WOW sheet

What is acceleration?

Here is what 'acceleration' means in physical science:

Acceleration is the change in the velocity of an object over the change in time.

In other words, acceleration is how much an object changes its **velocity** in a certain period of time.

Velocity is a measure of both speed and direction. If you change either speed or direction, you change velocity.

That means that acceleration is a measure of how much an object changes its speed (by going either faster or slower) or its direction or both during a certain amount of time.

Formulaically, it can be written as:

$$a = \Delta v / \Delta t$$

In this equation:

- (a) is acceleration,
- (v) is velocity,
- (t) is time, and
- the delta symbol (Δ) means 'change in'.

In other words, this equation says that acceleration (a) is the change in velocity (Δv) over the change in time (Δt).

Acceleration is NOT the same as 'going fast'

Outside of physical science, the term 'accelerate' is sometimes used to mean 'go fast'. In physical science, however, that's not what 'acceleration' means.

For something to be accelerating, there needs to be a change happening to how that object is moving. In other words, there needs to be a change to its velocity. Either the speed needs to be changing (faster or slower), the direction needs to be changing, or both. If nothing is changing, then the object is not accelerating, no matter how fast it might be moving!

Here's an example

In a car, you can accelerate by hitting the gas (increasing speed) or by hitting the break (decreasing the speed) or by turning the steering wheel (changing direction). If you are just coasting in a straight line at a constant speed, no matter how fast, you aren't accelerating. You are moving, of course, but being in motion is different to accelerating.

Have you ever been in a train or a plane that was traveling along really smoothly? If the ride was smooth enough and you closed your eyes, you probably wouldn't even be able to tell you were moving and not just sitting still. But when the vehicle changes velocity, you can definitely tell you are moving. Think about what it feels like when the train slows down as it approaches a stop or the plane speeds up for take-off. Or how it feels when a train goes around a sharp bend. These are all examples of acceleration.

Think about that last example again. Even if the train doesn't change its speed when it goes around a bend, it does change its direction. Direction and speed both matter when you talk about acceleration. That's because acceleration is a **vector**.

A **vector** is a quantity that has both a direction and a magnitude (a size).

Here's an example

Speed is a measurement that tells you how fast something is going, but not what direction it is going. Velocity is a different measurement that tells you both how fast something is going AND what direction it is going. Velocity has both direction and magnitude (in this case, speed) so it's a vector.

In equations, acceleration is often written with a bold lowercase **a**. This shows that acceleration is a vector. An example of this is Newton's second law:

$$\mathbf{F} = m\boldsymbol{a}$$

Unit of measure

The unit that acceleration (**a**) is measured in is meters per second squared ($\frac{m}{s^2}$).

Remember that acceleration is measuring the change in velocity over the change in time. You can think about the unit of measure as explaining the change in velocity, which is 'meters per second' over the change in time, which is 'per second'. In other words, 'meters per second per second.' It's just easier to say 'meters per second squared'.

Calculating acceleration

To calculate acceleration, you need to use the formula:

$$a = \Delta v / \Delta t$$

To find the change in velocity, subtract the starting velocity from the end velocity.

To find the change in time, subtract the starting time from the end time.

You then divide the change in velocity by the change in time. That gives you your answer.

Example: the snail's sports car

For this example, we will calculate the acceleration for a sports car owned by a snail.

Have you ever noticed that speedometers are written as 'distance per time'? It's true! A car's speedometer shows how many kilometres per hour it is traveling (or maybe how many miles per hour). If a police officer says you were going 100 kilometres per hour, that means that your speed was such that you could travel 100 kilometres in 1 hour. You can write that as $100\frac{km}{hr}$ (which you may have seen written as 100 km/hr).

Our snail's car has a speedometer that shows metres per second.

The snail's car is on a straight road, pointing east. To start, the snail's car isn't moving. It has a speed of zero metres per second, which we can write as $0\frac{m}{s}$.

The snail pushes down the gas pedal and the car starts to go! After five seconds, the car's speedometer shows $10\frac{m}{s}$.

What's the snail's acceleration?

The maths

The formula for calculating acceleration is:

$$a = \Delta v/\Delta t$$

First, let's find the change in the snail's velocity. To find the change in velocity, we subtract the starting velocity from the end velocity:

$$\Delta v = (10\frac{m}{s} - 0\frac{m}{s})$$

To find the change in time, we subtract the starting time from the end time:

$$\Delta t = (5\ s - 0\ s)$$

Altogether, that gives us:

$$a = (10\frac{m}{s} - 0\frac{m}{s})/(5\ s - 0\ s)$$

Do the subtractions:

$$a = (10\frac{m}{s})/(5\ s)$$

And then the division:

$$a = (2\frac{m}{s})/(1\ s)$$

Which is the same as:

$$a = (2\frac{m}{s})/(s)$$

Which can also be written as:

$$a = 2\ \frac{m}{s^2}$$

The acceleration is two meters per second per second. We can also say the acceleration is two meters per second squared.

In other words…

The snail's car accelerates two metres per second every second. Another way to say that is: every one second, the snail's car increases its velocity by two meters per second (moving east).

But the simplest way to say this is: the snail's car's acceleration is $2\frac{m}{s^2}$.

That's why after five seconds, the speedometer showed 10 meters per second ($10\frac{m}{s}$). After one second, the speedometer would have shown $2\frac{m}{s}$. And if the car keeps accelerating, after 10 seconds, the speedometer will show $20\frac{m}{s}$.