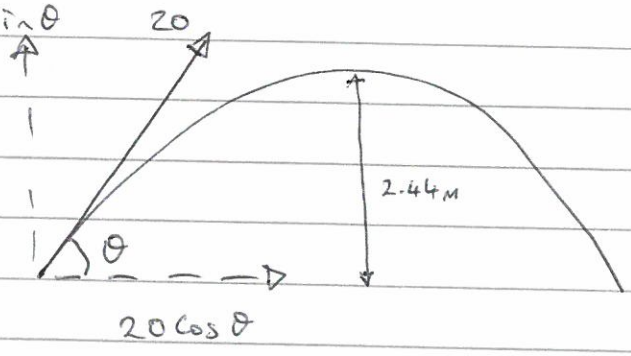
M2 Mock from March '15 (June '14 paper)

1.



i) Vertical Motion ↑ +ve

$s = 2.44$, $u = 20\sin\theta$, $v = 0$, $a = -9.8$, $t = x$

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

$0 = 400\sin^2\theta + 2(-9.8)(2.44)$

$$\sin\theta = \sqrt{\frac{2 \times 9.8 \times 2.44}{400}} \Rightarrow \theta = 20.2^\circ$$

ii) To find range, find time of flight first.

Vertical Motion ↑ +ve $s = 0$, $u = 20\sin 20.2$, $v = x$, $a = -9.8$, $t = ?$

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

$0 = 20\sin 20.2\, t - 4.9t^2$

$t(20\sin 20.2 - 4.9t) = 0$

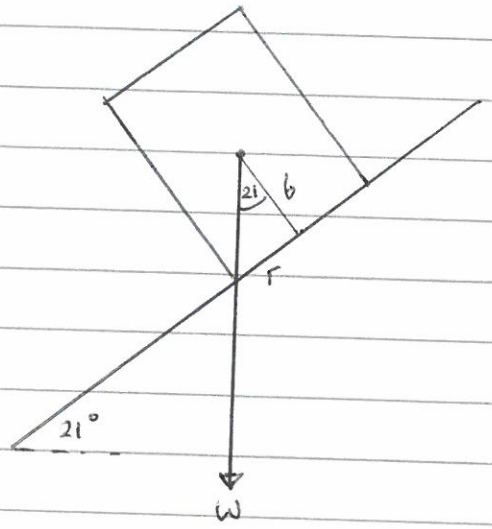
$$t = \frac{20\sin 20.2}{4.9} = 1.41\text{ s}$$

Horizontal Motion $s = ut$

$s = 20\cos 20.2 \times 1.41 = 26.5\text{ m}$

Range = 26.5 m

2 (i)

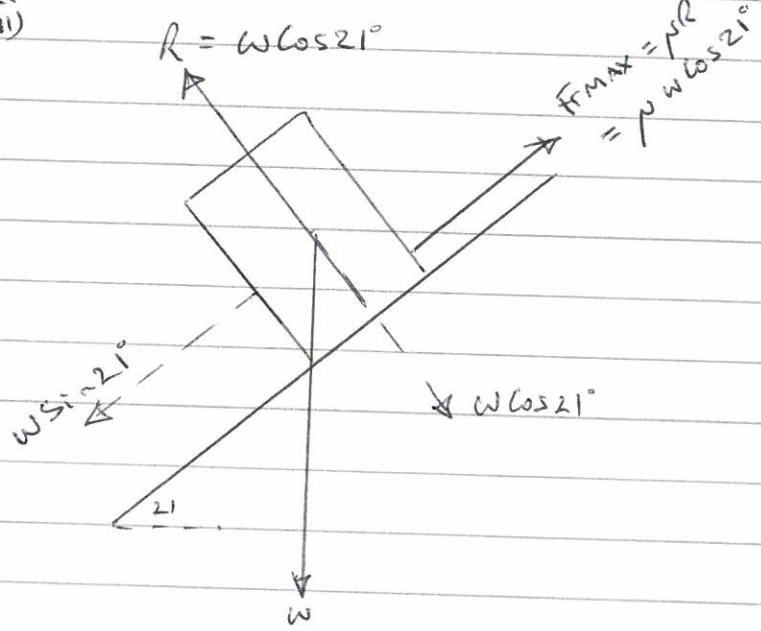


Note: C.o.M of cylinder is at its geometric centre.

$$\tan 21 = \frac{r}{6}$$

$$r = 6 \tan 21 = 2.30\,cm$$

(ii)



Since cylinder slides $W \sin 21 > F_{max}$

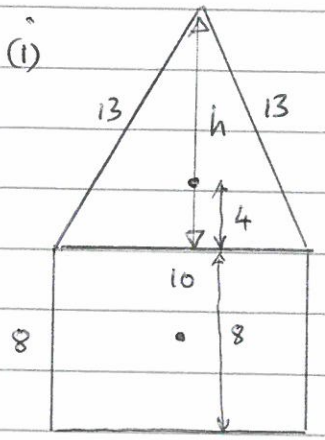
$W \sin 21 > \mu W \cos 21$

$$\mu < \frac{\sin 21}{\cos 21}$$

$$\mu < \tan 21$$

$$\mu < 0.384$$

3. (i)



For triangle

$13^2 = 5^2 + h^2$

$\therefore h = 12$

c.o.m of Δ is $\frac{1}{3}$ up

$\therefore \bar{y}_1 = 8 + 4 = 12$

$M_1 = \frac{1}{2} \times 10 \times 12k = 60k$

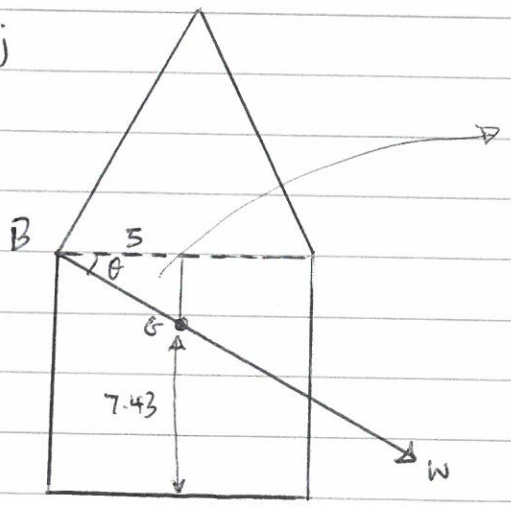
For rectangle c.o.m $\bar{y}_2 = 4$

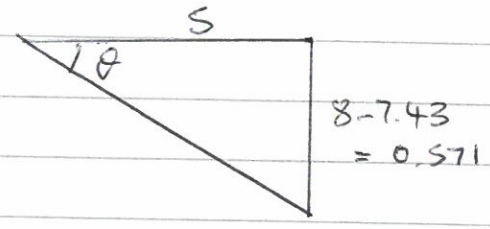
$M_2 = 8 \times 10k = 80k$

$$\bar{y} = \frac{M_1\bar{y}_1 + M_2\bar{y}_2}{M_1 + M_2} = \frac{60k \times 12 + 80k \times 4}{60k + 80k}$$

$$\text{C.o.M from AE} = \frac{1040}{140} = 7.43\text{cm}$$

(ii)

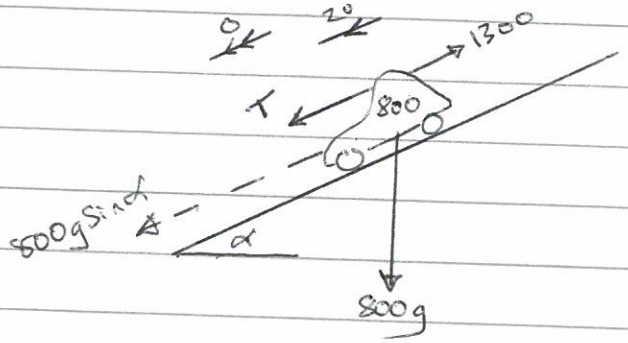




$\tan\theta = \frac{0.571}{5}$

$\theta = 6.52°$

5 (i)



Power = TV

$10000 = 20T$

$T = 500\ N$

R(⇄) $\quad 800g\sin\alpha + 500 = 1300$

$$\sin\alpha = \frac{1300 - 500}{800g}$$

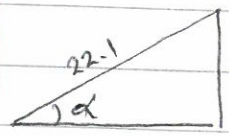
$$\sin\alpha = \frac{1}{g} = \frac{1}{9.8} = \frac{5}{49}$$

(ii) This question asks about time so we need to use power = rate of doing work = $\frac{\text{work done}}{\text{time}}$

The work done by the engine increases the K.E & P.E. of the car and overcomes the work done by the resistance force.

Work done by engine = Increase in KE + Increase in PE + work against resistance

need height gain



$\frac{h}{22.1} = \sin\alpha \quad \therefore \quad h = 22.1 \times \frac{5}{49} = 2.255_M$

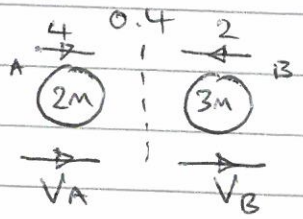
$\frac{1}{2}mv^2$ $\quad$ mgh $\quad$ force × dist

Work done $= \frac{1}{2} \times 800 \times 8^2 + 800g \times 2.255 + 1300 \times 22.1 = 72010\ J$

$$\text{Power} = \frac{\text{Work done}}{\text{time}} \qquad 20000 = \frac{72010}{\text{time}}$$

$$\text{time} = \frac{72010}{20000} = 3.60\ s$$

6. (i)



(Make things simpler to assume V_A & V_B are positive to the right).

Law of rest $\quad 0.4 = \dfrac{V_B - V_A}{6} \quad \therefore \quad V_B - V_A = 2.4$ ①

Cons of mom $\quad 8m - 6m = 2mV_A + 3mV_B \quad \therefore \quad 2 = 2V_A + 3V_B$ ②

$2\times$① $\quad 2V_B - 2V_A = 4.8$

② $\quad 3V_B + 2V_A = 2$

$\quad 5V_B \quad\quad = 6.8 \quad \Rightarrow V_B = 1.36\,ms^{-1}$ sub in ①

$\quad V_A = -1.04\,ms^{-1}$

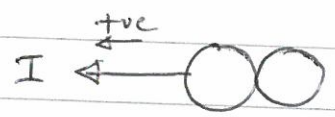
Speed of A is $1.04\,ms^{-1}$ Speed of B is $1.36\,ms^{-1}$

(ii) K.E. before $\quad \frac{1}{2}(2m)\times 4^2 + \frac{1}{2}(3m)\times 2^2 = 22\,m$

K.E. after $\quad \frac{1}{2}(2m)\times 1.04^2 + \frac{1}{2}(3m)\times 1.36^2 = 3.856\,m$

KE Loss $= 18.1\,m$ J

(iii)



$I = m(v-u)$

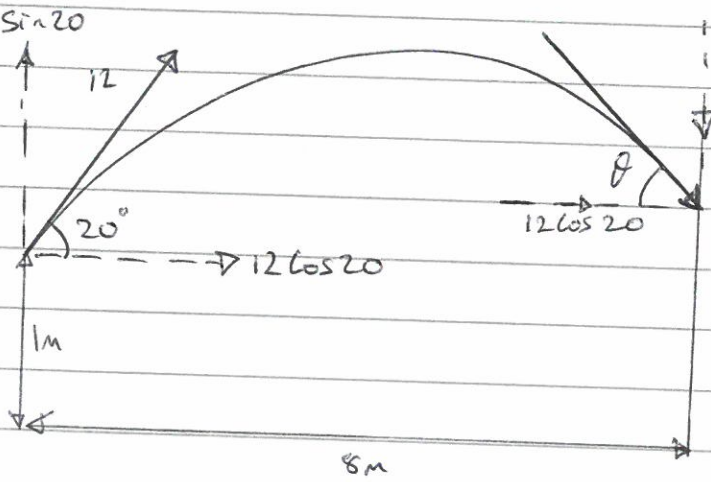
+ve

$2.52 = 2m\,(1.04 - -4)$

$2.52 = 10.08\,m$

$m = \dfrac{2.52}{10.08} = 0.25$

8. i)



← Find vertical component of velocity and combine with horizontal component to find direction of final velocity.

Vertical ↑ Motion +ve

$s = x,\ u = 12\sin 20,\ v = ?,\ a = -9.8,\ t =$ need this

Horizontal Motion

$s = ut$

$8 = 12\cos 20\, t$

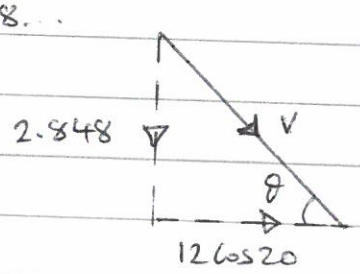
$t = \frac{8}{12\cos 20} = 0.709\ldots$

$= 0.709\ldots$

$v = u + at$

$v = 12\sin 20 - 9.8 \times 0.709$

$v = -2.848\ldots$



$\tan\theta = \frac{2.848}{12\cos 20}$

$\theta = 14.2°$ below horizontal

ii)

Vertical

$s = 1.5,\ u = V\sin 20,\ v = x,\ a = -9.8,\ t = t$

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

$1.5 = V\sin 20\, t - 4.9t^2$

Horizontal $s = ut$, $8 = V\cos 20\, t$ $\therefore t = \frac{8}{V\cos 20}$ sub in

$1.5 = \frac{V\sin 20 \cdot 8}{V\cos 20} - 4.9 \times \frac{8^2}{V^2\cos^2 20}$

$\frac{4.9 \times 8^2}{V^2\cos^2 20} = 8\tan 20 - 1.5$ $\therefore V = \sqrt{\frac{4.9 \times 8^2}{\cos^2 20(8\tan 20 - 1.5)}}$

$V = 15.9\ ms^{-1}$