Using and changing formulae to solve problems – Firing into the air

The SUVAT formulae

These are used to describe motion under constant acceleration, such as under the influence of gravity.

$$v = u + at$$

$$v^2 = u^2 + 2as$$

$$s = \frac{u+v}{2}t$$

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

where: *s = distance*
u = initial speed
v = final speed
a = acceleration
t = time

A shot is fired directly upwards from ground level.

1) **Using the second formula from the list, rearrange to make *s* the subject. Then use this to calculate the maximum height reached by the bullet when the initial speed is 200ms^{-1}. You may assume that acceleration due to gravity is 9.8ms^{-2}**

Hint 1:
Treat the journey as starting when the bullet is fired and ending when it reaches its maximum height. Then the final speed, *v*, must be 0.

Hint 2:
Acceleration due to gravity acts downwards, in the opposite direction to the motion of the bullet, so acceleration, a, will be given by -9.8ms^{-2}.

2) **The fastest rifles can propel a bullet with an initial speed of 1500ms^{-1}. Using the first formula from the list, rearrange to make** t **the subject. Then use this to calculate the time it will take for the bullet to return to ground level. You may assume that gravity is constant throughout.**

Hint 1:
There are two ways of approaching this problem: First, you can set v = 0 as before, but remember that this will give you the time it takes the bullet to reach maximum height, not the total time. Second, you may notice that the bullet will return at the same speed it left, but going in the opposite direction, so v = -1500ms^{-1}.

Extra Challenge

3) **An arrow from a bow is known to fly to a maximum height of 100m. Using similar techniques to parts 1 and 2, calculate the initial speed of the arrow, and the length of time you would have to move out of the way before it came back down.**