Leave blank

2. A ball is thrown vertically upwards with speed u m s^{-1} from a point P at height h metres above the ground. The ball hits the ground 0.75 s later. The speed of the ball immediately before it hits the ground is 6.45 m s^{-1}. The ball is modelled as a particle.

(a) Show that $u = 0.9$

(3)

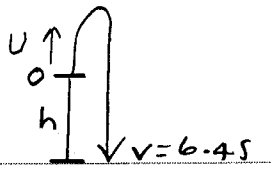
(b) Find the height above P to which the ball rises before it starts to fall towards the ground again.

(2)

(c) Find the value of h.

(3)

$a\uparrow = -9.8$
$t = 0.75$
$v = -6.45$



a)

$v = u + at \Rightarrow -6.45 = u - 9.8 \times 0.75$

$-6.45 = u - 7.35$

$7.35 - 6.45 = u$

$0.9 = u$

$u = 0.9 \text{ m s}^{-1}$

---

b) $v\uparrow = 0$, $u\uparrow = 0.9$, $a\uparrow = -9.8$

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

$0 = 0.9^2 - 19.6s$

$19.6s = 0.81$

$s = \frac{0.81}{19.6}$

$s = 0.041 \text{ m}$

---

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

$-h = 0.9(0.75) - 4.9(0.75)^2$

$-h = -2.081$

$h = 2.08 \text{ m}$

$u\uparrow = 0.9$, $a\uparrow = -9.8$, $t = 0.75$

Leave blank

1. At time $t = 0$ a ball is projected vertically upwards from a point O and rises to a maximum height of 40 m above O. The ball is modelled as a particle moving freely under gravity.

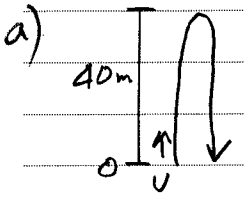
(a) Show that the speed of projection is 28 m s^{-1}.

(3)

(b) Find the times, in seconds, when the ball is 33.6 m above O.

(5)

a)



At top $v = 0$

$s = 40$

$a = -9.8$

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

$0 = u^2 - 19.6 \times 40$

$784 = u^2$

$\sqrt{784} = u$

$u = 28 \text{ ms}^{-1}$

b)

$s = 33.6$

$u = 28$

$a = -9.8$

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

$33.6 = 28t - 4.9t^2$

$4.9t^2 - 28t + 33.6 = 0$

By calc $t = 4$, $t = \frac{12}{7}$

$t = 1.7\text{s}$ and $t = 4\text{s}$

Leave blank

5. A stone is projected vertically upwards from a point A with speed $u\,\text{m s}^{-1}$. After projection the stone moves freely under gravity until it returns to A. The time between the instant that the stone is projected and the instant that it returns to A is $3\frac{4}{7}$ seconds.

Modelling the stone as a particle,

(a) show that $u = 17\frac{1}{2}$, **(3)**

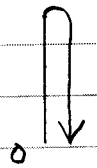
(b) find the greatest height above A reached by the stone, **(2)**

(c) find the length of time for which the stone is at least $6\frac{3}{5}$ m above A. **(6)**

a) $t = 3\frac{4}{7}\,s = \frac{25}{7}\,s$

$a = -9.8$

$s = 0$



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

$0 = \frac{25}{7}u - 4.9\left(\frac{25}{7}\right)^2$

$\frac{125}{2} = \frac{25}{7}u$

$u = \frac{125}{2} \times \frac{7}{25} = 17\frac{1}{2}$

b) At top $v = 0$, $a = -9.8$, $u = 17.5$

$v^2 = u^2 + 2as \Rightarrow 0 = 17.5^2 - 19.6s$

$19.6s = 306.25$

$s = \frac{306.25}{19.6} = 15.625 = 15.6\,m$

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

$6.6 = 17.5t - 4.9t^2$

$4.9t^2 - 17.5t + 6.6 = 0$

By calc $t_2 = \frac{22}{7}$ $t_1 = \frac{3}{7}$

Above 6.6m for $\frac{22}{7} - \frac{3}{7} = \frac{19}{7}\,s$

$= 2.71\,s$

Leave blank

5. A particle P is projected vertically upwards from a point A with speed u m s^{-1}. The point A is 17.5 m above horizontal ground. The particle P moves freely under gravity until it reaches the ground with speed 28 m s^{-1}.

(a) Show that $u = 21$

(3)

At time t seconds after projection, P is 19 m above A.

(b) Find the possible values of t.

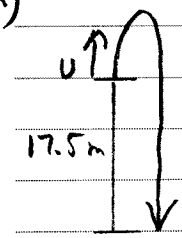
(5)

The ground is soft and, after P reaches the ground, P sinks vertically downwards into the ground before coming to rest. The mass of P is 4 kg and the ground is assumed to exert a constant resistive force of magnitude 5000 N on P.

(c) Find the vertical distance that P sinks into the ground before coming to rest.

(4)

a)



Lands when $v = -28$

$s = -17.5$

$a = -9.8$

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

$(-28)^2 = u^2 - 19.6 \times (-17.5)$

$784 - 343 = u^2$

$441 = u^2$

$\sqrt{441} = u$ $\quad u = 21\ ms^{-1}$

b) $s = ut + \frac{1}{2}at^2 \Rightarrow 19 = 21t - 4.9t^2$

$4.9t^2 - 21t + 19 = 0$

By calc

$t = 2.99s$, $t = 1.29s$

c) $F = ma \quad 4g - 5000 = ma \quad a = \frac{4 \times 9.8 - 5000}{4}$

$a = -1240.2$

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

$0 = 28^2 - 2 \times 1240.2s$

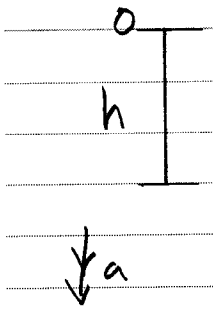
$2480.4s = 784$

$s = \frac{784}{2480.4} = 0.316\ m$

Leave blank

4. The points P and Q are at the same height h metres above horizontal ground. A small stone is dropped from rest from P. Half a second later a second small stone is thrown vertically downwards from Q with speed $7.35\ \text{m s}^{-1}$. Given that the stones hit the ground at the same time, find the value of h.

(7)



$t = T$ $\quad u = 0$ $\quad a = 9.8$

$t = T - \frac{1}{2}$ $\quad u = 7.35$ $\quad a = 9.8$

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

$h = 4.9T^2$ $\qquad h = 7.35\left(T-\frac{1}{2}\right) + 4.9\left(T-\frac{1}{2}\right)^2$

Sub for h $\qquad 4.9T^2 = 7.35T - 3.675 + 4.9\left(T^2 - T + \frac{1}{4}\right)$

$4.9T^2 = 7.35T - 3.675 + 4.9T^2 - 4.9T + 1.225$

$0 = 2.45T - 2.45$

$2.45 = 2.45T$

$T = 1\text{s}$

$h = 4.9T^2 = 4.9 \times 1^2 = 4.9$

$h = 4.9\text{m}$