s^2

It has **Two types**

Average acceleration

It’s the change of velocity divided by the total change time

$$avg\ acceleration = \frac{change\ in\ velocity}{total\ change\ time}$$

So let’s say a car has sped up from 4m/s to 12m/s in the span of 4 seconds

It’s avg acceleration is $8/4 = +2m/s^2$

Instantaneous acceleration

It’s the acceleration of an object in a specific point in time, so let’s say a car is speeding up and you took a photo, the car in this moment has an acceleration of about $+5m/s^2$, this is called “instantaneous acceleration”, or it’s like the change of velocity divided by a small time interval

Positive acceleration -> speeding up in a positive direction

Slowing down in a negative direction

Negative acceleration -> slowing up in a positive direction

Speeding up in a negative direction

It’s often called “(deceleration)”

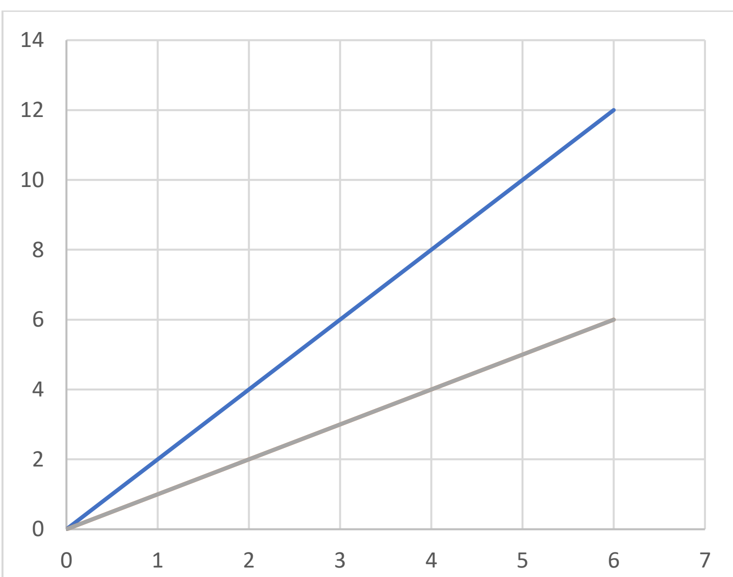
Graphical analysis

Every graph has 4 key elements

Slope

it represents the steepness of the graph, it’s measured by dividing the change in the Y axis by the change in the X axis

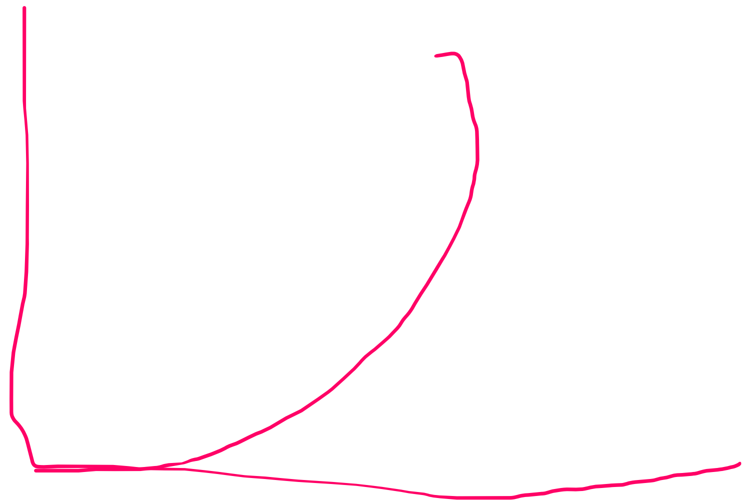
the higher the slope value is, the steeper the graph



The blue line has a slope value of 2 -> Δx = 1 & Δy = 2

The grey line has a slope value of 1 -> Δx = 1 & Δy = 1

A parabolic curve means that the slope or change rate is not constant



Area under curve

it’s the area enclosed between the curve and the x axis

imagine this

we all know that **work = displacement x force**

so if I used 4 constant newtons of force to push something for about 5 meters

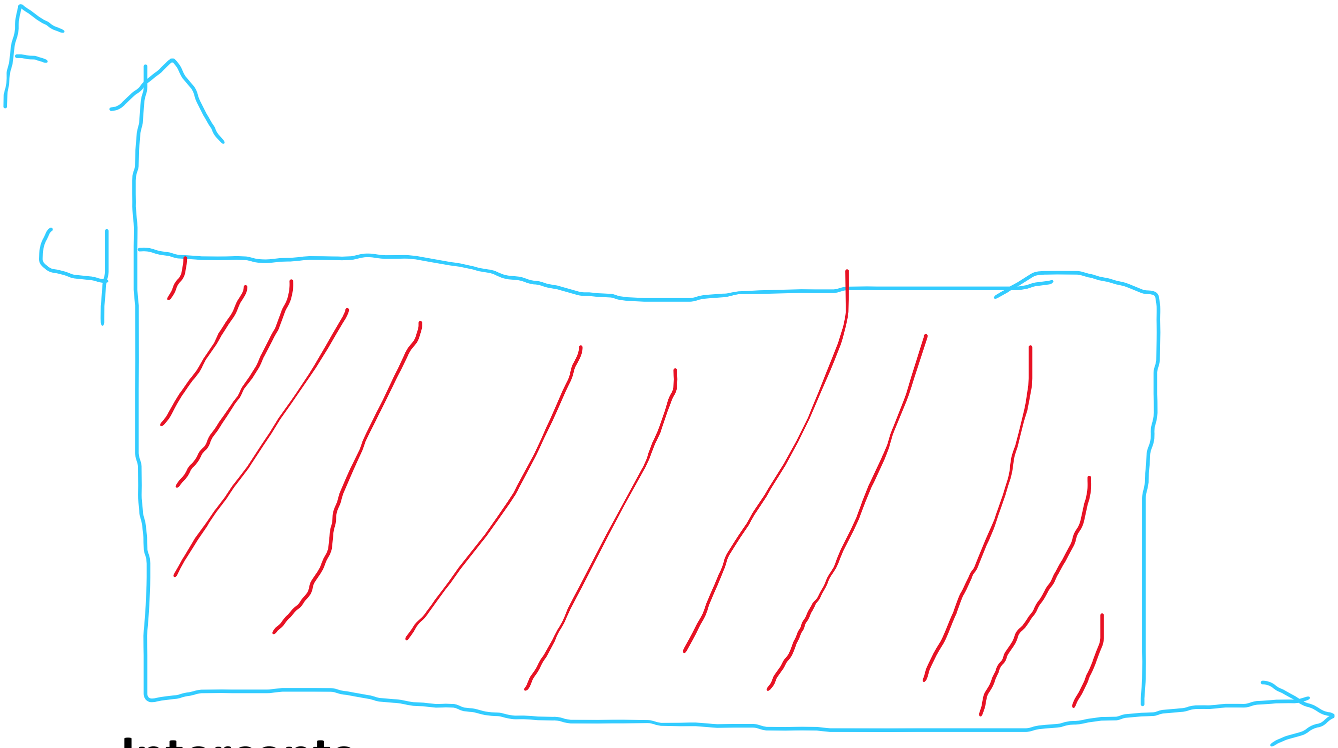
the work will be +20 j

observation

you would see a rectangle enclosed between the force curve and the displacement x axis

and the rectangle has an area of about 4 x 5 = **20**

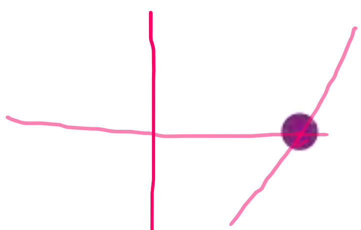
SO THE AREA UNDER CURVE EQUALLED THE ACTUAL LAW



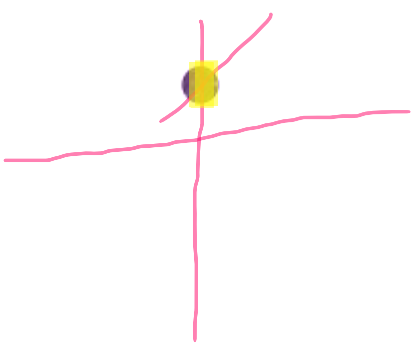
Intercepts

They are the point where the line crosses the x or y axes

X intercept -> line cross x axis



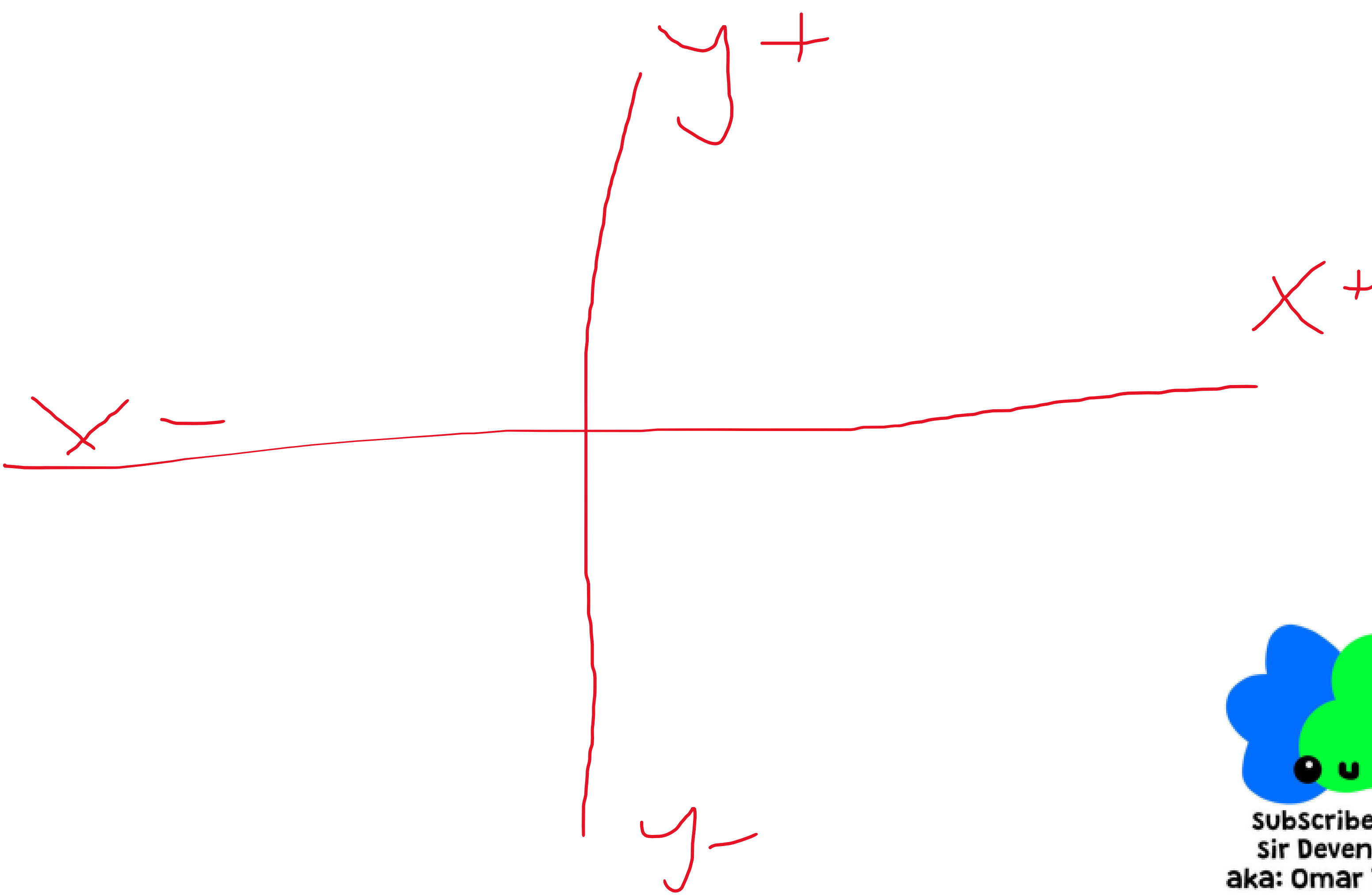
Y intercept -> line cross y axis



Trends

They are patterns and points that are suggested by data points

Upward trend on both axes means that we are going upwards from left to right

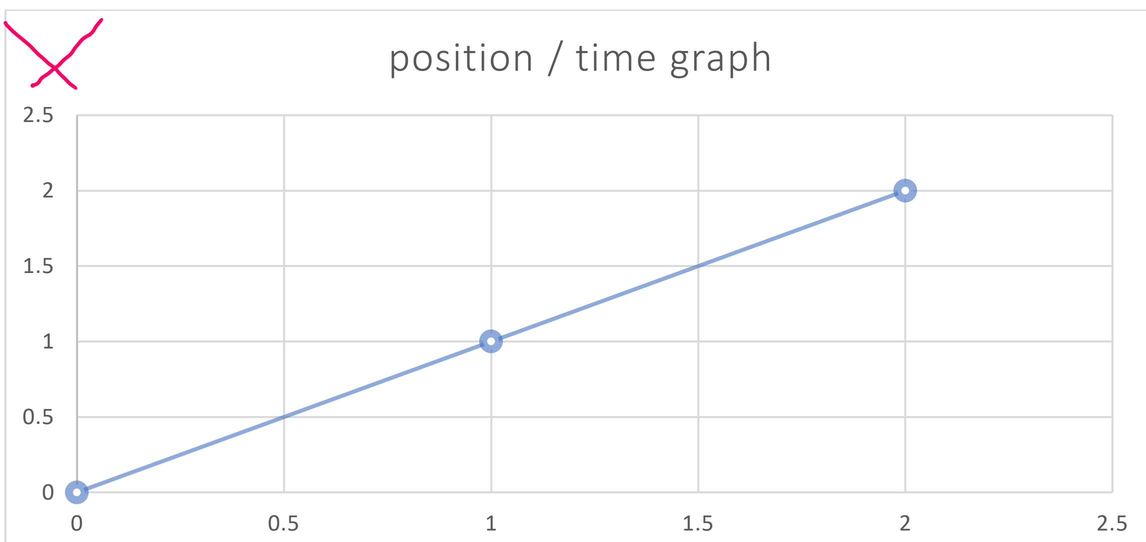


Position time graph

Slope > object's velocity at that instance (instantaneous velocity), because velocity is the changing rate of position

Area > null, because position x time does not mean anything in physics

$$\frac{D}{T} = V$$

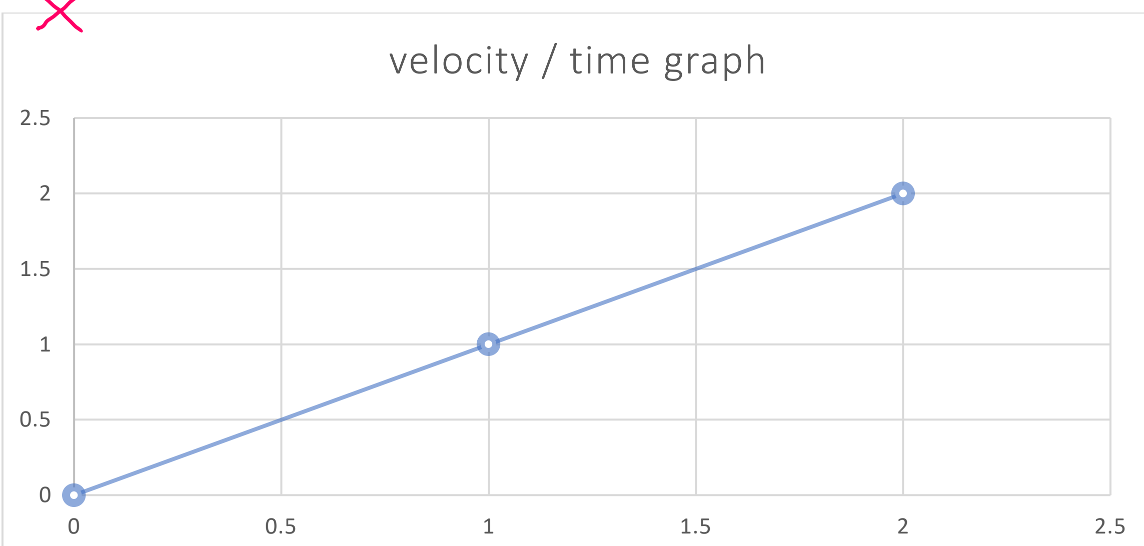


Velocity time graph

Slope > object's acceleration at that instance (instantaneous acceleration), because acceleration is the changing rate of velocity

Area > displacement at that instance, because displacement is the product of velocity and time

$$\frac{D}{T} = V \quad \frac{V}{T} = A$$



Acceleration Time graph

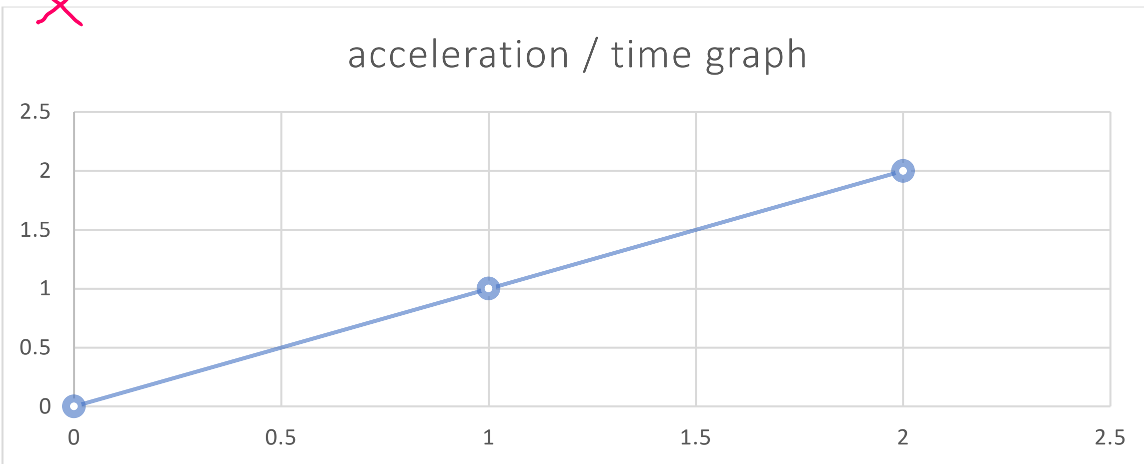
Slope > change rate of acceleration (jerk), like a care increasing it's speed at changing rates

Area > the change in velocity, because change of velocity is product of acceleration and time, how? Let me explain

$$\frac{A}{T} = J$$

$$\frac{V}{T} = A$$

So let's say



In 2 seconds, my speed changed by +2m/s
because it might have the same unit as velocity

But that acceleration x time = the amount of velocity that will be added

Relative Velocity

It's the velocity of an object as observed from another object (observer)

It's the difference between velocities measured to the same reference frame

You have 3 scenarios

Observer is moving in the same direction

Relative velocity = actual velocity - observer velocity

Relative velocity < actual velocity

Observer is moving in the opposite direction

Relative velocity = actual velocity + observer velocity

Relative velocity > actual velocity

Observer is static

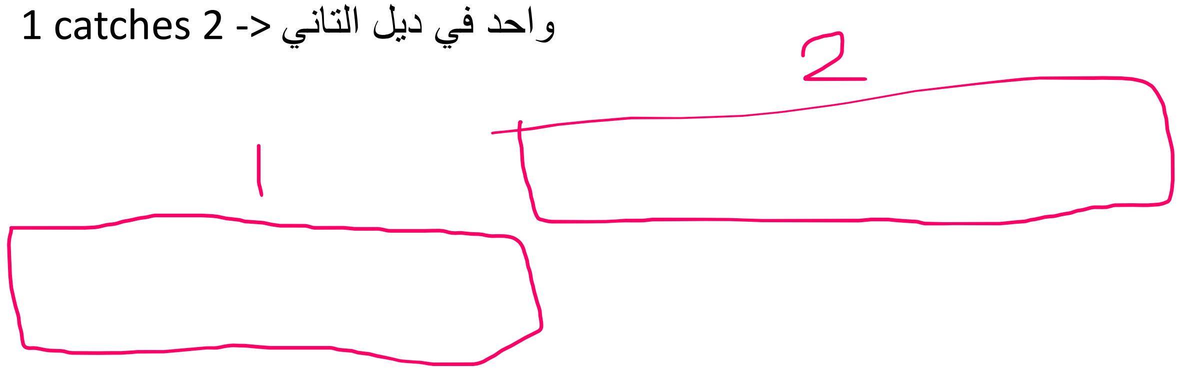
Relative velocity = actual velocity

When we have two objects moving at opposite direction and have a space between them, how to calculate the time?
(1) get the relative velocity
(2) distance / relative velocity = time
if you want to get the space then

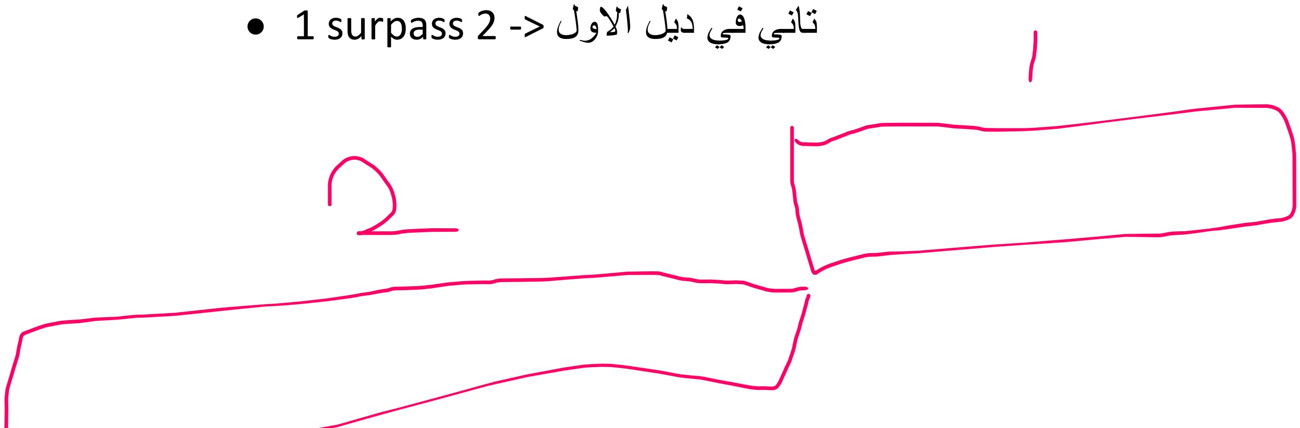
Relative velocity x time = space

when he gives you trains, lets say 1 and 2, if he said

- 1 catches 2 -> واحد في ديل التاني



- 1 surpass 2 -> تاني في ديل الاول



The Reference Frame

It's a coordinate system or set of axes that we use to describe motion

For example

- If we have a ball and we set the reference frame to you
  The ball is static
  But if we set the reference frame to the sun
  The ball is moving
- If rightwards is a positive direction, then displacement to the right is positive and negative if left

What does it mean to stay still?

It means not changing location while having 0 acceleration and velocity relative to the reference point

Will it ever be the case that all observers agree on the motion of an object?

Yes, but when they are all not moving relative to each other, because motion is relative to the observer's reference frame

Relation with the capstone

This LO can help with predicting with the water flow and vector value will help with measuring pressure, and how much stress can it handle, we can also use graphical analysis to help with making a solid data-set

IMPORTANT

- To convert km/h to m/s you multiply by $\frac{5}{18}$ and divide if otherwise
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