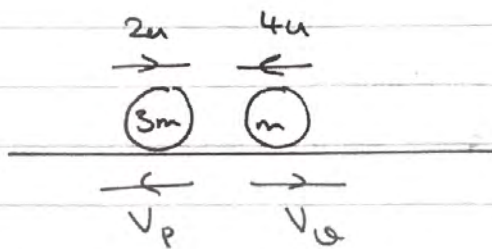


M1 June 2018 (MA)

Q(a)



$$\underline{\text{C.L.M}} : 3m(2u) - 4mu = mV_q - 3mV_p$$

$$2u = V_q - 3V_p \quad \text{--- (1)}$$

$$I = m(v - u)$$

$$\left[\text{for P} \right] \frac{21mu}{4} = 3m(V_p - -2u)$$

$$\Rightarrow \frac{21mu}{4} = 3mV_p + 6mu$$

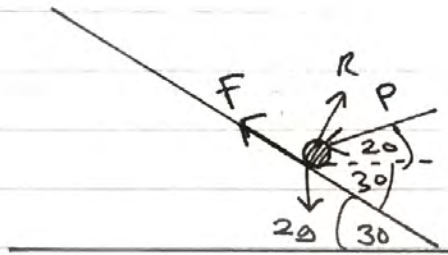
$$\Rightarrow -\frac{3u}{4} = 3V_p \quad \therefore V_p = -\frac{u}{4}$$

$$\text{so speed} = \boxed{\frac{u}{4}}$$

$$\text{b) (i): } V_q = 2u + 3V_p = 2u + 3\left(-\frac{u}{4}\right)$$

$$\therefore \boxed{V_q = \frac{5u}{4} = \text{speed}}$$

Q2)



note that we want the least possible value of P . This least value occurs when friction acts up the plane.

$$\underline{R(\text{Parallel to plane})} : P \cos 50 + F = 2g \sin 30 \quad \text{--- (1)}$$

$$\underline{R(\text{Perp. to plane})} : R = 2g \cos 30 + P \sin 50$$

$$F = \frac{1}{4} R$$

$$\text{(1)} : P \cos 50 + \frac{1}{4} R = 2g \sin 30$$

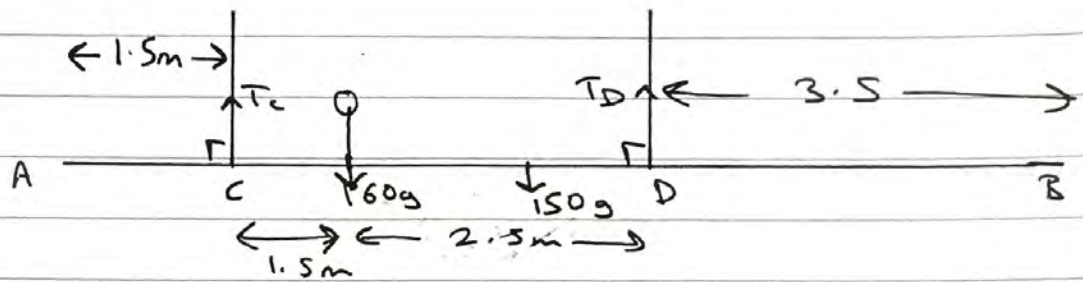
$$\underline{\times 4} : 4P \cos 50 + (R) = 4g$$

$$\underline{\text{sub (2)}} : 4P \cos 50 + (2g \cos 30) + (P \sin 50) = 4g$$

$$P(4 \cos 50 + \sin 50) = 4g - 2g \cos 30$$

$$P = \frac{4g - 2g \cos 30}{4 \cos 50 + \sin 50} = \boxed{6.66 \text{ N}}$$

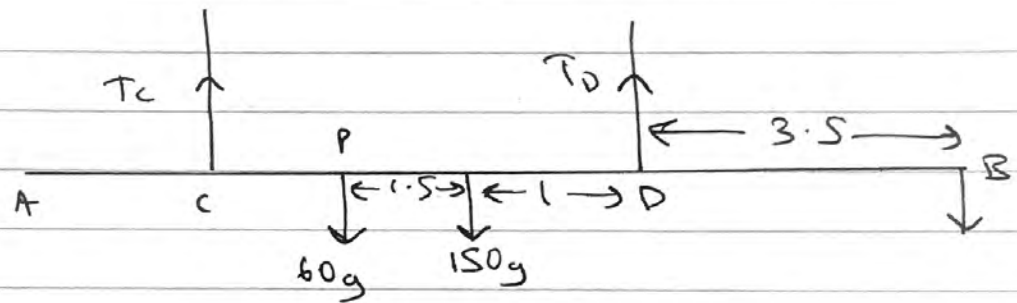
(Q3a)



$$\underline{M(C)} : T_c (4) = 150g(1) + 60g(2.5)$$

$$T_c = \frac{150g + 60g(2.5)}{4} = 75g = \boxed{735N}$$

b)



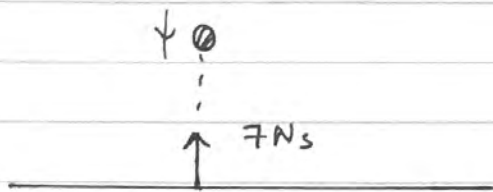
mass of gymnast at B is largest possible for beam to remain horizontal $\rightarrow T_c = 0$

$$\underline{M(B)} : 150g(4.5) + 60g(6) = T_d(3.5)$$

$$\therefore T_d = \frac{150g(4.5) + 60g(6)}{3.5}$$

$$= \boxed{2900N}$$

Q4g)



$$\left. \begin{array}{l} s = 2.5 \\ u = u \\ v = v_1 \\ a = g \\ t = \end{array} \right\} \begin{array}{l} v_1^2 = u^2 + 2as \\ v_1^2 = u^2 + 5g \\ v_1 = \sqrt{u^2 + 5g} \end{array}$$

$$I = m(v - u)$$

$$7 = 0.2(v - -v_1)$$

$$7 = 0.2(10 + \sqrt{u^2 + 5g})$$

$$35 = 10 + \sqrt{u^2 + 5g}$$

$$25 = \sqrt{u^2 + 5g}$$

$$u^2 + 5g = 625$$

$$u^2 = 376 \quad \therefore \boxed{u = 24}$$

b)

$$\left. \begin{array}{l} s = 1 \\ u = 10 \\ v = \\ a = -g \\ t = t \end{array} \right\}$$

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

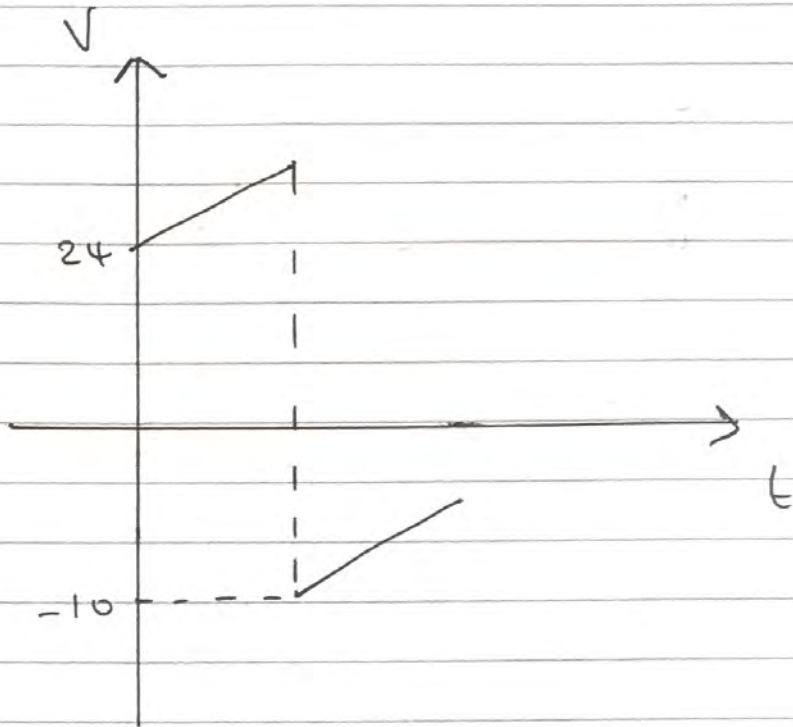
$$1 = 10t - 4.9t^2$$

$$4.9t^2 - 10t + 1 = 0$$

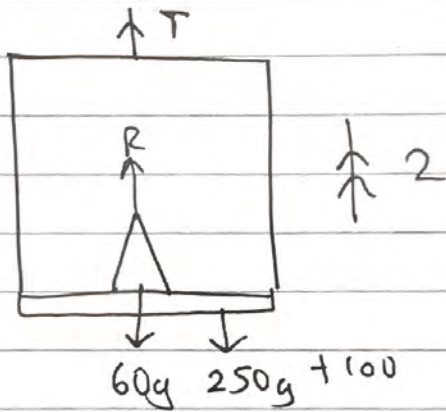
By Quadratic Formula : $t = 1.94$, $\boxed{0.105}$
 ↑
 reject!

$$\underline{t = 0.11s}$$

c)



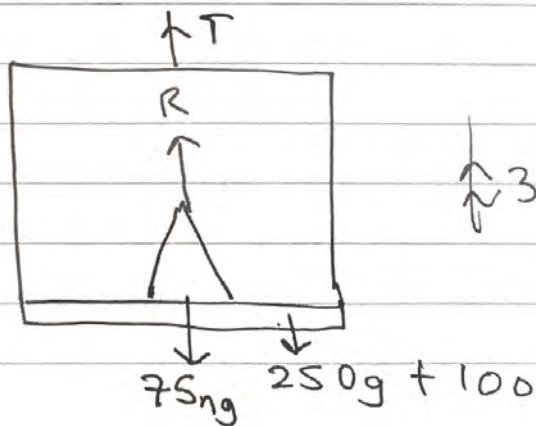
(Q5a)



$$\underline{N2L \uparrow^+ (woman)} : R - 60g = 60(2)$$

$$R = 60g + 120 = \boxed{708N}$$

b)



$$\uparrow^+ \\ \text{N2L (system)} : T - 250g - 100 = 75ng = (250 + 75n)c$$

$T = 10000$ for max no. of occupants to be carried...

$$10000 - 250g - 100 = 75ng + 250(3) + 75n(3)$$

$$6700 = n(75g + 3(75))$$

$$n = \frac{6700}{75g + 3(75)} = 6.979\dots$$

so max $n = 6$

this isn't quite 7!

$$\text{(Q6a)} \quad F_1 + F_2 = R = \begin{pmatrix} 4 \\ -6 \end{pmatrix} + \begin{pmatrix} p \\ q \end{pmatrix} = \begin{pmatrix} p+4 \\ q-6 \end{pmatrix}$$

We are told R acts in the direction $-2\mathbf{i} - \mathbf{j}$

$$\text{so } \dots \quad 2(q-6) = p+4$$

\mathbf{i} component \rightarrow $\Rightarrow 2q - 12 = p + 4$
is double the \mathbf{j} .

$$\Rightarrow p - 2q = -16$$

$$\text{b) } \underline{q=3} : p = 2q - 16 = 2(3) - 16 = -10 //$$

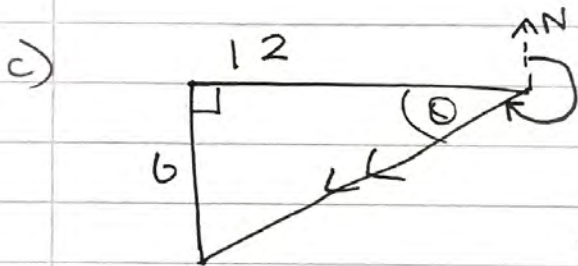
$$\text{so } R = \begin{pmatrix} -6 \\ -3 \end{pmatrix} = \Sigma F //$$

$$\sum F = ma$$

$$|R| = \sqrt{6^2 + 3^2} = 3\sqrt{5}$$

$$R = ma; \quad 3\sqrt{5} = 0.5a$$

$$\therefore a = 6\sqrt{5} = \boxed{13.4 \text{ ms}^{-2}}$$



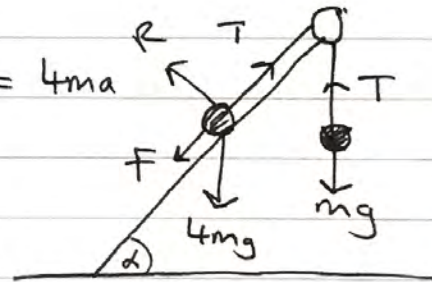
$$\tan \theta = \frac{6}{12} = \frac{1}{2}$$

$$\theta = \tan^{-1}\left(\frac{1}{2}\right) = 26.6^\circ$$

$$\text{Bearing: } 270 - 26.6 = \boxed{243^\circ}$$

(Q7a) Inextensible string

b) $\underline{N2L(P)} \swarrow$: $4mg \sin \alpha - T - F = 4ma$ (1)



$\underline{N2L(Q)} \uparrow$: $T - mg = ma$ (2)

c) $\underline{(1) + (2)}$: $4mg \sin \alpha - T + T - F - mg = 5ma$

$$\sin \alpha = \frac{3}{5} \quad \therefore \frac{12mg}{5} - F - mg = 5ma$$

$$F = \frac{1}{4}R, \quad R = 4mg \cos \alpha //$$

$$\therefore \frac{7}{5}mg - \frac{1}{4}(4mg)\left(\frac{4}{5}\right) = 5ma$$

$$\frac{3}{5}g = 5a \quad \therefore a = \boxed{\frac{3g}{25}} \text{ ms}^{-2}$$

d) $\left. \begin{array}{l} s = h \\ u = 0 \\ v = v \\ a = \frac{3g}{25} \\ t = \end{array} \right\} \begin{array}{l} v^2 = u^2 + 2as \\ v^2 = 0^2 + \frac{6gh}{25} \quad // \end{array}$

(For Q) $\left. \begin{array}{l} s = s \\ u = \sqrt{\frac{6gh}{25}} \\ v = 0 \\ a = -g \\ t = \end{array} \right\} \begin{array}{l} v^2 = u^2 + 2as \\ 0^2 = \frac{6gh}{25} - 2gs \end{array}$

(Q is under influence of g only once P hits the ground.) $s = \frac{3h}{25} //$

so after P hits the ground (and string is not taut), Q travels an extra distance of $\frac{3h}{25}$.

Q does not reach the pulley so d) total distance travelled

$$\therefore d > \frac{3h}{25} + h$$

$$\boxed{d > \frac{28h}{25}}$$