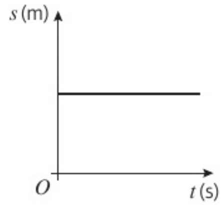
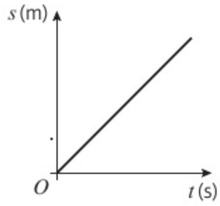
Displacement-Time Graphs

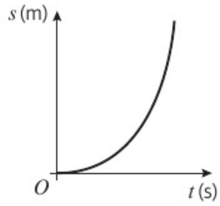
Displacement is always plotted on the **vertical** axis and time on the horizontal axis.



There is no change in the displacement over time and the object is stationary.



The displacement increases at a constant rate over time and the object is moving with constant velocity.



The displacement is increasing at a greater rate as time increases. The velocity is increasing and the object is accelerating.

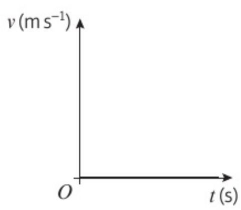
$\boldsymbol{s}$ represents the **displacement** of an object from a given point in metres and $\boldsymbol{t}$ represents the **time** taken in seconds.

Velocity is the rate of change of displacement. On a displacement-time graph, the gradient represents the velocity.

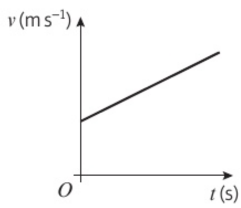
$$\text{Average velocity} = \frac{\text{displacement from starting point}}{\text{time taken}} \qquad \text{Average speed} = \frac{\text{total distance travelled}}{\text{time taken}}$$

Velocity-Time Graphs

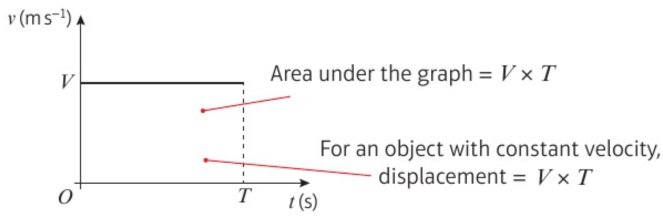
Velocity is always plotted on the **vertical** axis and time on the horizontal axis.



The velocity is zero and the object is stationary.



The velocity is increasing at a constant rate and the object is moving with constant acceleration.



The velocity is unchanging and the object is moving with constant velocity.

$\boldsymbol{v}$ represents the **velocity** of an object in metres per second and $\boldsymbol{t}$ represents the **time** taken in seconds.

Acceleration is the rate of change of velocity. On a velocity-time graph the gradient represents the acceleration.

If the velocity-time graph is a **straight line**, then the acceleration is **constant**.

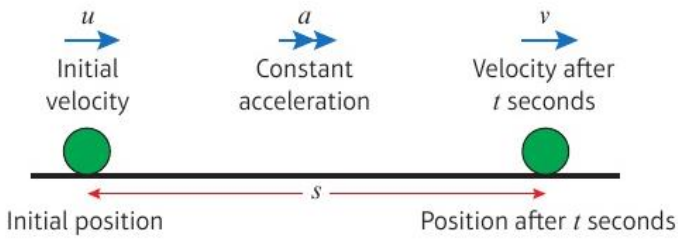
The area between a velocity-time graph and the horizontal axis represents the distance travelled.

For motion in a straight line with positive velocity, the area under the velocity-time graph represents **displacement**.

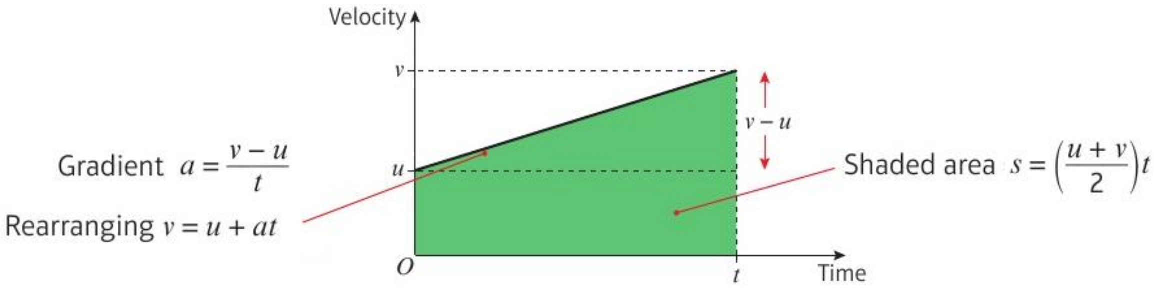
Constant Acceleration Formulae

A standard set of letters is used for the motion of an object moving in a straight line with constant acceleration.

- s is the displacement.
- u is the initial velocity.
- v is the final velocity.
- a is the acceleration.
- t is the time.



You can use these letters to label a velocity-time graph representing the motion of a particle moving in a straight line accelerating from velocity u at time 0 to velocity v at time t:



The gradient gives an expression for acceleration, and the area gives an expression for displacement. From these, you can derive the formulae for solving problems about particles moving in a straight line with constant acceleration:

$$\boldsymbol{v = u + at}$$

$$\boldsymbol{s = \left(\frac{u+v}{2}\right)t}$$

$$\boldsymbol{v^2 = u^2 + 2as}$$

$$\boldsymbol{s = ut + \frac{1}{2}at^2}$$

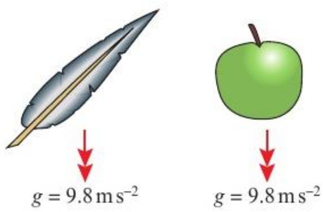
$$\boldsymbol{s = vt - \frac{1}{2}at^2}$$

These are sometimes referred to as the **kinematics** or ***suvat* formulae**. They are given in the formulae booklet.

Gravity

You can use the formulae for constant acceleration to model an object moving vertically under gravity.

The force of gravity causes all objects to accelerate towards the earth. If you ignore the effects of air resistance, this acceleration is constant. The acceleration does not depend on the mass of the object, so in a vacuum an apple and a feather would both accelerate downwards at the same rate.



On earth, acceleration due to gravity is represented by g and is roughly 9.8ms^{-2}.

Exam questions use g = 9.8 as the default value, but they may ask you to use g = 10 or g = 9.81 instead.

An object moving vertically under gravity can be modelled as a particle with a constant downward acceleration of g.

Acceleration due to gravity is always downwards, so if the positive direction is upwards then g = –9.8 ms^{-2}.