

## M 2 Jan 09

$$\begin{aligned} \text{i. (i)} \quad F &= ma \\ &= m\left(\frac{V-u}{t}\right) \\ &= \frac{m \times 2u}{5} \end{aligned}$$

= 0.4 mu in direction of the velocity

(ii) Using conservation of momentum:-

$$\begin{aligned} m \times 2u + 3m \times u &= mV_p + 3mV_Q \\ (\because m) \quad 5u &= V_p + 3V_Q \quad \dots \textcircled{1} \end{aligned}$$

Using Newton's Law of Restitution: (where  $e = 1$ )

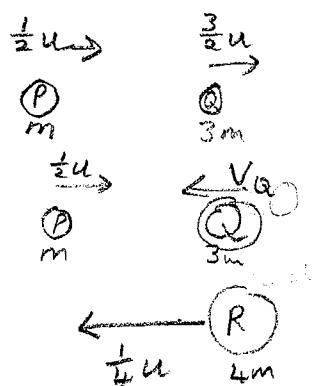
$$\frac{\text{Speed of separation}}{\text{Speed of approach}} = \frac{V_Q - V_p}{2u - u} = e = 1$$

$$\Rightarrow V_Q - V_p = u \quad \dots \textcircled{2}$$

$\textcircled{1} + \textcircled{2}$

$$\begin{aligned} 4V_Q &= 6u \\ V_Q &= \frac{3}{2}u \quad , (V_p = \frac{1}{2}u) \end{aligned}$$

(iii)



Hitting barrier :-  
Using Newton's Law of Rep. for Q

$$\frac{V_Q}{\frac{3}{2}u} = e$$

$$V_Q = \frac{3}{2}eu$$

2nd collision:-

Using Conserv. of Mome.

$$m \times \frac{1}{2}u + 3m(-\frac{3}{2}eu) = 4m(-\frac{1}{4}u)$$

$$\frac{1}{2} - \frac{9}{2}e = -\frac{1}{4}$$

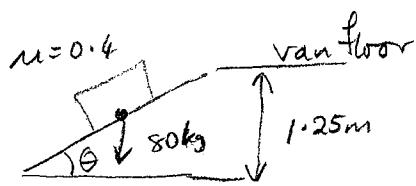
$$\frac{9}{2}e = \frac{3}{2}$$

$$e = \frac{1}{3}$$

Loss of momentum when Q hits the

$$\begin{aligned} \text{barrier} &\text{ is } 3m \times \frac{3}{2}u - 3m \times \frac{3}{2} \times \frac{1}{3}u \\ &= 3m[\frac{3}{2}u + \frac{1}{2}u] \\ &= 3m \times 2u \\ &= 6mu \end{aligned}$$

$\Rightarrow$  Impulse on Barrier is 6mu



2.

$$(i) \text{ Limiting frictional force} = \mu R$$

$$= \mu mg \cos \theta$$

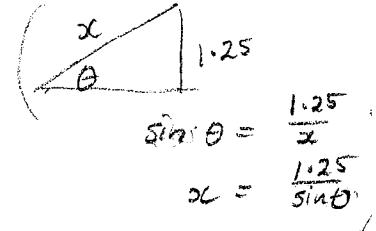
$$= 0.4 \times 80g \cos \theta$$

$$= 32g \cos \theta \quad (= 313.6 \cos \theta \text{ (1dp.)})$$

$$(ii) \text{ Work done against friction} = 32g \cos \theta \times x$$

$$= 32g \cos \theta \times \frac{1.25}{\sin \theta}$$

$$= \frac{392}{\tan \theta} \text{ J} \quad (3 \text{s.f.})$$



$$(iii) \text{ Gain in G.P.E.} = mgh$$

$$= 80 \times 9.8 \times 1.25$$

$$= \underline{980 \text{ J}}$$

$$(iv) \theta = 35^\circ \text{ Let Driving force} = F_D$$

You need  $F_D - mgs \sin \theta - \mu mg \cos \theta = ma = 0$  (because it reaches a steady speed)

$$F_D = 80g \sin 35^\circ + 32g \cos 35^\circ$$

$$\begin{aligned} P &= F_D \times v \\ &= (80g \sin 35^\circ + 32g \cos 35^\circ) \times 1.5 \\ &= \underline{1060 \text{ W}} \quad (3 \text{s.f.}) \end{aligned}$$

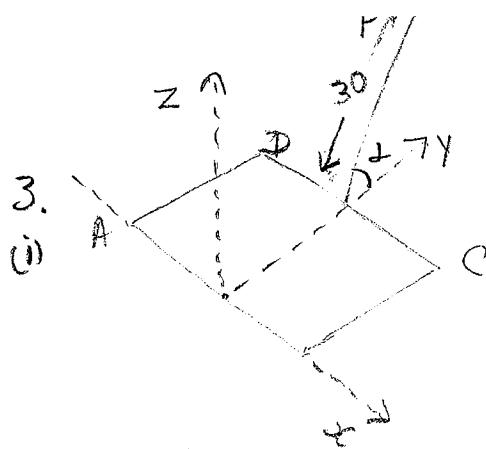
$$(v) \text{ Loss in PE} = \text{Gain in KE} + \text{Work done against Resistance}$$

$$\begin{aligned} \frac{980}{40(V^2 - \frac{1}{4})} &= \left( \frac{1}{2} \times 80 \times V^2 - \frac{1}{2} \times 80 \times 0.5^2 \right) + \frac{392}{\tan 35^\circ} \\ &= 980 - \frac{392}{\tan 35^\circ} \end{aligned}$$

$$V = \sqrt{\left( 980 - \frac{392}{\tan 35^\circ} \right) \times \frac{1}{40} + \frac{1}{4}}$$

$$= \underline{3.28 \text{ ms}^{-1}} \quad (3 \text{s.f.}) \quad = \text{velocity at bottom of ramp}$$

$\Rightarrow$  Answer is yes. It does reach  $3 \text{ ms}^{-1}$  while on the ramp

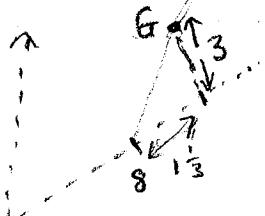


$$\begin{aligned}\bar{y} &= \frac{250 \times 4 + 125 \times (8 + 15 \times 0.8)}{375} \\ &= \frac{1000 + 2500}{375}\end{aligned}$$

$$\bar{Z} = \frac{125 \times 15 \times 0.6}{375}$$

	Blade	Handle	Total
Masses	250	125	375
$x$	0	0	0
$y$	4	$8 + 15 \cos \alpha$	$\bar{y}$
$z$	0	$15 \sin \alpha$	$\bar{z}$

iii



c.o.m. at  $9\frac{1}{3}$  cm is along the handle (i.e.  $1\frac{1}{3}$  cm) beyond the 8 cm wide base. Taking moments along CD, the turning effect is clockwise downwards and so the fish slice will topple.

(iii)	Blade	Handle without extra mass	Extra mass handle	Total
Masses	250	125	125	500
y	4	$8 + 15 \times 0.8$	$8 + 25 \times 0.8$	$\bar{y}$
z	0	$15 \times 0.6$	$25 \times 0.6$	$\bar{z}$

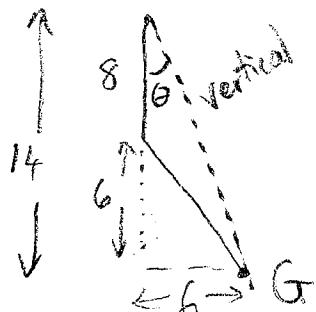
$$y = \frac{250 \times 4 + 125 \times 20 + 125 \times 28}{500}$$

$$= 14 \text{ cm}$$

$$\bar{z} = \frac{125 \times 9 + 125 \times 15}{500}$$

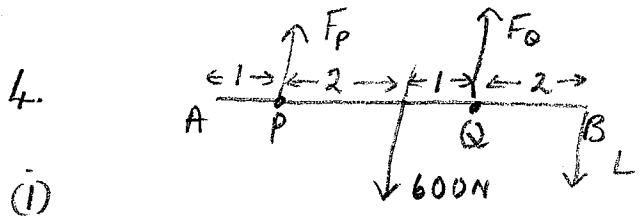
$$= 6$$

(iv)



$$\tan \theta = \frac{6}{14}$$

$$\theta = 23.2^\circ \text{ (3.s.f)}$$



(i) Resolving vertically  $F_p + F_Q = 600$

Taking moments about P  $3 \times F_Q - 2 \times 600 = 0$

$$F_Q = \frac{1200}{3}$$

$= 400 \text{ N}$  upwards

$$F_p = \underline{200 \text{ N}}$$
 upwards

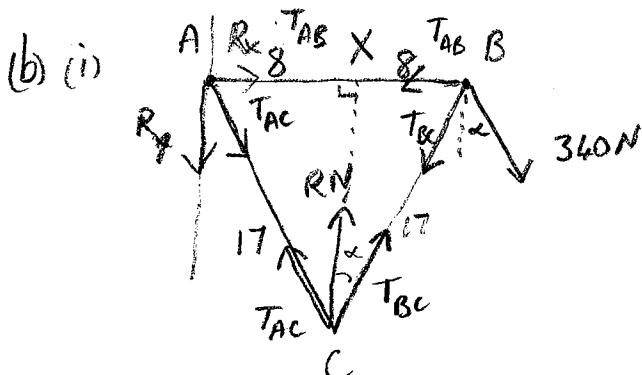
(ii) If beam is on point of tipping

$$F_p = 0$$

Taking moments about Q

$$2 \times L - 1 \times 600 = 0$$

$$L = \underline{300 \text{ N}}$$



$$\sin \alpha = \frac{8}{17} \Rightarrow \cos \alpha = \frac{15}{17}$$

$$\begin{aligned} R &= 340 \cos \alpha + R_y \\ &= 340 \times \frac{15}{17} + R_y \\ &= \underline{300 \text{ N}} + R_y \end{aligned}$$

Taking moments about A

$$16 \times 340 \cos \alpha - 17 \times R \sin \alpha = 0$$

$$R = \frac{16 \times 340 \times \frac{15}{17}}{17 \times \frac{8}{17}}$$

$$= \underline{600 \text{ N}}$$

A + C  $\left(\begin{array}{c} \uparrow \\ \downarrow \end{array}\right) R + T_{AC} \cos \alpha + T_{BC} \cos \alpha = 0$

$$\Leftrightarrow T_{AC} \sin \alpha - T_{BC} \sin \alpha = 0$$

$$T_{AC} = T_{BC}$$

$$\Rightarrow 2 T_{AC} \cos \alpha = -R$$

$$\begin{aligned} T_{AC} &= \frac{-600}{2} \times \frac{17}{15} \quad \text{and } T_{BC} = -360 \\ &= -340 \text{ N (i.e. Thrust)} \end{aligned}$$

4. (cont'd) At B (J)  $T_{BC} \cos\alpha + 340 \cos\alpha = 0 \Rightarrow T_{BC} = -340 N$  as before  
 $T_{AB} + T_{BC} \sin\alpha - 340 \sin\alpha = 0$

$$\begin{aligned}T_{AB} &= 680 \sin\alpha \\&= 680 \times \frac{8}{17} \\&= \underline{\underline{320 \text{ N}}} \text{ (Tension)}\end{aligned}$$