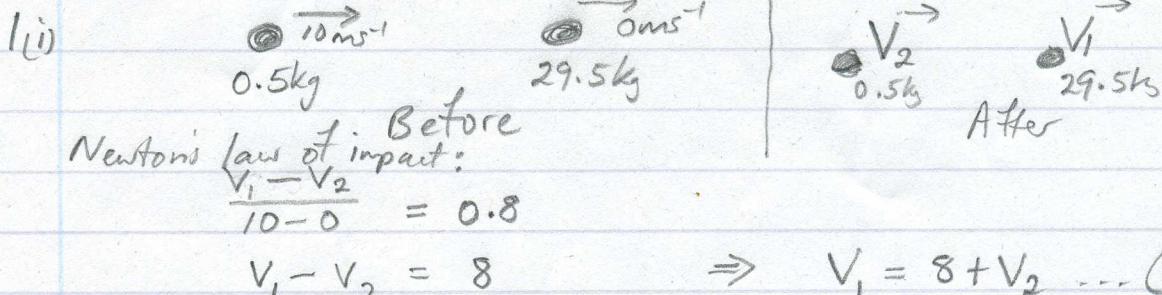


M<sub>2</sub> Jan 07



Conservation of momentum:

$$0.5 \times 10 + 29.5 \times 0 = 0.5 V_2 + 29.5 V_1$$

$$5 V_2 + 295 V_1 = 50$$

$$V_2 + 59 V_1 = 10 \dots \textcircled{2}$$

$$\text{sub } \textcircled{1} \text{ in } \textcircled{2} \quad V_2 + 59(8 + V_2) = 10$$

$$V_2 + 472 + 59 V_2 = 10$$

$$60 V_2 = -462$$

$$V_2 = -7.7 \text{ ms}^{-1} \therefore \text{speed } V_2 = 7.7 \text{ ms}^{-1}$$

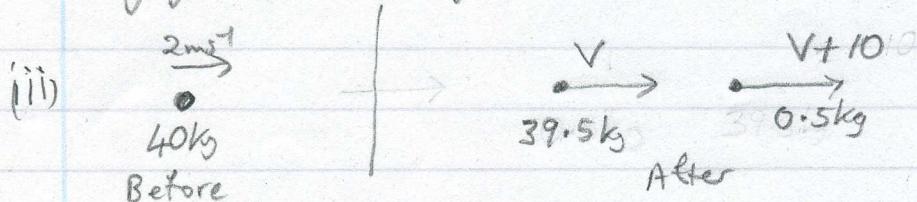
$$V_1 = 8 - 7.7$$

$$= 0.3 \text{ ms}^{-1}$$

(ii) (A)  $0.5 \times 10 + 29.5 \times 0 = 30 V$

$$V = \frac{1}{6} \text{ ms}^{-1}$$

(B) Since no force is applied to the sledge and resistance is negligible the sledge should continue at the same velocity



$$0.5(V+10) + 39.5V = 40 \times 2$$

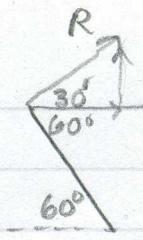
$$0.5V + 5 + 39.5V = 80$$

$$40V = 75$$

$$V = 1.875 \text{ ms}^{-1}$$

2.(i) horizontally:

$$X - R \cos 30^\circ = 0 \\ \Rightarrow X = R \cos 30^\circ$$



vertically:

$$Y + R \sin 30^\circ - L = 0 \quad \dots \textcircled{3} \\ \Rightarrow Y + R \sin 30^\circ = L$$

(ii) From  $\leftrightarrow$   $X = \frac{\sqrt{3}}{2} R$   
 $\Rightarrow R = \frac{2}{\sqrt{3}} X \dots \textcircled{1}$

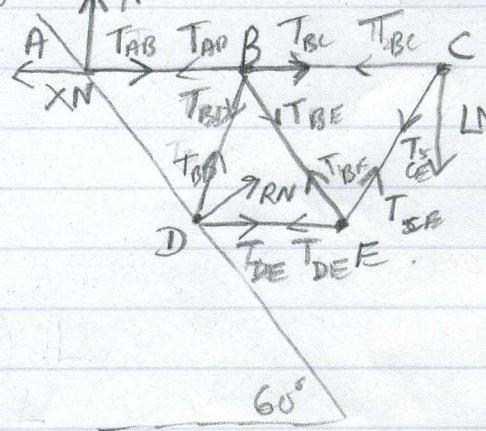
Taking moments about A

$$2xL = xR \\ 2L = R \quad \dots \textcircled{2}$$

putting  $\textcircled{1} = \textcircled{2}$

$$\frac{2}{\sqrt{3}} X = 2L \\ X = \frac{\sqrt{3}}{2} \times 2L \\ X = \sqrt{3} L \quad \dots \textcircled{3}$$

(iii)



Sub  $\textcircled{2}$  in  $\textcircled{3}$

$$Y + \left(\frac{2}{\sqrt{3}} X\right) \times \frac{1}{2} - L = 0$$

$$\text{sub } \textcircled{3} \quad Y + \frac{2 \times \sqrt{3}}{\sqrt{3}} \times \frac{1}{2} L - L = 0 \\ \Rightarrow Y = 0$$

(iv) (i) At A,  $Y - T_{AD} \sin 60^\circ = 0$

$$\text{since } Y = 0, T_{AD} \sin 60^\circ = 0 \\ \Rightarrow T_{AD} = 0$$

(iv) Resolving at A: (ii)  $T_{AD} \sin 60^\circ - Y = 0 \Rightarrow T_{AD} = 0$

$$(\rightarrow) T_{AB} - X - T_{AD} \cos 60^\circ = 0 \Rightarrow T_{AB} = \sqrt{3} L \quad (\text{Tension})$$

Resolving at C (↓)  $T_{CE} \cos 30^\circ + L = 0$

$$(\rightarrow) T_{CE} \sin 30^\circ + T_{BC} = 0$$

$$T_{CE} = -\frac{2}{\sqrt{3}} L \quad (\text{compression})$$

$$T_{BC} = \frac{1}{\sqrt{3}} L \quad (\text{Tension})$$

(v) AHB (↓)  $T_{BD} \sin 60^\circ + T_{BE} \sin 60^\circ = 0$

$$T_{BD} = -T_{BE} \quad \text{i.e. equal magnitude & opposite direction}$$

3. (i)  $(10, 2, 2.5)$

C.G.C. (Left)			Total
(ii)	Base	Original Frame	
	80	$(20+20+100+100) = 240$	320
C.M.O. x from	20	10	$\bar{x}$
y + 2 from	2	2	$\bar{y}$
z - 2	0	2.5	$\bar{z}$

$x$  and  $y$  remain the same

$$\bar{z} = \frac{240 \times 2.5}{320}$$

$$= 1.875$$

Lidless box			Lid	Total
(iii)	mass	$\bar{x}$	$\bar{y}$	$\bar{z}$
	320	80	400	
$x$	10	10	$\bar{x}$	
$y$	2	4	$\bar{y}$	
$z$	1.875	3.5	$\bar{z}$	

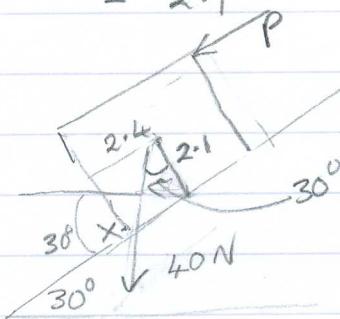
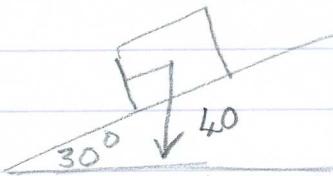
$$\bar{x} = \frac{320 \times 10 + 80 \times 10}{400} = 10$$

$$\bar{y} = \frac{320 \times 2 + 80 \times 4}{400} = 2.4$$

$$\bar{z} = \frac{320 \times 1.875 + 80 \times 3.5}{400}$$

$$= 2.1$$

(iv) Looking at Box side on



(2) Taking moments about X

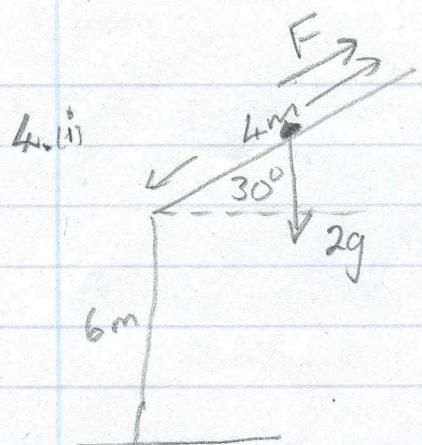
$$40 \times 0.024 \cos 30^\circ - 40 \times 0.021 \sin 30^\circ$$

$$= 0.411 \text{ Nm (3.s.f)}$$

(2)

$$0.41138... - 0.05P = 0$$

$$P = 8.23 \text{ N (3.s.f)}$$



$$\begin{aligned}
 F &= \mu R = \mu mg \cos \theta \\
 &= 0.75 \times 2 \times 9.8 \times \cos 30^\circ \\
 &= \underline{12.7 \text{ N}} (3s.f)
 \end{aligned}$$

$$mg \sin\theta = 2 \times 9.8 \times \sin 30^\circ$$

$$= 9.8 N$$

since  $F > mg \sin \theta$  i.e.  $12.7 > 9.8$   
 tile does not slide.

$$\begin{aligned}
 \text{(ii) (A) Gain in GPE} &= mgh + mg \sin\theta x \\
 &\quad (\text{for the } 6\text{m}) \qquad \qquad (\text{for the } 4\text{m}) \\
 &= 2 \times 9.8 \times 6 + 2 \times 9.8 \times \sin 30^\circ \times 4 \\
 &= 156.8 \text{ J}
 \end{aligned}$$

$$\begin{aligned}
 (B) \text{ Work done against friction} &= F \times l \\
 &= (1.5 \times 9.8 \times \frac{\sqrt{3}}{2}) \times 4 \\
 &= 50.9 \text{ J (3.s.f.)}
 \end{aligned}$$

$$\begin{aligned}
 (c) \quad \text{Power} &= \frac{\text{work done}}{\text{time}} = \frac{\text{wd. against grav.} + \text{wd. against air}}{\text{grav.} + \text{air}} \\
 &= \frac{156.8 \times 10}{60} + \frac{50.9 \times 10}{60} \\
 &= 34.6 \text{ W (33.1)}
 \end{aligned}$$

$$\begin{aligned}
 \text{(iii) Final K.E.} &= \text{Initial K.E.} + \text{G.P.E. lost} - \text{Work done against resistance} \\
 a &= \frac{1}{2}mv^2 + 2 \times 9.8 \times 6 + 2 \times 9.8 \times \sin\theta \times x - 90 \\
 \frac{1}{2} \times 2 \times 9^2 &= \frac{1}{2} \times 2 \times 4^2 + 117.6 + 9.8x - 90 \\
 9.8x &= 81 - 16 - 117.6 + 90 \\
 x &= 3.82 \text{ m (3 s.f.)}
 \end{aligned}$$