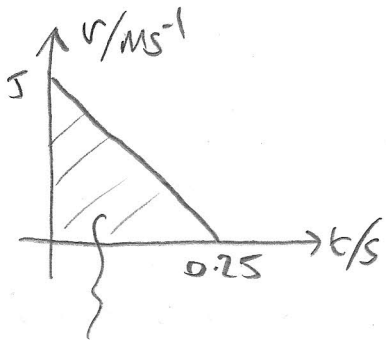
KINEMATICS

1 (i)



$v = 5 - 20t$

$v = 0$ when $20t = 5$

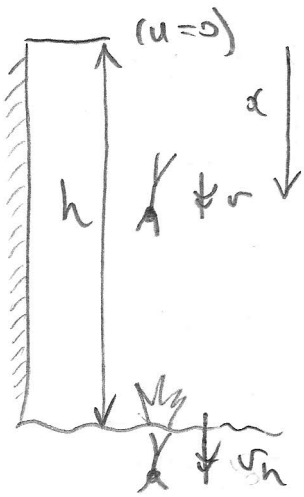
$t = 5/20$

$\boxed{t = 0.25s}$

Displacement $x = \frac{1}{2}(0.25)(5)$

$= \boxed{0.625\ m}$ (62.5 cm)

(ii)



$g = 9.81\ m/s^2$

$v^2 = 2gx$ $\therefore$ $v_h = \sqrt{2gh}$

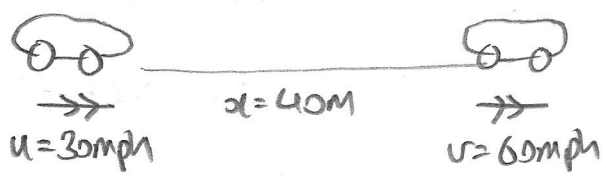
$v_h = \sqrt{2 \times 9.81 \times 27}$

$= \boxed{23.0\ m/s}$

$h = \frac{1}{2}gt^2$ $\therefore$ $\sqrt{\frac{2h}{g}} = t$

$\therefore$ $t = \sqrt{\frac{2 \times 27}{9.81}} = \boxed{2.35s}$

(iii)



$v^2 = u^2 + 2ax$

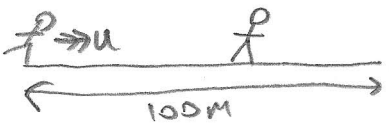
$\therefore$ $\frac{v^2 - u^2}{2x} = a$

$\therefore$ Since $1\ mph = \frac{1}{2.24}\ ms^{-1}$

$\Rightarrow$ $a = \dfrac{\left(\frac{60}{2.24}\right)^2 - \left(\frac{30}{2.24}\right)^2}{240}$ (m/s^2)

$\Rightarrow$ $\boxed{a = 6.73\ m/s^2}$

(iv)



$$x = ut + \tfrac{1}{2}at^2$$

$$\therefore \frac{x - \frac{1}{2}at^2}{t} = u$$

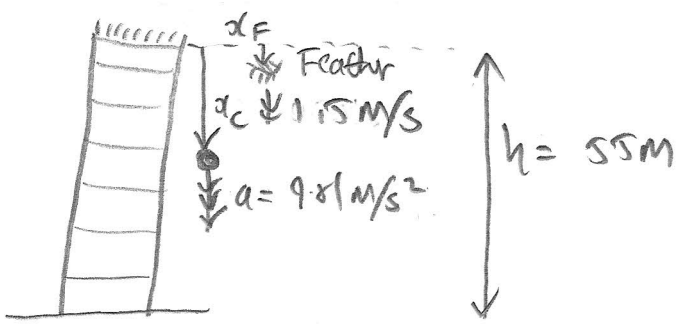
$$\therefore \frac{100 - \frac{1}{2} \times 0.1 \times 12.0^2}{12.0} = u$$

$$\therefore \boxed{u = 7.73 \text{ m/s}}$$

[Note he crosses the line at $v = 7.73 + 0.1 \times 12.0$

$\boxed{v = 8.93 \text{ m/s}}$]

v)



Leaning tower of Pisa.

a) For cannon ball impact speed

$$v = \sqrt{2ah}$$

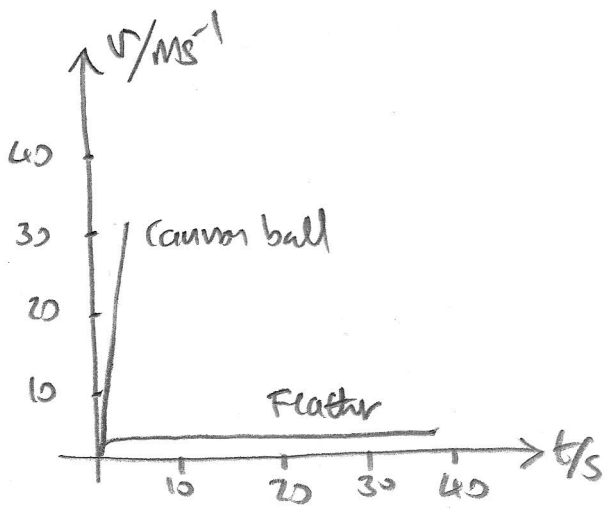
[$v^2 = u^2 + 2ah$]

↑ zero

$$\Rightarrow v = \sqrt{2 \times 9.81 \times 55}$$

$$\boxed{v = 32.8 \text{ m/s}}$$

b)



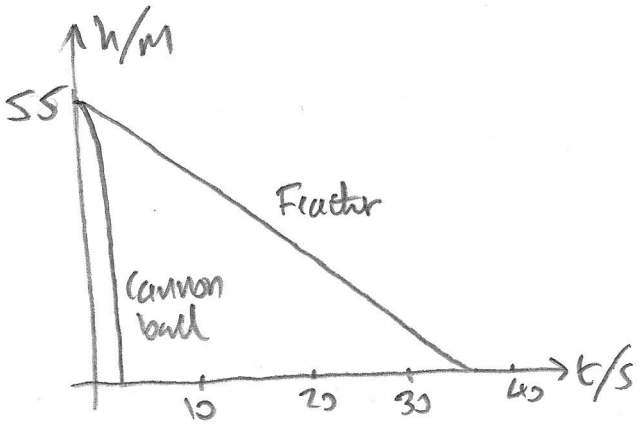
For cannon ball:

$$h = \tfrac{1}{2}at^2 \Rightarrow t = \sqrt{\frac{2h}{a}}$$

$$t = \sqrt{2 \times 55 / 9.81} = \boxed{3.345}$$

For feather:

$$h = 1.5t \therefore t = \frac{55}{1.5} = \boxed{36.7s}$$



c) At time t, feather is height:

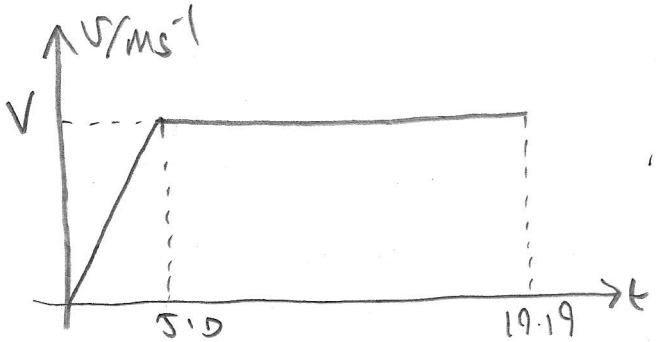
$$h = 55 - 1.5t \quad \text{metres}$$

so after $\sqrt{\frac{2\times 55}{9.81}} = 3.34\text{s}$

$$h = 50.0\text{ m}$$

Feather hits the ground after 36.75, so you have to wait 33.4s after the cannon ball hits the ground for the feather to join it. $(36.7 - 3.34 = 33.4)$.

vi) Usain Bolt's 2009 200m world record in Berlin (2)



Area under graph is 200m.

$\therefore \frac{1}{2}(19.19 + 14.19)V = 200$

$\therefore V = 11.98\text{ m/s}$

Initial acceleration was $a = \frac{V}{5.0}\ \text{ms}^{-2}$

$$a = 2.40\text{ m/s}^2$$

[Actually this is just the tangential acceleration. As he was running a bend, he would have to accelerate radially inwards too].