1

(a) $s_x = u_x t$

$u_x = \dfrac{24}{1.5} = 16\ m\ s^{-1}$

$\tan 28° = \dfrac{v_y}{v_x}$

$v_y = 8.51 = 8.5\ m\ s^{-1}$

(b) Taking upwards as positive

$v_y = u_y + a_y t$

$t = (0 - 8.5) / (-9.81)$

$= 0.87\ s$

(c)

(d) acceleration (of freefall) is unchanged / not dependent on mass, and so no effect (on maximum height and time taken)

(e) Since air resistance acts downwards, net downward force is larger hence, shorter time taken

2

(a) Using $v^2 = u^2 + 2as$

$v = \sqrt{0 + 2(5.0)(4.0)}$

$= 6.32\ m\ s^{-1}$

(b) Horizontal component $= 6.32 \cos 37.0°$

$= 5.05\ m\ s^{-1}$

Using $v_y^2 = u_y^2 + 2a_y s_y$

$v_y = \sqrt{3.80^2 + 2(9.81)(15.0)}$

$= 17.6\ m\ s^{-1}$

(c) Ball rolling down: $v = u + at$

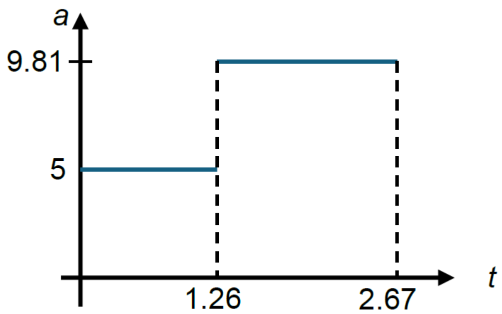
$t_1 = \dfrac{6.32}{5.00} = 1.264\ s$

Ball falling from roof to ground: $v = u + at$

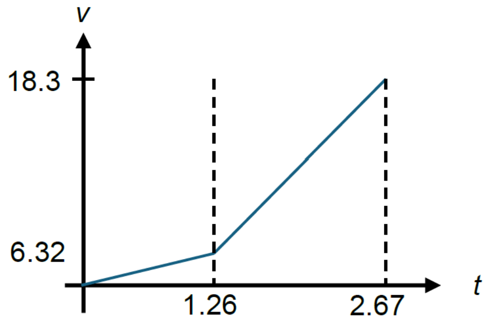
$t_2 = \dfrac{17.57 - 3.80}{9.81} = 1.404\ s$

Total time = $t_1 + t_2 = 2.67\ s$

(d) **(i)**



(ii)



3

(a) **(i)** By conservation of energy

$TE_i = TE_f$

$GPE_i + KE_i = GPE_f + KE_f$

$0 + \frac{1}{2}mu^2 = mgh + \frac{1}{2}mv^2$

$u^2 = 2gh + v^2$

$= \sqrt{2(9.81)(10)} + 5.00^2$

$= 14.9\ m\ s^{-1}$

(ii) $14.873 \cos\theta = 5.00$

$\theta = 70.4°$

(iii) Consider the vertical motion,

$v = u + at$

$0 = 14.873 \sin 70.4° + (-9.81)t$

$t = 1.428\ s$

Hence total time for motion $= 1.428 \times 2$

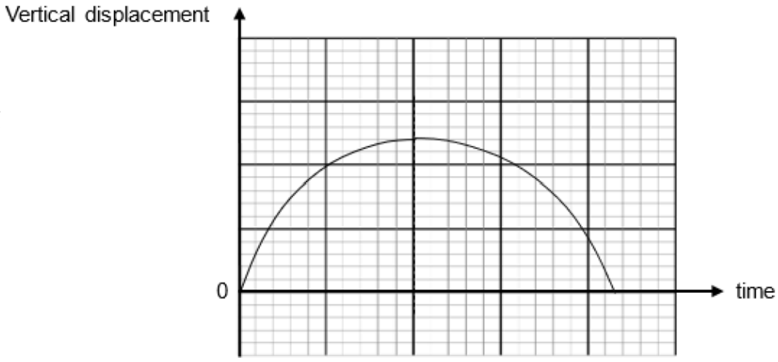
$= 2.86\ s$

(iv) Rate of change of momentum = resultant force = weight = mg

$= \ 8.00\ \times 10^{-3} \times\ 9.81$

$= \ 0.0785\ N$

(b)

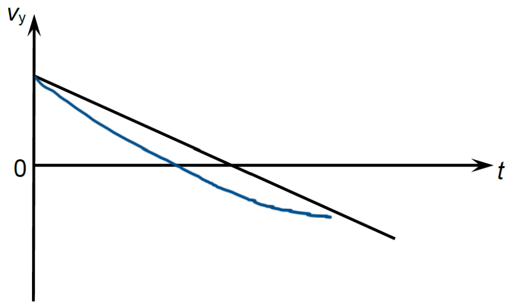


4

(a) $s_x = u_x t$
$x = (u\cos\theta)t$
$t = \dfrac{x}{u\cos\theta}$
$s_y = u_y t + \dfrac{1}{2}a_y t^2$
$y = (u\cos\theta)\,t + \dfrac{1}{2}(-9.81)t^2$
$y = x\tan\theta - 4.91\left(\dfrac{x}{u\cos\theta}\right)^2$

(b) $23 = 115\tan 60° - 4.91\left(\dfrac{115}{u\cos 60°)}\right)^2$
$u = 38\ m\ s^{-1}$

(c)



5

(a) $v^2 = u^2 + 2as$
$v = \sqrt{2(9.81)(1.96)}$
$v = 6.20\ m\ s^{-1}$

(b) Unchanged. Normal contact force on ball is vertical.

(c) $v^2 = u^2 + 2as$
$v = \sqrt{2(9.81)(0.98)}$
$v = 4.38\ m\ s^{-1}$

Impulse = change in momentum
$= m(v - u)$
Impulse = $0.034\big(4.38 - (-6.20)\big) = 0.36\ N\ s$

6

(a) **(i)** $v^2 = u^2 + 2as$

$v = \sqrt{2(9.81)(32)}$

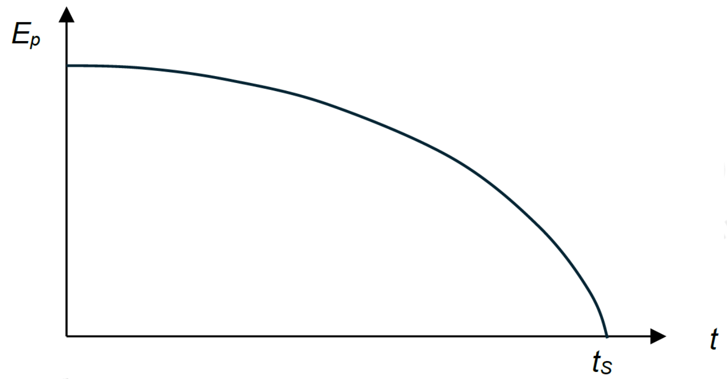
$v = 25.1\ m\ s^{-1}$

(ii) $\sin\theta = \frac{25.1}{34}$

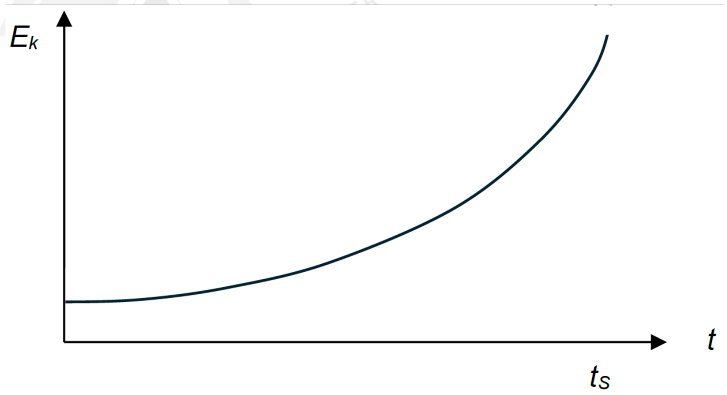
$\theta = 47.6°$

(b) With splashing, there is a transfer of KE of stone to KE of water. Less KE of stone available to do work against resistive forces in the water.

(c) **(i)**



(ii)



7

(a) $u_y = 50\sin 40° = 32.139\ m\ s^{-1}$

At the highest point, $v_y = 0$

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

$0 = 32.139^2 + 2(-9.81)(s)$

$s = 52.647$

Max height $= 52.647 + 7.0 = 60\ m$

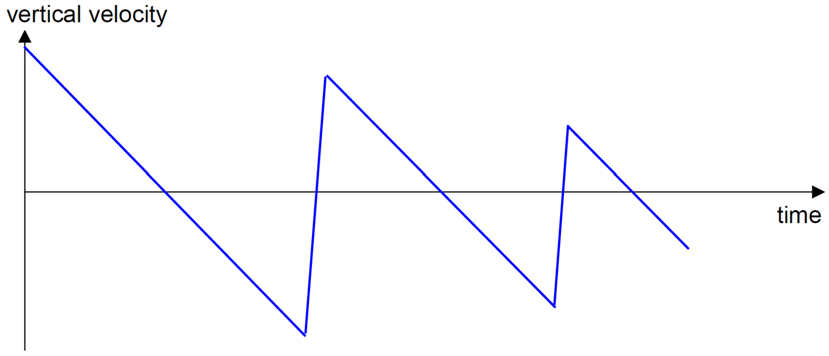
(b) When ball touches the ground, $s_y = -7.0\ m$

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

$-7 = 32.139t + \frac{1}{2}(-9.81)t^2$

$t = 6.8\ s$

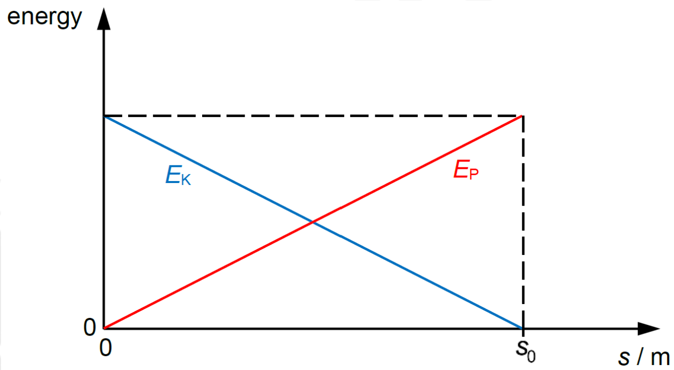
(c)



8

(a) **(i)** Take direction up the slope as positive.
$v^2 = u^2 + 2as$
$0 = 7.0^2 + 2(-9.81 \sin 30°)s_0$
$s_0 = 4.99\ m$

(ii)



(b) **(i)** $v^2 = u^2 + 2as$
$v^2 = 14.0^2 + 2(-9.81 \sin 30°)\left(\frac{4.0}{\sin 30°}\right)$
$v = 10.8\ m\ s^{-1}$

(ii) Take directions right and up as positive
Vertical: $s = ut + \frac{1}{2}at^2$
$-4.0 = (10.8 \sin 30°)t + \frac{1}{2}(-9.81)t^2$
$t = 1.6080\ s$ or $t = 0.50712\ s\ (NA)$

Horizontal: $s = ut + \frac{1}{2}at^2$
$= (10.8 \cos 30°)\ (1.6080) + 0$
$= 15.0\ m$

9

(a) The acceleration of an object is its rate of change of velocity with respect to time.

(b) **(i)** Taking upwards as positive, $v_y^2 = u_y^2 + 2a_y s_y$
$0 = (210 \sin 30°)^2 + 2(-9.81)(s_y)$
$s_y = 560\ m$

(ii) Taking upwards as positive, $v_y = u_y + a_y t$

$0 = 210\sin 30° + (-9.81)t$

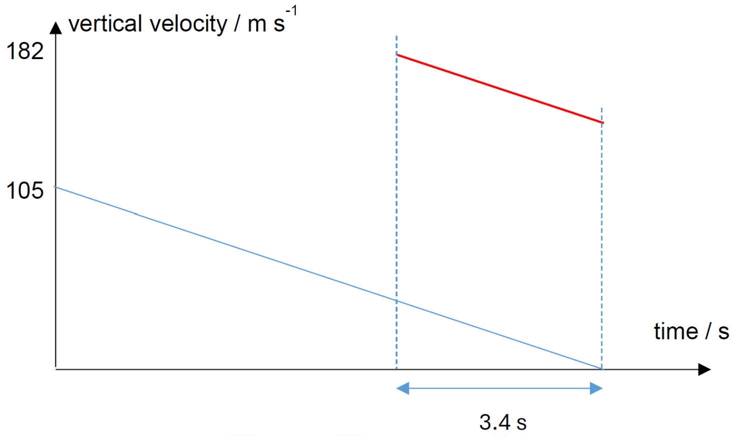
$t = 10.7\ s$

(iii) 1. $s_y = u_y t + \frac{1}{2}a_y t^2$

$561.9 = (210\sin 60°)\,t + \frac{1}{2}(-9.81)t^2$

$t = 3.4\ s$ or $t = 33.7\ s$ (NA)

(iii) 2.



10

(a)

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

$a = \frac{2s}{t^2}$

$= \frac{2(1.75)}{0.600^2}$

$= 9.72\ m\ s^{-1}$

(b) % uncertainty = actual uncertainty/ data point.

Hence the larger the data point, the smaller the % uncertainty since the absolute uncertainty is fixed. Hence more reliable.

(c) $\frac{\Delta g}{g} = \frac{\Delta s_y}{s_y} + \frac{2\Delta t}{t}$

$\Delta g = \left(\frac{0.001}{1.75} + 2\left(\frac{0.006}{0.600}\right)\right)9.722$

$= 0.2\ m\ s^{-2}$

$g \pm \Delta g = 9.7 \pm 0.2\ m\ s^{-2}$

(d) Since $s_y = \frac{1}{2}gt^2$, plot a graph of s_y against t^2, where, s_y = vertical distance travelled by the sphere, t = time taken to travel s_y. The gradient = $\frac{1}{2}g$

Random error is reduced when a best fit line is drawn using all the data points.