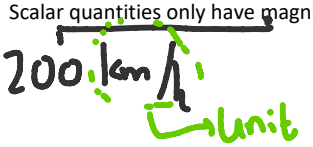
Motion

Tuesday, September 1, 2020 9:41 PM

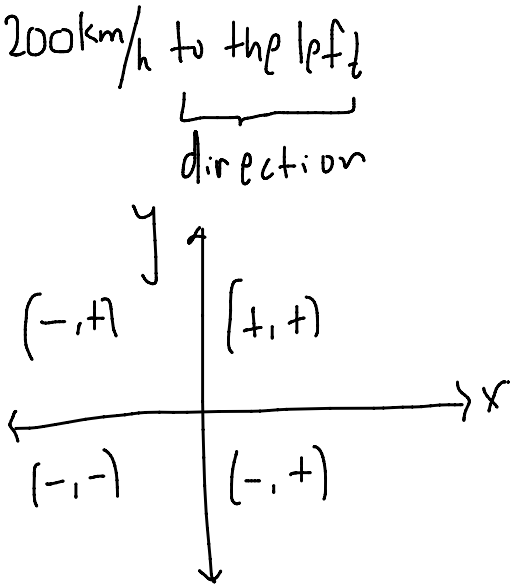
1.2:

Before delving into motion, it is important to understand the difference between scalar and vector quantities.

Scalar quantities only have magnitude.



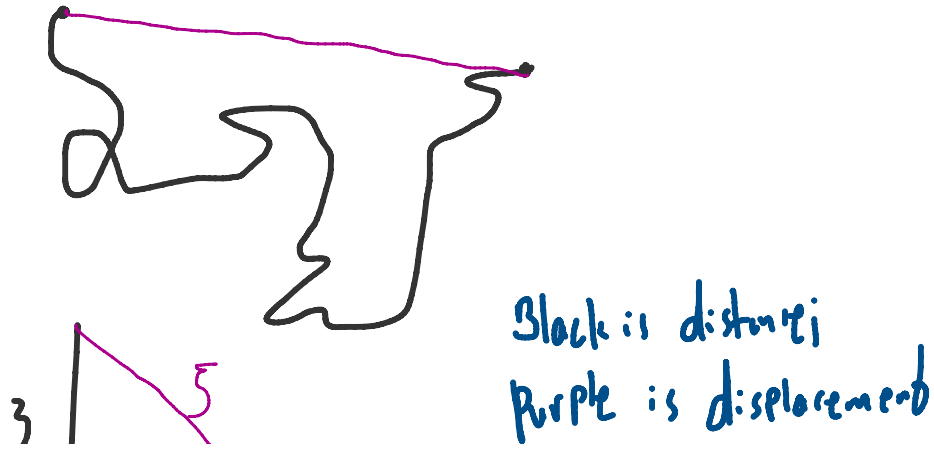
Vector quantities have both magnitude and direction.

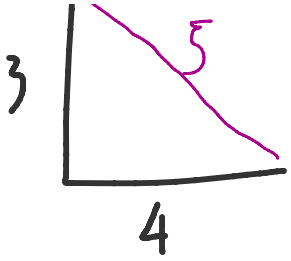


In Physics, a negative sign does not mean that the value is less. It means that the direction is the opposite. Take an example when Mike walks 5m. He then walks -5m. This means that, assuming (+) is to the right, he walks 5 meters to the right and then 5 meters to the left.

Displacement vs Distance

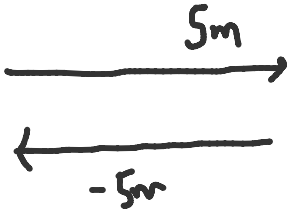
The simplest way to differentiate displacement and distance is that distance is the total length you travel whereas displacement is the short distance or the short cut. It is also known as the distance from your starting point directly to the end point. If I were to travel around a circle with radius 25m, distance covered would be its circumference whereas displacement would be zero.
Take an example below.





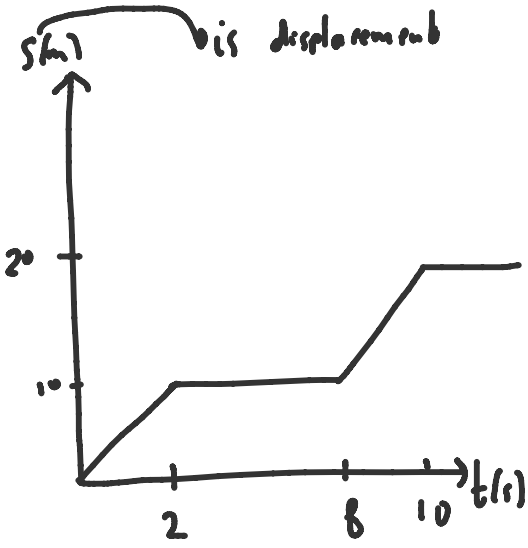
Purple is displacement

A major difference between displacement and distance is that **displacement is a vector quantity** whereas **distance is a scalar quantity.** The difference simply lies in this example. It would have not made a difference if I walked 5 m to the right and then 5 back. The distance would be 10m. If it is displacement, it is a different case.



Take note that when it is to the right, we took it as positive 5m. Hence, when travelling back, which is in the opposite direction, we placed a negative sign and hence, displacement would be 5 + -5 = 0m

With this knowledge, we can construct graphs. **Graphs are especially useful in Physics as not only does it represent relationships between two variables, it helps us visualize information for it to be easily interpreted.**



This graphs has presented us valuable information. First of all, we know the object has started from rest or in a sense, not moving. Then, in 2 seconds time, it was able to travel 10m. Then, it stopped moving for 6 seconds and continued moving for another 2 seconds until it reached 20m. Then, it stopped moving again.

From the graph, we able to obtain another precious information. From t= 0 to t=2, it was able to cover 10m. This tells us about its speed or velocity. The difference would be explained below but right now, it is apparent that if we divide displacement by time, we can another value, which is velocity.

Hence, we get $velocity = \frac{10-0}{2} = 5m/s$

This is its gradient or otherwise known as its slope.

Now, this may seem confusing but it really is not. The speed/velocity of an object is merely the total distance it has covered divided by the time it takes.

From the graph, we then can tell in 2 seconds time, it would have travelled 10m and hence, it was travelling at a speed of 5m/s.

I have been using speed and velocity interchangeably. It is just like displacement and distance. Velocity has direction whereas speed doesn't. As simple as that.

From the graph, we are also able to tell, from t=8 to t=10, it was travelling at the same speed as in also 2 seconds time, it also travelled (20-10 =10m).

Hence, with the graph above, we are able to tell that velocity is the rate of change in velocity. **What is 'rate of.' It basically is a value divided by change in time.**

$$v = \frac{\Delta s}{\Delta t}$$

$F = \frac{\Delta p}{\Delta t}$ ∴ rate of change in momentum

Hence, speed is also simply the rate of change in distance, instead of displacement. With this in mind, we are able to construct graphs for these values.

We can deduce from this graph that the object, initially at rest, is increasing its velocity. What do we say about this type of motion?

We say it is accelerating.

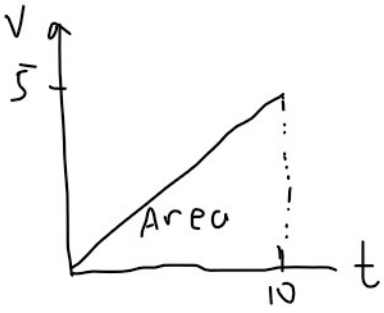
Now, what is the value for this acceleration. If you notice, if we take velocity divided by time, we get acceleration, which is the gradient for the graph.

$$\text{Acc} = \frac{\text{Final Velocity} - \text{Initial Velocity}}{\text{Final time} - \text{initial time}}$$

$$\text{acc} = \frac{(5-0)}{(10-0)}$$

$$\text{acc} = 0.5 \text{m/s}^2$$

Another thing we can get from this graph is the displacement travelled by the object.



This Δs is represented by the area.

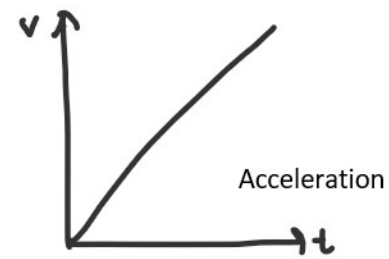
Hence, $\Delta s = \frac{5 \times 10}{2} = 25\text{m}$

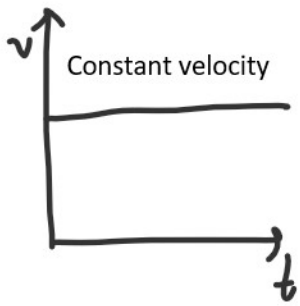
If you realise

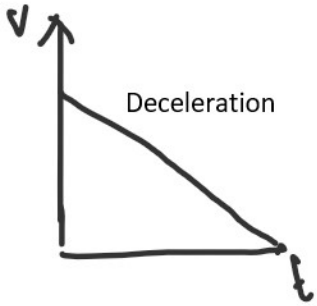
$$V = \frac{\Delta s}{\Delta t}$$

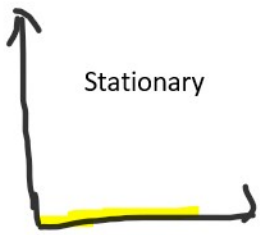
$$\Delta s = V \times \Delta t$$

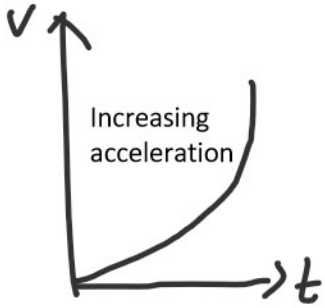
These are common graphs you need to know.

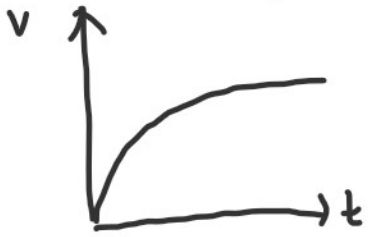




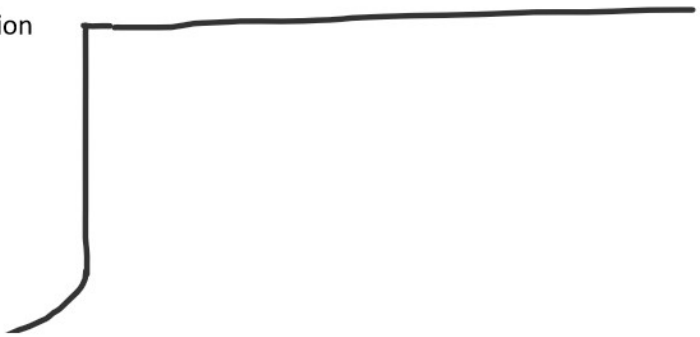


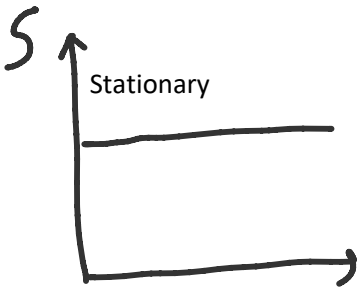


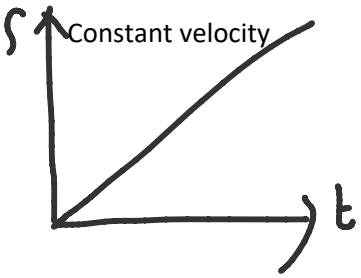


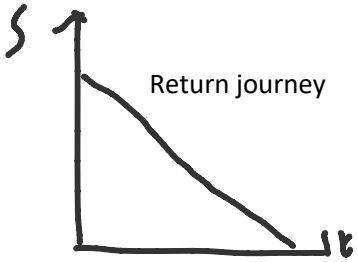


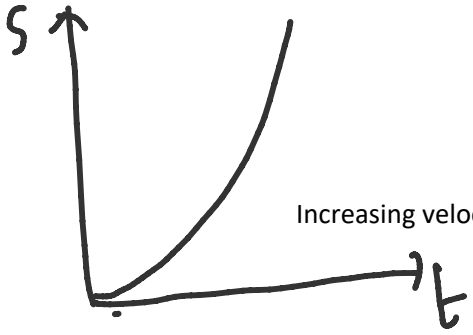
Decreasing acceleration





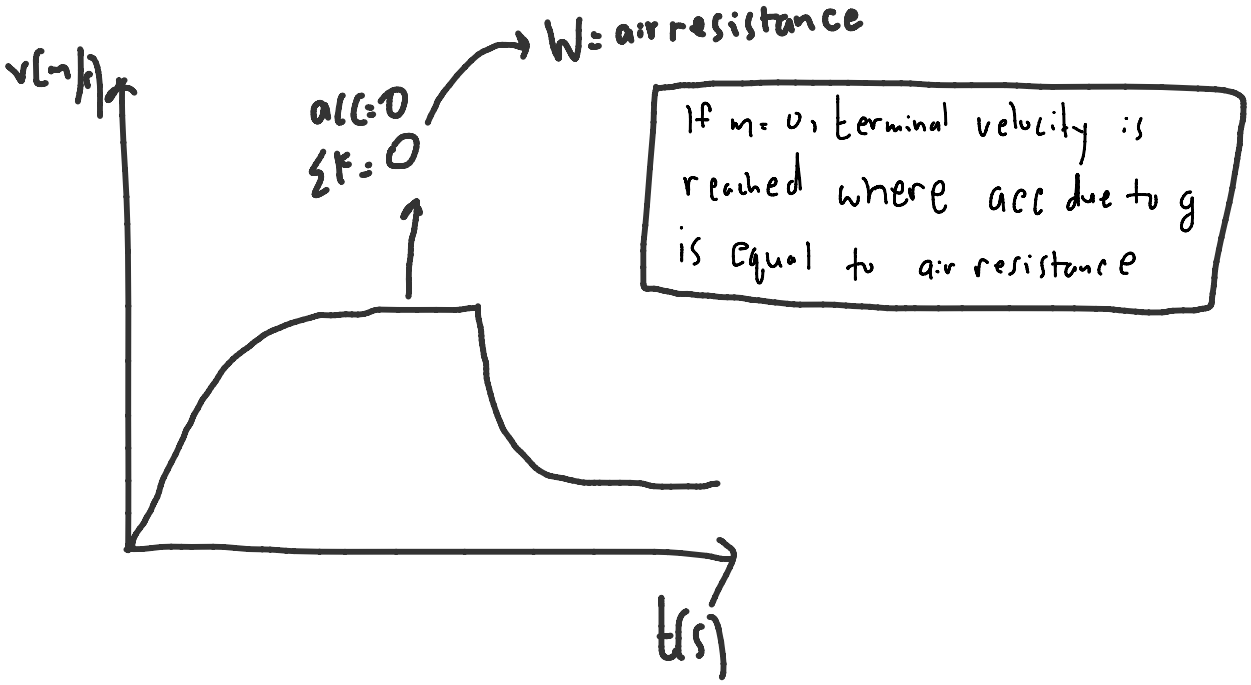






Freefall

A body near the Earth's surface will experience constant acceleration, which is acceleration due to gravity.



When the object is dropped from a great height, its velocity will increase. The gradient will be approximately 9.81 m/s^2. As velocity increases, the air resistance acting on the object will start to increase as well.

The magnitude of air resistance is proportional to the velocity of an object.

Hence, as air resistance increases, there will come a point where this air resistance is equal to the acceleration of the object. Hence, the object will no longer speed up and this is called terminal velocity. When the parachute opens, velocity will dramatically decrease as seen from the graph.

Exam Tips:

1) If an object is travelling in decreasing acceleration, this does not mean that the object is not speeding up. It merely means that the rate at which the object is increasing its speed is decreasing. For example: (20, 40, 50, 60,65) The numbers are still increasing but it is just increasing at a slower pace over time. This is decreasing acceleration
2) When an object travels around a circle in **constant speed,** it is still accelerating. Going back to vector quantities. They are effected by direction. Although speed is constant, due to the fact that the direction of the car is always changing along the track, its velocity is always changing. Hence, if there is a change in velocity over a period of time, object is accelerating
3) When doing exam questions, always utilize graphs whenever possible. Do not still use formula of s=d/t . Draw out the motion of the object and then calculate the area under the graph
4) If they ask you to predict the acceleration of a certain object, often times than not, it is asking you to calculate the gradient of the graph
5) Remember that if air resistance is negligible, a metal ball and a plastic ball dropped at the same height will reach the ground at the same time
6) When the velocity of a graph turns into a negative value (the line extends to the point the y axis is of negative value), take note that this does not mean it is slowing down. It merely gives a hint regarding the direction of the velocity of the object.