AS Maths Mechanics 2021

(1a)

$g = -9.8\ ms^{-2}$

$v = u + at$

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

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

$t=0$ $\quad 0 \uparrow 14.7\ ms^{-1}$

$s=0 \quad u=14.7 \quad a=-9.8$

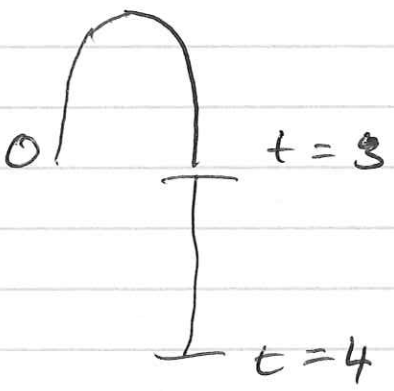
$s = ut + \frac{1}{2}at^2 \quad 0 = t(14.7 - 4.9t)$

$t=0$ or $t=3$

$t=0$: initial value

$t=3$: second time $s=0$

b



So at $t = 1\frac{1}{2}$

$s = 14.7 \times \frac{3}{2} + \frac{1}{2} \times -9.8 \times \left(\frac{3}{2}\right)^2$

$= \frac{441}{40}$

So $\frac{441}{40}x^2 = \frac{441}{20}$

From $t=3$ to $t=4$ $\quad s = 14.7 \times 4 + \frac{1}{2} \times -9.8 \times 4^2$

$= -19.6$

So $\frac{441}{20} + 19.6 = \frac{833}{20} = 41.65\ m$

(c) Use a more accurate value for g.

(2) (a) $V = 10t - t^2 - k \qquad t \geq 0$

$a = \frac{dV}{dt} = \underline{\underline{10 - 2t}}$

(b) if $t = 6 \quad V = 0$

so $0 = 10 \times 6 - 6^2 - k \Rightarrow \underline{\underline{k = 24}}$

$0 = 10t - t^2 - 24$

$t = 6 \quad$ or $\quad \underline{\underline{t = 4}}$

(c) $0 \leq t \leq 6$

$$\int_0^6 10t - t^2 - 24 \, dt$$

$$\left[-\frac{t^3}{3} + 5t^2 - 24t + C \right]_0^6$$

$C = 0$ as $S = 0$ when $t = 0$

Check if change direction

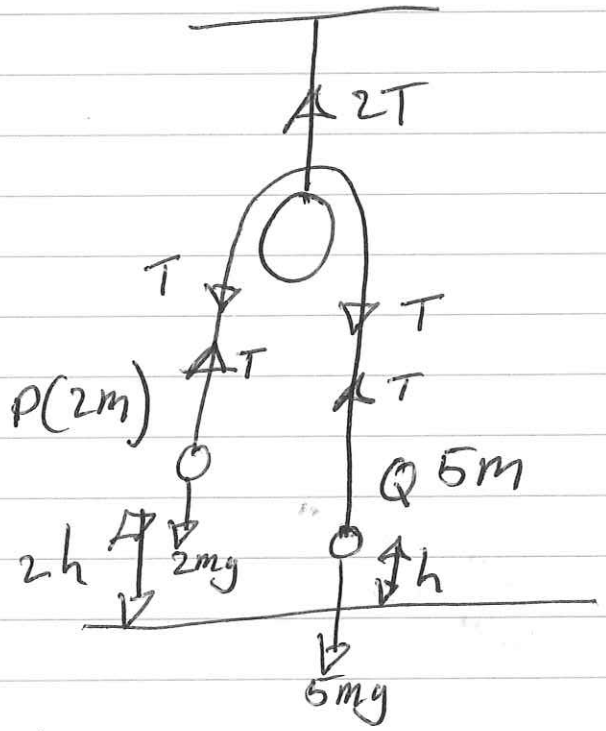
$V = 0 \qquad -t^2 + 10t - 24 = 0$ when $t = 6$ or 4

$$\left[-\frac{t^3}{3} + 5t^2 - 24t \right]_0^4 - \left[-\frac{t^3}{3} + 5t^2 - 24t \right]_4^6$$

$$2\,c\ \frac{-112}{3} + 0 - \left(-36 + \frac{112}{3}\right) = \text{[illegible]} - \frac{116}{3}$$

Distance $\frac{116}{3}$ m

(3)



Q not rebound

P $\quad F = ma$

$T - 2mg = 2ma$

Q $\quad 5mg - T = 5ma$

③ When travelled distance h (so $3h$ above ground)

add previous equations $3mg = 7ma \Rightarrow a = \frac{3g}{7}$

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

$v^2 = 0 + 2 \times \frac{3g}{7} \times h$

$v = \sqrt{\frac{6gh}{7}}$ use as u for next stage

Distance beyond h (so $3h$ above ground) $a = -9.8$ now

$s = ut + \frac{1}{2}at^2$ Time to $v = 0$
$v = u + at$

$0 = \sqrt{\frac{6gh}{7}} + -9.8 \times t$

$t = \sqrt{\frac{6gh}{7}} = \sqrt{\frac{6gh}{7 \times 9.8^2}}$

$s = \sqrt{\frac{6gh}{7}} \sqrt{\frac{6gh}{7 \times 9.8^2}} + \frac{1}{2}(-9.8) \times \frac{6gh}{7 \times 9.8^2}$

$s = \frac{6gh}{7 \times 9.8} - \frac{6gh}{2 \times 7 \times 9.8} = \frac{3}{2} \frac{6gh}{7 \times 9.8}$

$s = \frac{3h}{7}$

Total height $2h + h + \frac{3}{7}h = \frac{24h}{7}$

(c) The distance Q falls to the ground would not be exactly h.

(d) The accelerations of the balls would not have equal magnitude.