$(15\underline{i} + 5\underline{j}) + (5q\underline{i} + q\underline{j}) + (-3p\underline{i} - q\underline{j})$

in equilibrium $\therefore$ ~~for~~ resultant = 0

equate coeffs of $\underline{i}$

$15 + 5q - 3p = 0 \quad \cdots (1)$

equate coeffs of $\underline{j}$

$1 - p - q = 0 \quad \cdots (2)$

$1 - p = q$

Sub into equation (1)

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

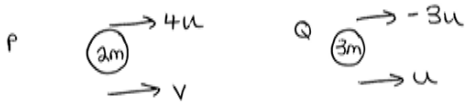
$15 + 5 - 5p - 3p = 0$

$20 = 8p$

$p = 2.5$ $\quad \therefore q = 1 - 2.5$

$q = -1.5$

a)



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

$-um = 3mu + 2mv$

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

speed $= |-2u|$

$= 2u$

b) direction of P has been reversed as I took initial direction as positive $\rightarrow +$ and the ~~dire~~ answer was negative.

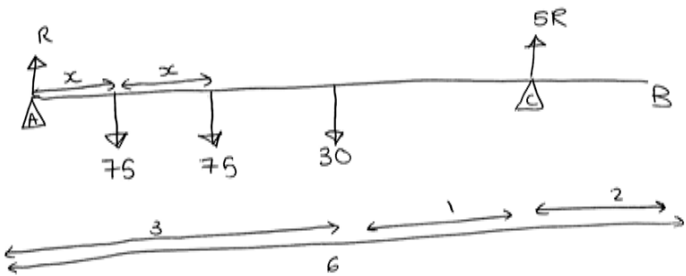
c) on Q $I = m(v-u)$

$= 3m(u--3u)$

$= 3m \times 4u$

$= 12mu$

3



moments $\curvearrowright$ A: $75x + (75 \times 2x) + (30 \times 3) - (5R \times 4) = 0$

$: 225x + 90 - 20R = 0$

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

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

$630 - 225x = 4R$ ... ①

$90 + 225x = 20R$ ... ②

multiply ① × 5

$3150 - 1125x = 90R$ .... ③

equate ③ and ②

$3150 - 1125x = 90 + 225x$

$3060 = 1350x$

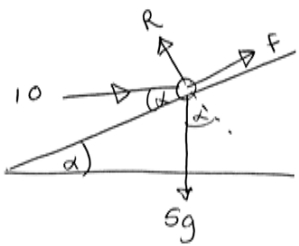
$x = 2.27$ m

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)



$F = \mu R$

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

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

$R = 45.2$

$\therefore F = \mu 45.2$

$\sin\alpha = \frac{3}{4}$

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

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

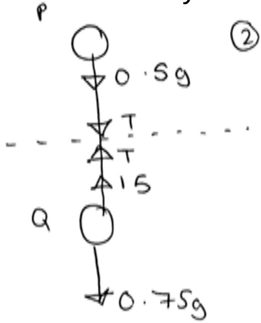
$\rightarrow + \quad 45.2\mu + 10\cos\alpha - 5g\sin\alpha = 0$

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

$45.2\mu = 21.4$

$\mu = 0.47$

5) ① ... at P ↑+ $-0.5g - T = 0.5a$



② ... at Q ↑+ $-0.75g + 15 + T = 0.75a$

add ① and ② together

$-1.25g + 15 = 1.25a$

$2.75 = 1.25a$

$a = \underline{2.2}$

sub 'a' into ①

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

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

$T = -6\,N$

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

6) $\overrightarrow{AB}$

$s = 40$
$u =$
$v = 10$
$a = ?$
$t = 5$

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

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

$-20 = -25a$

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

b) $\overrightarrow{A}$mid

$s = 20$
$u =$
$v =$
$a = 0.8$
$t =$

$\overrightarrow{AB}$

$s = 40$
$u = ?$
$v = 10$
$a = 0.8$
$t = 5$

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

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

$\underline{u = 6}$

$s = 20$
$u = 6$
$v =$
$a = 0.8$
$t = ?$

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

$20 = 6t + 0.4t^2$

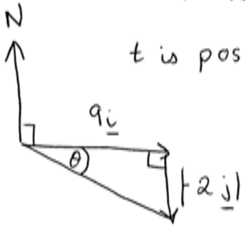
$0.4t^2 + 6t - 20 = 0$

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

$t = 2.81$ or -17.8

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

7)



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

bearing $= 12.5 + 90$
$= \underline{\underline{103°}}$

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

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

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

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

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

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

d) distance between two points = pythagoras.

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

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

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

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

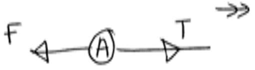
$$125t^2 - 40t = 0$$

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

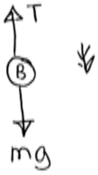
$t = 0$ or $125t = 40$

$t = 0.32$

8) a i)

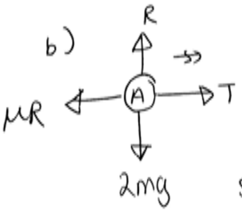


A $\rightarrow +$ $T - F = 2ma$



B ii) $mg - T = ma$

b)



$\uparrow^{+}$ $R = 2mg$

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

sub into equation for A

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

as T is

for both B and A

$mg - ma = T$

$\therefore$

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

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

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

c) When b ~~hist~~ hits floor $s = h$

$+\downarrow$

$s = h$
$u = 0$
$v = ?$
$a = \frac{g}{3}(1 - 2\mu)$
t

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

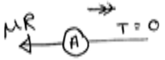
$v^2 = 0^2 + \frac{2hg}{3}(1 - 2\mu)$

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

d) when B hits floor => no tension

$\therefore$

$s = d - h$
$u = \sqrt{\frac{2}{9}gh}$
$v = 0$
$a = -\frac{1}{3}g$
$t =$



$\therefore -\mu R = 2ma$

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

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

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

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

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

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

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

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

e) the system would not move