## 4.3.4 Acceleration due to gravity

In the absence of air resistance, falling objects undergo uniform acceleration. Close to the Earth's surface, this is $9.8ms^{-2}$ (to 2 sig. fig.). We can therefore apply all the equations derived in the previous section to describe the motion of these objects.

videos

These equations are:

(1) $v = u + at$

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

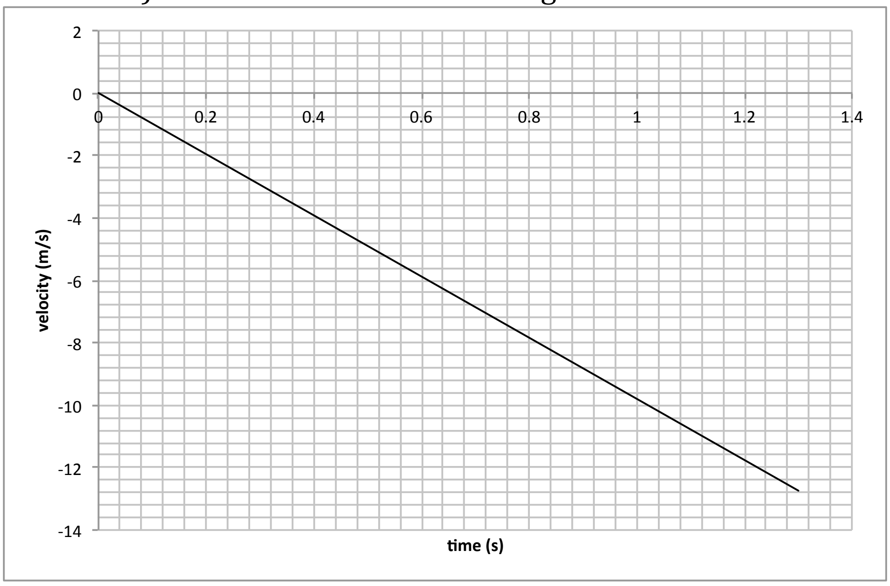
(3) $s = \frac{1}{2}(v + u)t$

(4) $v^2 = u^2 + 2as$

*where s=displacement, u=initial velocity, v=final velocity, a=acceleration, t=time*

Collectively, these are known as the 'suvat' equations.

A velocity-time graph of an object dropped from rest (in the absence of air resistance) would look like the following:




*(1)✏Why are the velocities plotted as negative?*

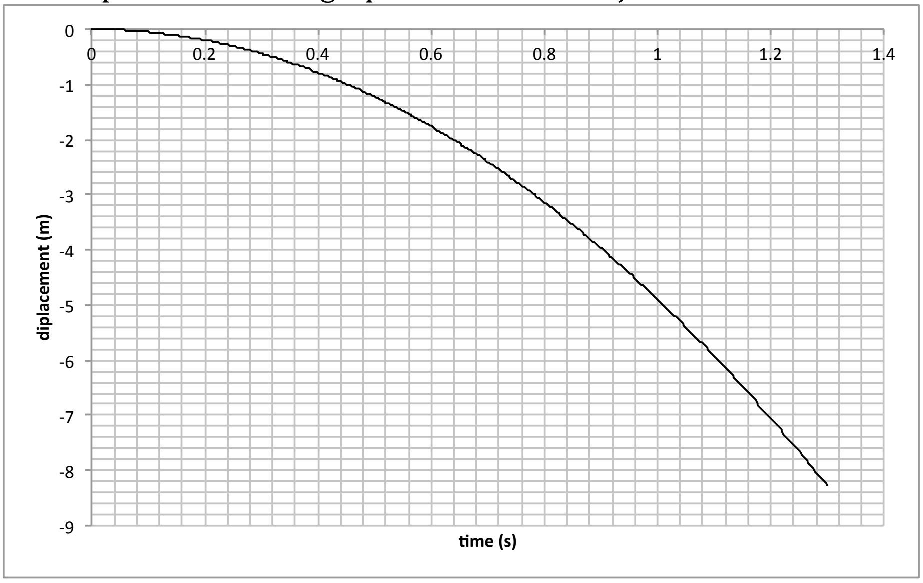
*(2)✏Work out the gradient of the graph. What does it represent?*

*(3)✏How would air resistance affect the shape of the graph? Sketch a second line on the graph, above, to show this.*

*(4)✏Using the velocity-time graph, work out the displacement at t=1.2s.*

*(5)✏Using one of the suvat equations, calculate the displacement at t=1.2s.*

The displacement time graph for the same object is shown below:




*(6)✐Why is the graph curved?*

*(7)✐How could you work out the instantaneous velocity from this graph?*

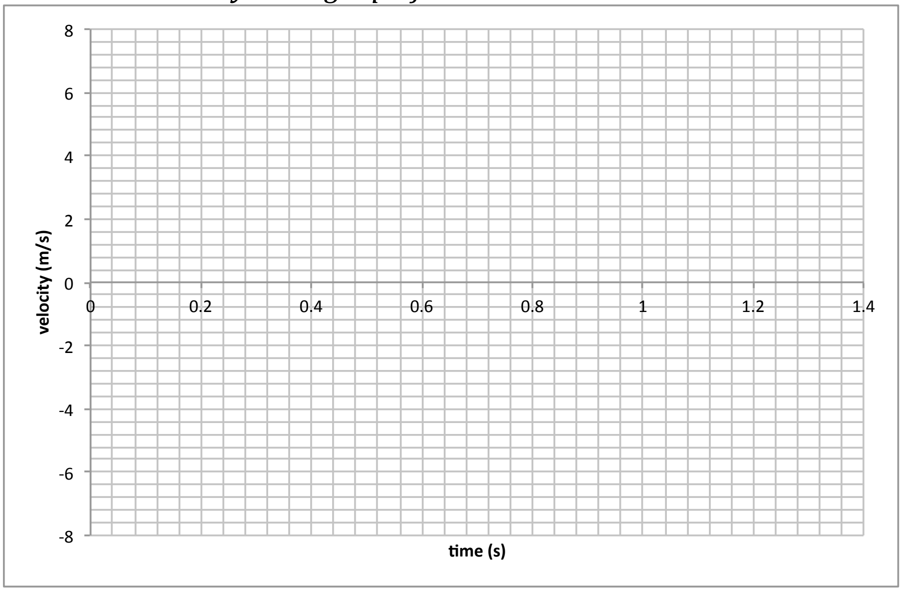
*(8)✐Using the displacement-time graph, find the instantaneous velocity at t=0.8s.*

*(9)✐Use one of the suvat equations to find the velocity at t=0.8s.*

**Objects launched vertically upwards**

When objects are thrown straight upwards, they start accelerating downwards at $9.8ms^{-2}$ as soon as they leave the thrower's hand. This can appear puzzling, at first. Just remember that the object is launched with a positive (upwards) velocity. As soon as it leaves the hand, the force of gravity (the object's weight) is the only force acting on the object. This is a force downwards (negative), so it causes the object to decelerate. The object will continue to decelerate until its velocity is zero. At this point the object is at its maximum height. Its velocity will then start increasing in the negative direction (downwards), so the object will accelerate downwards.

(10)✏*An object is thrown vertically upwards with an initial velocity of 6ms*$^{-1}$*.*
*Sketch the velocity-time graph for this motion below.*

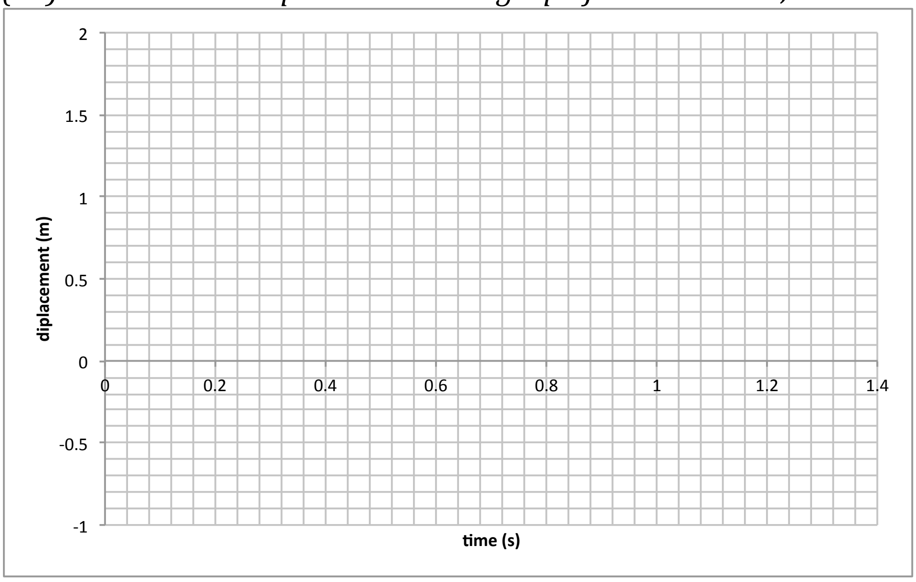



(11)✏*Use the graph to find when the object reaches its maximum height.*

(12)✏*Use a suvat equation to find when it reaches its maximum height.*

(13)✏*At what time would the object return to the thrower's hand?*

(14)✏*Sketch the displacement-time graph for this motion, below.*



**Bouncing balls**

*(15)✏Sketch, below, a velocity-time graph of a dropped ball bouncing.*