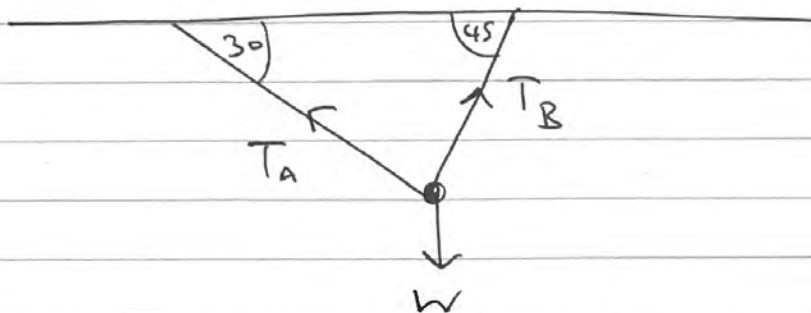


M1 January 2018 (IAL) (MA)

Q1:)



$$R(\uparrow\downarrow): T_A \sin 30 + T_B \sin 45 = W$$

$$\frac{T_A}{2} + T_B \frac{\sqrt{2}}{2} = W \quad \text{--- (1)}$$

$$R(\leftrightarrow): T_A \cos 30 = T_B \cos 45$$

$$\therefore T_A \cdot \frac{\sqrt{3}}{2} = T_B \cdot \frac{\sqrt{2}}{2}$$



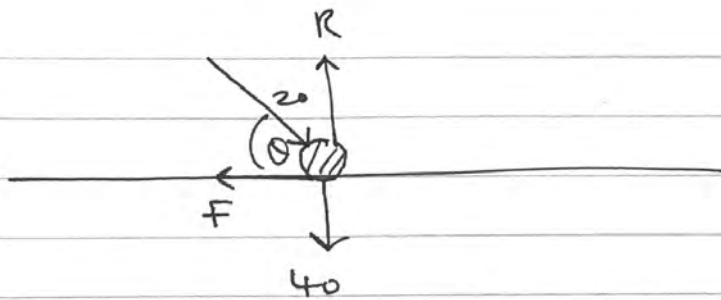
$$\text{Subbing into (1): } \frac{T_A}{2} + T_A \cdot \frac{\sqrt{3}}{2} = W$$

$$T_A \left(\frac{\sqrt{3}+1}{2} \right) = W$$

$$\text{so } \boxed{T_A = \frac{2W}{\sqrt{3}+1}} = 0.73W$$

$$\text{ii) } T_B = T_A \cdot \sqrt{\frac{3}{2}} = \boxed{\frac{2W\sqrt{3}}{\sqrt{6}+\sqrt{2}}} = 0.90W$$

Q2)



$$F \leq \mu R \quad \text{so} \quad \mu \geq \frac{F}{R}$$

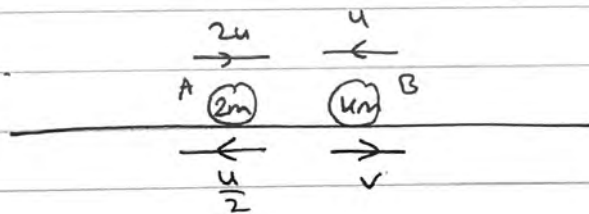
$$R (\leftrightarrow) : 20 \cos \theta = F$$

$$R (\updownarrow) : 20 \sin \theta + 40 = R$$

$$\text{so} \quad \mu \geq \frac{20 \cos \theta}{20 \sin \theta + 40}$$

$$\stackrel{\div 20}{\implies} \mu \geq \frac{\cos \theta}{\sin \theta + 2}$$

Q3a)



$$\text{Impulse (on A)} = 2m(v - u) = 2m\left(\frac{u}{2} - 2u\right)$$

$$\therefore I = \boxed{5mu}$$

$$\text{b) C.L.M : } 2m(2u) - um(u) = 2m\left(-\frac{u}{2}\right) + um(v)$$

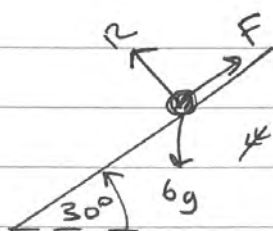
$$5mu - umu = kmv$$

$$\text{so } v = \frac{su - uu}{u} //$$

but $v > 0 \rightarrow su - uu > 0$
(since B's dir is reversed)

$$\therefore \boxed{u < s}$$

Q4a)



+ \swarrow N2L (Package) : $6g \sin 30 - F = 6a$

$$F = \mu R = \frac{1}{4} \times 6g \cos 30 //$$

$$\therefore a = \frac{\frac{6g}{2} - \frac{6g \cos 30}{4}}{6}$$

$$a \approx \boxed{2.78 \text{ ms}^{-2}}$$

b)

$$s = 10$$

$$u = 0$$

$$v = v$$

$$a = 2.78$$

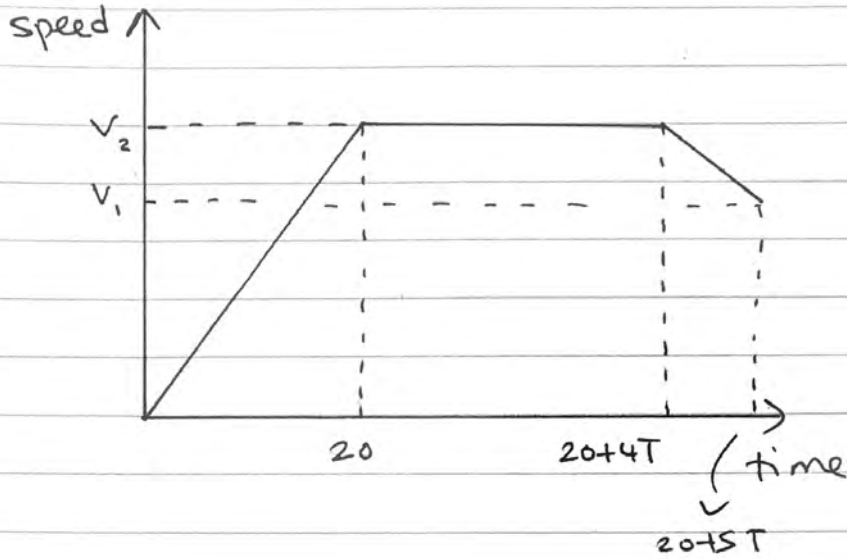
$$t =$$

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

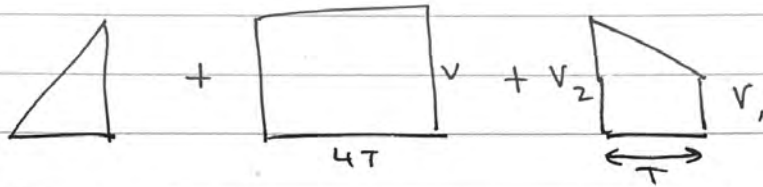
$$v^2 = 2(10)(2.78)$$

$$\therefore \boxed{v \approx 7.45 \text{ m/s}}$$

Q5a)



b) Total area = Total distance = 705m



$$\left(\frac{1}{2} \times 20 \times v_2\right) + (4T \times v_2) + \frac{(v_1 + v_2)(T)}{2} = 705$$

finding v_2 :

$$\left. \begin{array}{l} S = \\ u = 0 \\ v = v_2 \\ a = 0.6 \\ t = 20 \end{array} \right\} \begin{array}{l} v_2 = u + at \\ v_2 = 0.6 \times 20 = 12 \text{ms}^{-1} \end{array} //$$

finding v_1 :

$$\left. \begin{array}{l} S = \\ u = 12 \\ v = v_1 \\ a = -0.3 \\ t = T \end{array} \right\} \begin{array}{l} v_1 = u + at \\ v_1 = 12 - 0.3T \end{array} //$$

$$\text{so } 10(12) + 4T(12) + \frac{(24 - 0.3T)(T)}{2} = 705$$

$$120 + 48T + 12T - 0.15T^2 = 705$$

$$0.15T^2 - 60T + 585 = 0$$

By Quadratic formula : $T = 390$
 $T = 10$

$$T < 20 \text{ so } \boxed{T = 10}$$

c) from B to C :

$$\left. \begin{array}{l} S = \\ u = 9 \\ v = 0 \\ a = -0.3 \\ t = t \end{array} \right\} \begin{array}{l} v = u + at \\ 0 = 9 - 0.3t \\ t = \frac{9}{0.3} = \underline{\underline{30s}} \end{array}$$

so total time from A to C = $20 + 5(10) + 30$
 $= \boxed{100s}$

Q6a) $\Sigma F = ma$: $\begin{pmatrix} 2 \\ 3 \end{pmatrix} + \begin{pmatrix} 4 \\ -5 \end{pmatrix} = \Sigma f = 6\hat{i} - 2\hat{j}$

$$|F| = \sqrt{6^2 + 2^2} = 2\sqrt{10} = ma$$

$$2\sqrt{10} = 2a \quad \therefore \boxed{a = \sqrt{10} \text{ m/s}^2}$$

bi)

$$s =$$

$$u = -u\mathbf{i} + u\mathbf{j}$$

$$v = 10\mathbf{i} + 2\mathbf{j}$$

$$a = 3\mathbf{i} - \mathbf{j}$$

$$t = T$$

$$v = u + at$$

$$10\mathbf{i} + 2\mathbf{j} = -u\mathbf{i} + u\mathbf{j} + 3T\mathbf{i} - T\mathbf{j}$$

$$10\mathbf{i} + 2\mathbf{j} = (3T - u)\mathbf{i} + (u - T)\mathbf{j}$$

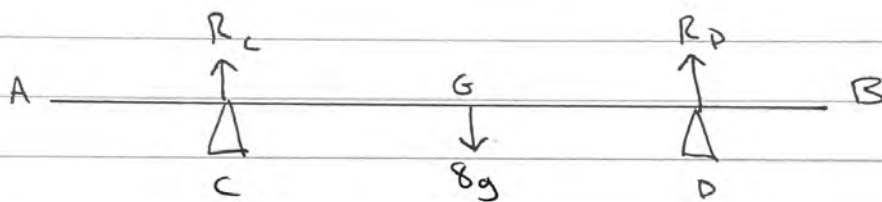
$$\text{compare } \mathbf{i} : 10 = 3T - u \quad \sim \textcircled{1}$$

$$\text{compare } \mathbf{j} : 2 = u - T \quad \sim \textcircled{2}$$

$$\textcircled{1} + \textcircled{2} : 12 = 2T \quad \therefore \boxed{T = 6} //$$

$$\textcircled{2} : 2 = u - 6 \quad \therefore \boxed{u = 8} //$$

Q7a)



$$\underline{R_D = 2R_C}$$

$$R(\uparrow\downarrow) : R_C + R_D = 8g \quad \therefore 3R_C = 8g //$$

$$\boxed{R_C = \frac{8g}{3}}$$

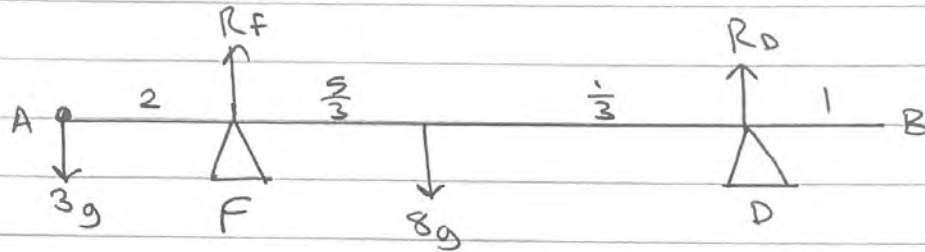
$$M(c) : 8g(x-1) = R_D(4)$$

$$8g(x-1) = \frac{64g}{3}$$

$$\therefore x-1 = \frac{64g}{3 \times 8g} = \frac{8}{3} //$$

$$\therefore x = 1 + \frac{8}{3} = \boxed{\frac{11}{3}}$$

b)



$$R(\uparrow\downarrow): R_F + R_D = 11g$$

$$\text{and } R_D = uR_F$$

$$\therefore (u+1)R_F = 11g //$$

$$M(F): 8g\left(\frac{5}{3}\right) = R_D(3) + 3g(2)$$

$$\frac{22g}{3} = 3R_D \therefore R_D = \frac{22g}{9} //$$

$$\text{so } R_F = \frac{22g}{9u}$$

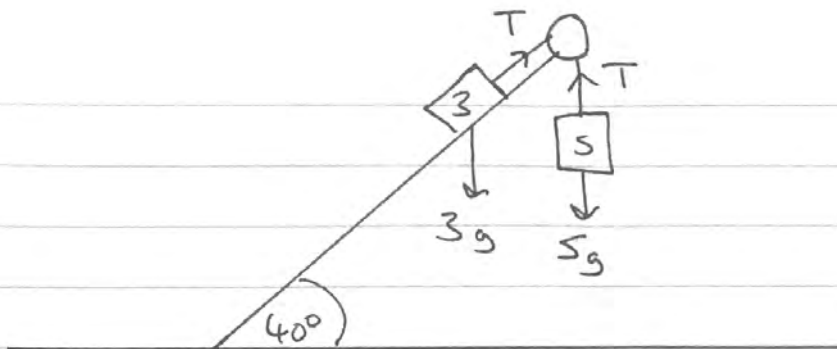
$$\Rightarrow \frac{11g}{u+1} = \frac{22g}{9u}$$

$$\frac{u+1}{11} = \frac{9u}{22}$$

$$\Rightarrow 2u+2 = 9u$$

$$\Rightarrow 7u = 2 \therefore \boxed{u = \frac{2}{7}}$$

(18a)



\nearrow N2L(A): $T - 3g \sin 40 = 3a \sim \textcircled{1}$

\downarrow N2L(B): $5g - T = 5a \sim \textcircled{2}$

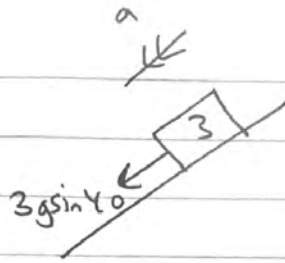
① + ②: $5g - 3g \sin 40 = 8a$

$\therefore a = 3.76 \dots \text{ms}^{-2} //$

from ② $\rightarrow T = 5g - 5(3.76) \approx \boxed{30.2 \text{N}}$

b) $\left. \begin{array}{l} s = \\ u = 0 \\ v = v \\ a = 3.76 \dots \\ t = 1.5 \end{array} \right\} \begin{array}{l} v = u + at \\ v = 0 + (3.76 \dots) \times 1.5 \approx \boxed{5.6 \text{ms}^{-1}} \end{array}$

c) for first 1.5s: $\left. \begin{array}{l} s = \\ u = 0 \\ v = \\ a = 3.76 \dots \\ t = 1.5 \end{array} \right\} \begin{array}{l} s = ut + \frac{1}{2} at^2 \\ s = \frac{1}{2} (3.76 \dots) (1.5)^2 \\ = 4.23 // \end{array}$



New a : $\sqrt{N2L(A)} : 3g \sin 40 = 3a$

$$\therefore a = g \sin 40 //$$

so for the rest of the motion:

$$s = d$$

$$u = 5.6$$

$$v = 0$$

$$a = -g \sin 40$$

$$t =$$

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

$$0^2 = (5.6)^2 - 2g d \sin 40$$

$$d = \frac{5.6^2}{2g \sin 40} \approx 2.52 //$$

so total distance = $2.52 + 4.23$

$$\approx \boxed{6.8m}$$