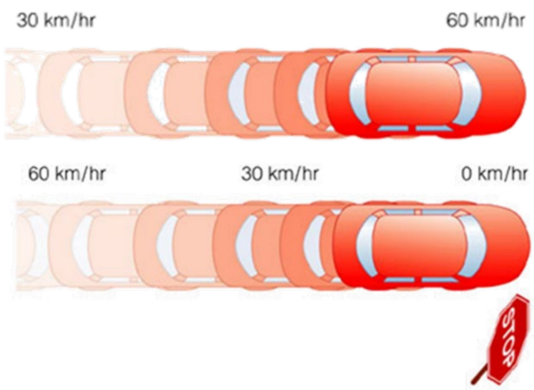
Acceleration is a change in velocity

Objects that have a **change in velocity** are said to have **acceleration**. An increase in velocity or a decrease in velocity (deceleration) are both types of acceleration.

A change in direction while travelling a constant speed is also acceleration. We notice when we are travelling on an object that is accelerating by experiencing a change in gravity or G-force.

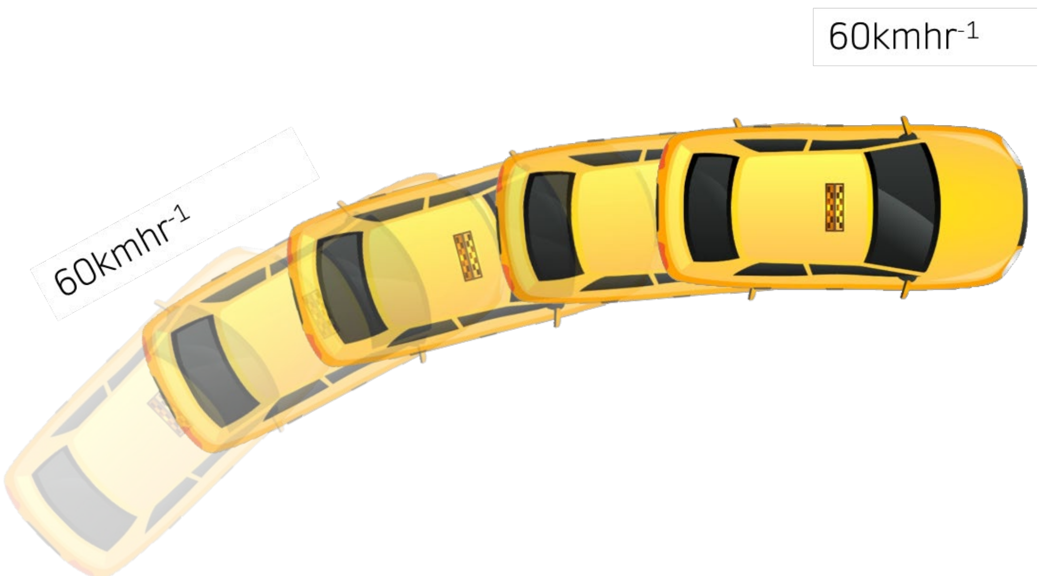


$$a_{ave} = \Delta v / \Delta t$$

a = acceleration (ms^{-2})
v = velocity (ms^{-1})
t = time (s)

The units for Acceleration depend on what velocity and time are measured in. If time is measured in seconds (s) and velocity is measured in metres per second (ms^{-1}) then the units for acceleration will be metres per second per second (ms^{-2})

EXTENSION: Speed and Velocity



Velocity measures the speed of an object **and** the direction it travels. An object can have a constant speed, but its velocity can change if it does not travel in a straight line, therefore it is said to be accelerating. Two objects can have the same speed but different velocities if they are not travelling the same direction.

This year we only consider velocity in a straight line – the speed component only, so we use the two terms to mean the same.

Acceleration or Deceleration

If an object is changing in speed and that change is positive, then the object is speeding up. When calculating a value, we can place a + sign in front of it if we wish.

If an object is changing in speed and that change is negative, then the object is slowing down.

When calculating acceleration, we need to show this with a – (negative sign) in front of the value.

Alternatively, if we clearly state the value is deceleration then we can leave the – sign off.

Acceleration calculations

The BMW 135i is a formidable sports car, accelerating from $0kmhr^{-1}$ to $97kmhr^{-1}$ in 4.6 seconds. What is the acceleration of this car in ms^{-2}?

$97kmhr^{-1} / 3.6 = 26.9ms^{-1}$

$a_{ave} = \Delta v / \Delta t$

$a_{ave} = 26.9ms^{-1} / 4.6s$

$a_{ave} = 5.9ms^{-2}$

The roller coaster with the fastest acceleration is the Dodonpa in Japan's Fuji-Q Highland park. It goes from $0kmhr^{-1}$ to 172kmhr-1 in 1.8 seconds. What is the acceleration experienced by a person travelling in this roller coaster in ms^{-2}?

$172kmhr^{-1} / 3.6 = 47.8ms^{-1}$

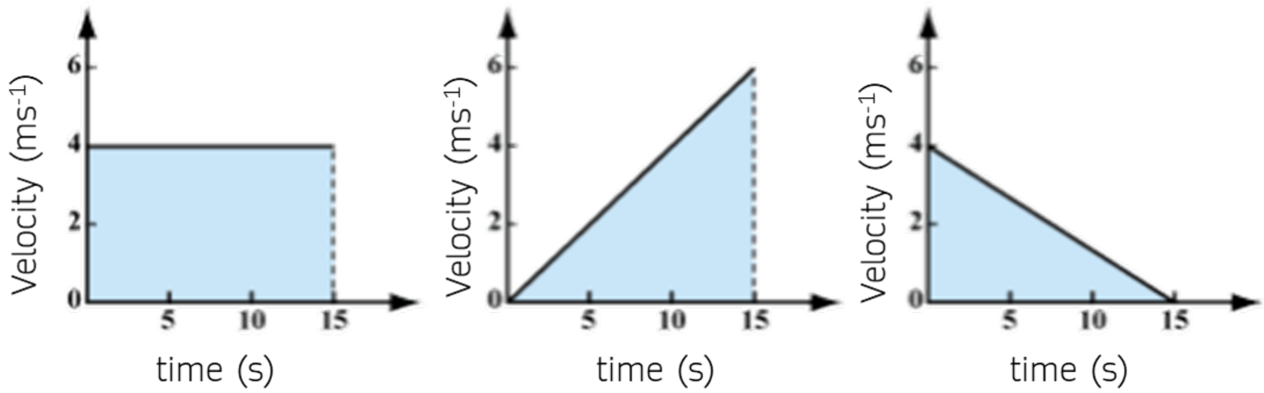
$a_{ave} = \Delta v / \Delta t$

$a_{ave} = 47.8ms^{-1} / 1.8s$

$a_{ave} = 26.5ms^{-2}$

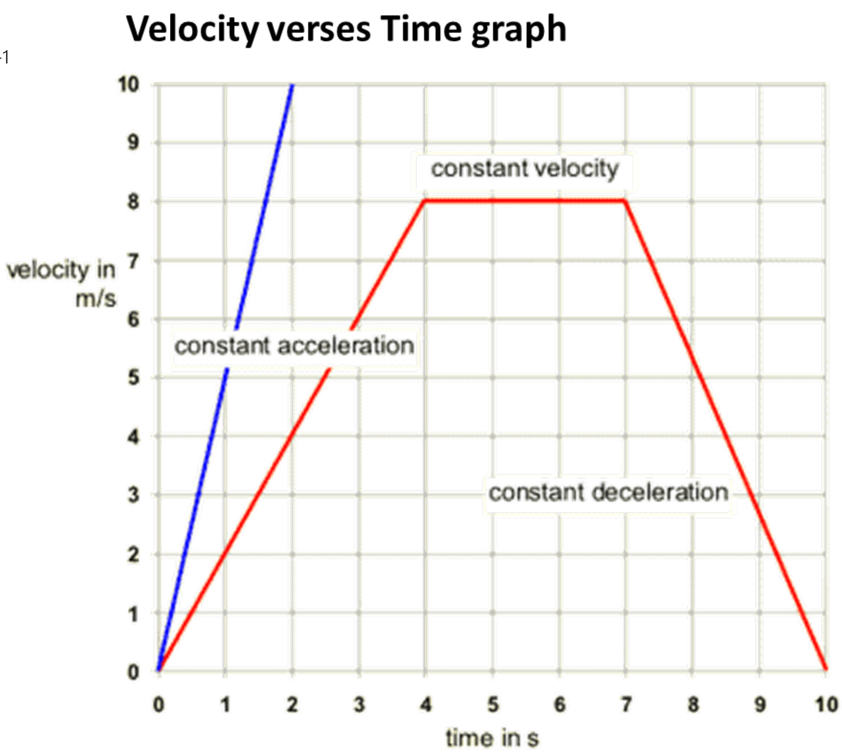
Acceleration can be calculated from a speed-time graph - EXTENSION

Use the start and finish points of the time and the velocity to work out the total change. If the time starts from 0 use that as your start point.



A velocity time graph can show acceleration with a diagonal line. Constant velocity is shown with a straight horizontal line. Values can be taken from the graphs and used to calculate acceleration.

The blue (left) line shows a velocity of $10ms^{-1}$ travelled in 2 seconds.
The acceleration would therefore be:
$a = \Delta v / t$
$= 0/2$
$a = 5ms^{-2}$



The Earth accelerates around the Sun - EXTENSION

The Earth travels at a constant average speed around the Sun (the speed varies slightly due to the elliptical path) and yet it is accelerating. This is because the direction that the Earth is travelling is constantly changing as it moves around the sun. The gravity force from the sun acts on the Earth and causes a change in velocity or acceleration. The Earth's speed is fast enough so that it does not spiral into the Sun but not so fast that it continues in a curved line away from the Sun.

Satellites including the Moon also accelerate around the Earth. If the Speed of a satellites falls beyond a set limit, then it will fall to the Earth

1. complete the missing values in the chart below. Remember a = Δv/ t

Acceleration (a) – ms^{-2}	Change in velocity (Δv) – ms^{-1}	Time (t) - s
	$10.8ms^{-1}$	3.9s
	Start $5.4ms^{-1}$ to finish $11.3ms^{-1}$	10.2s
	Start $22.4ms^{-1}$ to finish $8.5ms^{-1}$	11.3s
$3.4ms^{-2}$	$38ms^{-1}$	
$8.7ms^{-2}$		29.0s
	Start $6.5ms^{-1}$ to finish $15.4ms^{-1}$	Start 3.2s to finish 8.9s

2. Identify the type of motion in each of these velocity-time graphs