

Mathematics · 2017 · May/June · M1 · QP

in equilibrium  $\therefore$  for resultant = 0equate coeffs of  $\underline{i}$ 

$$15 + 5q - 3p = 0 \quad \dots \textcircled{1}$$

equate coeffs of  $\underline{j}$ 

$$1 - p - q = 0 \quad \dots \textcircled{2}$$

$$1 - p = q$$

Sub into equation  $\textcircled{1}$ 

$$15 + 5(1 - p) - 3p = 0$$

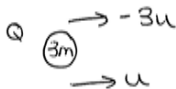
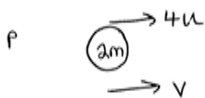
$$15 + 5 - 5p - 3p = 0$$

$$20 = 8p$$

$$\underline{p = 2.5} \quad \therefore q = 1 - 2.5$$

$$\underline{q = -1.5}$$

a)



$$4u \times 2m + (-3u) \times 3m = 3mu + 2mv$$

$$-4um = 3mu + 2mv$$

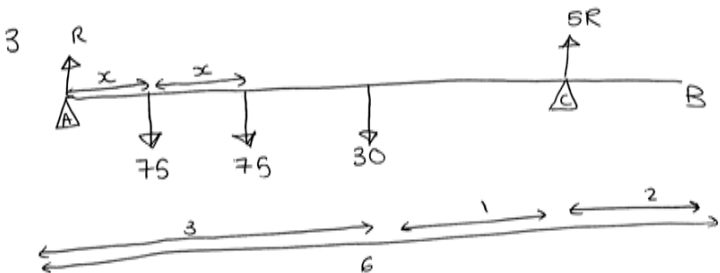
$$\frac{-4um}{2m} = v = -2u$$

$$\text{speed} = |-2u| = 2u$$

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as I took initial direction as positive  
 $\rightarrow$  and the ~~dir~~ answer was negative.

c) on Q  $I = m(v - u)$   
 $= 3m(u - -3u)$   
 $= 3m \times 4u$   
 $= \underline{12mu}$



moments  $\hat{A}$ :  $75x + (75 \times 2x) + (30 \times 3) - (5R \times 4) = 0$   
 $= \therefore 225x + 90 - 20R = 0$

moments  $\hat{C}$ :  $(30 \times 1) + (75 \times (4 - 2x)) + (75 \times (4 - x)) - 4R$

$$= 30 + 300 - 150x + 300 - 75x - 4R = 0$$

$$\boxed{630 - 225x = 4R} \dots \textcircled{1}$$

$$\boxed{90 + 225x = 20R} \dots \textcircled{2}$$

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$$\boxed{3150 - 1125x = 90 + 225x} \dots \textcircled{3}$$

equate  $\textcircled{3}$  and  $\textcircled{2}$ 

$$3150 - 1125x = 90 + 225x$$

$$3060 = 1350x$$

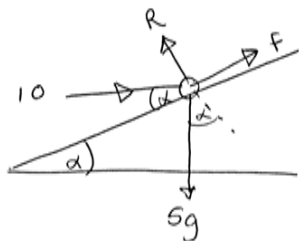
$$x = \underline{2.27 \text{ m}}$$

b) by assuming the plank is:

uniform = the mass acts at the centre of the plank.

a rod = does not bend when weight / forces are applied.

4)



$$F = \mu R$$

$$\uparrow R - 5g \cos \alpha - 10 \sin \alpha = 0$$

$$R = 5g \left(\frac{4}{5}\right) + 10 \left(\frac{3}{5}\right)$$

$$R = 45.2$$

$$\therefore F = \mu 45.2$$

$$\rightarrow + 45.2\mu + 10 \cos \alpha - 5g \sin \alpha = 0$$

$$45.2\mu = 5g \left(\frac{3}{5}\right) - 10 \left(\frac{4}{5}\right)$$

$$45.2\mu = 21.4$$

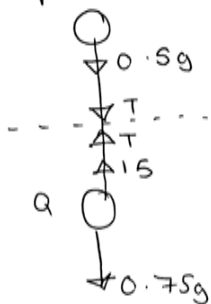
$$\mu = \underline{0.47}$$

$$\frac{5}{4} \text{ triangle}$$

$$\sin \alpha = \frac{3}{5}$$

$$\cos \alpha = \frac{4}{5}$$

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$$\textcircled{2} \dots \text{at Q } T - 0.75g + 15 + T = 0.75a$$

add  $\textcircled{1}$  and  $\textcircled{2}$  together

$$-1.25g + 15 = 1.25a$$

$$2.75 = 1.25a$$

$$a = \underline{\underline{2.2}}$$

sub 'a' into  $\textcircled{1}$ 

$$-0.5g - T = 0.5 \times 2.2$$

$$-0.5g - 0.5 \times 2.2 = T$$

$$T = -6 \text{ N}$$

$$T = |-6| = \underline{\underline{6 \text{ N}}}$$

6)  $\vec{AB}$ 

$$s = 40$$

$$u =$$

$$v = 10$$

$$a = ?$$

$$t = 5$$

$$s = vt - \frac{1}{2}at^2$$

$$40 = 50 - \frac{1}{2}a \times 25$$

$$-20 = -25a$$

$$a = \underline{\underline{0.8}}$$

 $\vec{A}^{\text{mid}}$ 

$$\text{b) } s = 20$$

$$u =$$

$$v =$$

$$a = 0.8$$

$$t =$$

 $\vec{AB}$ 

$$s = 40$$

$$u = ?$$

$$v = 10$$

$$a = 0.8$$

$$t = 5$$

$$s = \left( \frac{u+v}{2} \right) t$$

$$40 = \left( \frac{u+10}{2} \right) 5$$

$$\underline{\underline{u = 6}}$$

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$$y = 20$$

$$v = 0$$

$$a = 0.8$$

$$t = ?$$

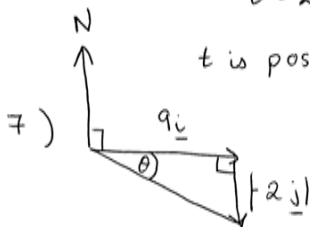
$$20 = 6t + 0.4t^2$$

$$0.4t^2 + 6t - 20 = 0$$

$$\frac{-6 \pm \sqrt{6^2 - 4(0.4)(-20)}}{2 \times 0.4}$$

$$t = 2.81 \text{ or } -17.8$$

$t$  is positive  $\therefore t = \underline{\underline{2.81}}$



$$\theta = \tan^{-1}\left(\frac{2}{9}\right) = 12.5^\circ$$

$$\text{bearing} = 12.5 + 90 = \underline{\underline{103^\circ}}$$

$$b) \quad p = (9\underline{i} + 10\underline{j}) + t(9\underline{i} - 2\underline{j})$$

$$q = (\underline{i} + 4\underline{j}) + t(4\underline{i} + 8\underline{j})$$

$$c) \quad \overrightarrow{QP} = p - q$$

$$= 9\underline{i} - \underline{i} + 10\underline{j} - 4\underline{j} + 9t\underline{i} - 4t\underline{i} - 2t\underline{j} - 8t\underline{j}$$

$$= 8\underline{i} + 6\underline{j} + 5t\underline{i} - 10t\underline{j}$$

$$= (8 + 5t)\underline{i} + (6 - 10t)\underline{j} \quad \text{+ as given}$$

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points = pythagoras.

$$\sqrt{(8+5t)^2 + (6-10t)^2} = 10$$

$$(8+5t)(8+5t) + (6-10t)(6-10t) = 100$$

$$64 + 80t + 25t^2 + 36 - 120t + 100t^2 = 100$$

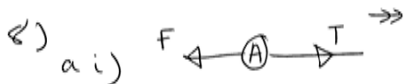
$$125t^2 - 40t + 100 = 100$$

$$125t^2 - 40t = 0$$

$$t(125t - 40) = 0$$

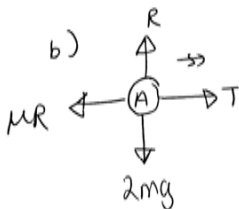
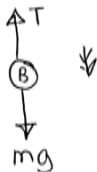
$$\underline{t=0} \text{ or } 125t = 40$$

$$\underline{t=0.32}$$



$$A \rightarrow + T - F = 2ma$$

$$B \text{ ii) } mg - T = ma$$



$$\uparrow R = 2mg$$

$$\therefore F = \mu R = 2mg\mu$$

sub into equation for A

$$T - 2mg\mu = 2ma$$

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for both B and A

$$mg - ma = T$$

∴

$$mg - ma - 2mg\mu = 2ma$$

$$mg(1 - 2\mu) = 3ma$$

$$a = \frac{mg}{3m}(1 - 2\mu) = \frac{g}{3}(1 - 2\mu)$$

c) When B hits floor  $s = h$ 

↓

$$s = h$$

$$u = 0$$

$$v = ?$$

$$a = \frac{g}{3}(1 - 2\mu)$$

t

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

$$v^2 = 0^2 + \frac{2hg}{3}(1 - 2\mu)$$

$$v = \sqrt{\frac{2gh}{3}(1 - 2\mu)}$$

d) when B hits floor  $\Rightarrow$  no tension

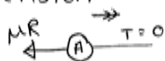
$$\therefore s = d - h$$

$$u = \sqrt{\frac{2gh}{3}}$$

$$v = 0$$

$$a = -\frac{1}{3}g$$

t =



$$\therefore -\mu R = 2ma$$

$$-\frac{1}{3} \times 2mg = 2ma$$

$$a = -\frac{1}{3}g$$

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

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$$0 = \frac{2}{9}gh - \frac{1}{3}g(d-h)$$

$$0 = \frac{2}{9}gh - \frac{1}{3}g(d-h)$$

$$0 = \frac{h}{9} - \frac{1}{3}d + \frac{1}{3}h$$

$$\frac{1}{3}d = \frac{4}{9}h$$

$$d = \frac{4}{3}h$$

e) the system would not move