WJEC (Eduqas) Physics GCSE

4.1: Speed, Velocity and Acceleration

Detailed Notes

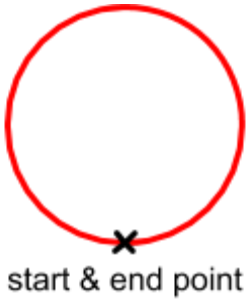
(Content in **bold** is for higher tier **only**)

Straight Line Motion

Distance & Displacement

Distance is a measure of how far an object has moved. It is a **scalar** quantity, meaning it has **no specific direction**. The **displacement** of an object is a **vector** quantity of distance meaning it also indicates a **direction**. This direction is normally shown using positive or negative values.

If an object travels in one direction then eventually ends up back at the same point, its **displacement is zero** but distance it has travelled is not.



Distance Travelled = Circumference ***Displacement = Zero***

Speed & Velocity

Speed is the measure of how **fast** something is travelling. It is a **scalar** quantity meaning it just has **magnitude** but **no sense of direction**, so is usually a positive value. Speed can be calculated from the distance travelled in a given time.

$$s = d / t$$

s is speed in m/s, d is distance in meters (m) and t is time in (s).
Other units may be used.

It is important to consider the **order of magnitude** of speed for different moving objects or motions and the **different units** it might be measured in.

Motion	Typical Speed (m/s)
Walking	1.5
Running	3
Average UK Wind	4.5
Cycling	6
Car	13-30
Aeroplane	250

Velocity is a **vector** quantity meaning it has **magnitude and direction**. It can be positive or negative, with the sign indicating the direction. It has the same relationship to distance and time as speed, except the distance is referred to as **displacement**, the distance moved **from a given point**.

$$v = d / t$$

v is velocity in m/s, d is displacement in meters (m) and t is time in (s). Other units may be used.

Acceleration

If the velocity of an object changes, it is **accelerating or decelerating**. This change in velocity is measured as the change in velocity per second (**m/s^2**).

$$a = (v - u) / t$$
or
$$a = \Delta v / t$$

a is acceleration in m/s^2, v is initial velocity in m/s, u is final velocity in m/s and t is time in s. Other units may be used.

Acceleration due to gravity (g) on Earth is approximated to **10 m/s^2** and it is important to consider the other magnitudes of acceleration for different moving objects relative to this.

Motion	Typical Acceleration (m/s^2)
Running from stationary	6
Overtaking car	4
Skydiver (falling under gravity)	10
Racing car setting off	15

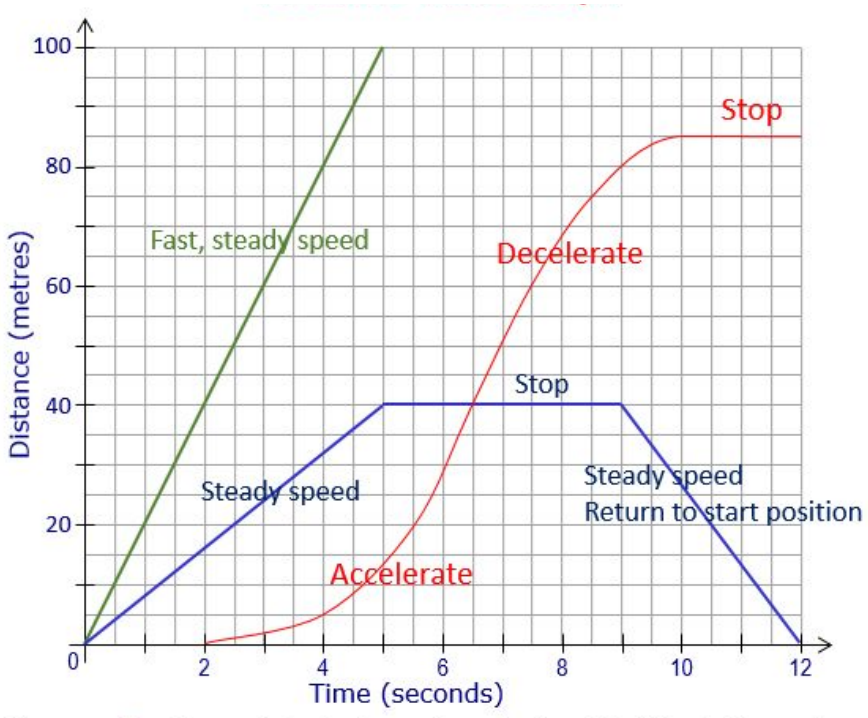
Motion Graphs

Distance-time Graphs

These graphs have time on the x-axis and distance on the y-axis meaning the **gradient shows velocity** (distance/time).

The **steeper** the gradient, the **faster** the speed. A **negative** gradient indicates the moving object is returning back to the starting point. A **horizontal** line indicates the object is **stationary**.

If the gradient is not constant (a curved line) it shows the velocity is changing and the object is accelerating or decelerating. For this scenario, velocity at a given time can be found by drawing a tangent to the curve and calculating its gradient.

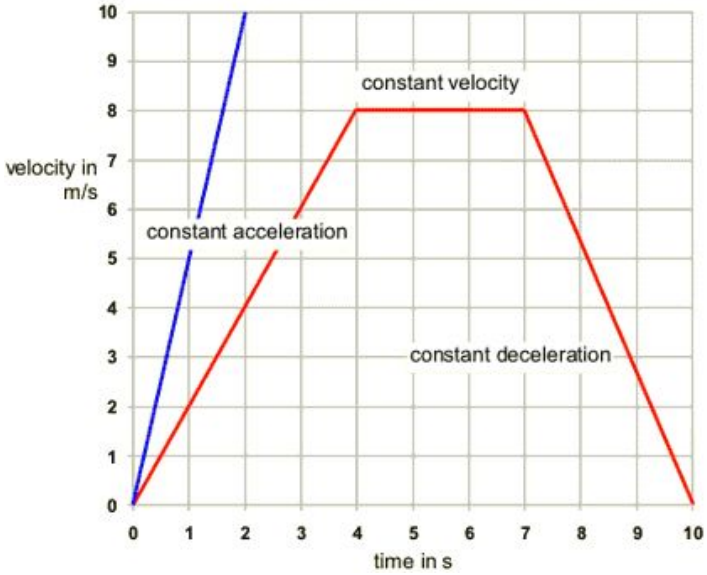


Distance-time graph showing different possible motions (onlinemathlearning.com).

Velocity-time Graphs

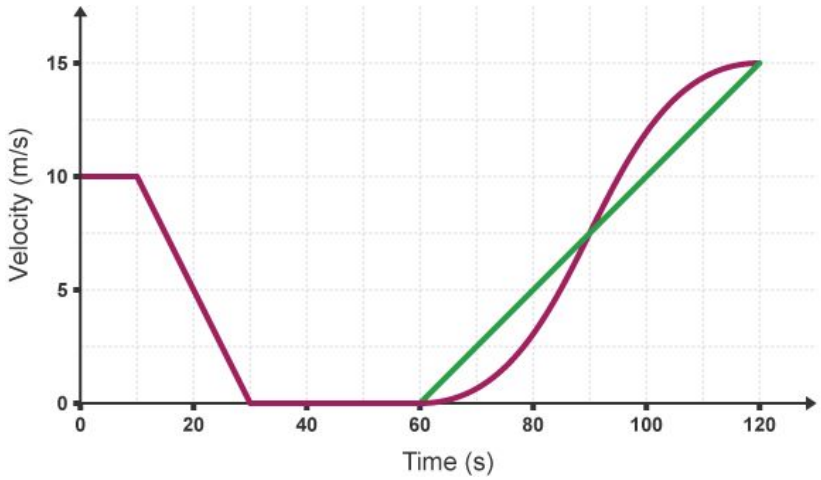
These graphs have time on the x-axis and velocity on the y-axis meaning the **gradient shows acceleration** (change in velocity/time).

The **steeper** the gradient, the **greater** the acceleration. A **negative** gradient indicates the object is **decelerating**. A **horizontal** line indicates the object is moving at a **constant speed**.



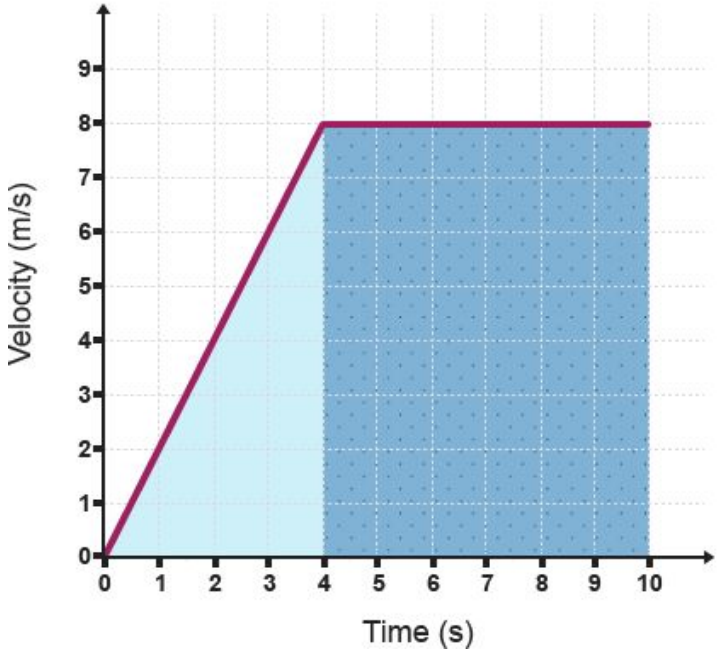
Velocity-time graph showing different possible motions (onlinemathlearning.com).

The **average acceleration** or the **distance travelled** over a curved region of a graph may need to be calculated. Draw a straight line through the curve and find its **gradient** to calculate the average acceleration. [ie: the green line shows average acceleration.]



The green line shows the average acceleration through the curved region (bbc.co.uk).

The distance travelled over a period of acceleration can be found as the area under the curve. In some situations, the acceleration curve needs to be broken down into different segments to make this possible.



The areas of the two shaded segments will sum together to give the total distance travelled (bbc.co.uk).

Equations of Motion

The movement of objects can be quantified and related through a set of equations known as the **SUVAT equations**. SUVAT uses displacement, initial and final velocities, acceleration and time through a series of related equations with one unknown.

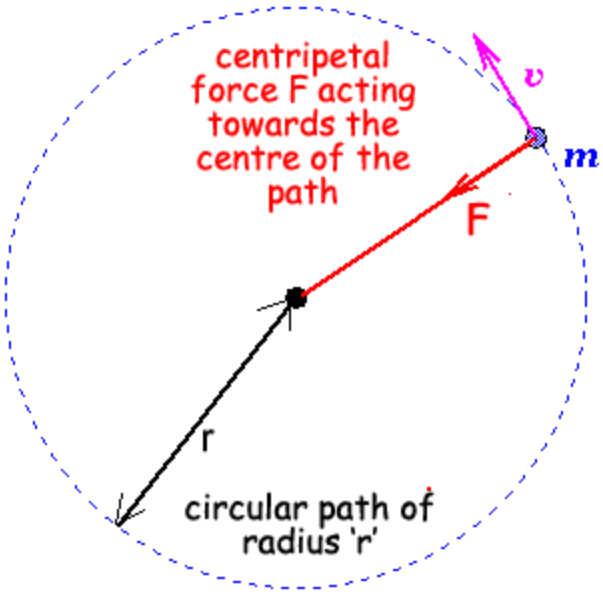
$$v = u + at \qquad s = (u+v) / 2t \qquad v^2 = u^2 + 2as \qquad s = ut + \tfrac{1}{2}at^2$$

s = displacement (m) ***u*** = initial velocity (m/s) ***v*** = final velocity (m/s)
a = acceleration (m/s^2) ***t*** = time (s)

Circular Motion & Orbits

Objects moving in a circle are in a unique situation where speed remains constant but velocity is constantly changing. This is because the direction of motion is constantly changing and a change in velocity requires a change in direction.

A changing velocity also means the object is accelerating despite travelling at a constant speed. This type of acceleration is called centripetal acceleration and it is produced as a result of a resultant force directed towards the center of the circle of motion. The resultant force is called the centripetal force.



Centripetal acceleration and force for an object in circular motion (cyberphysics.co.uk).