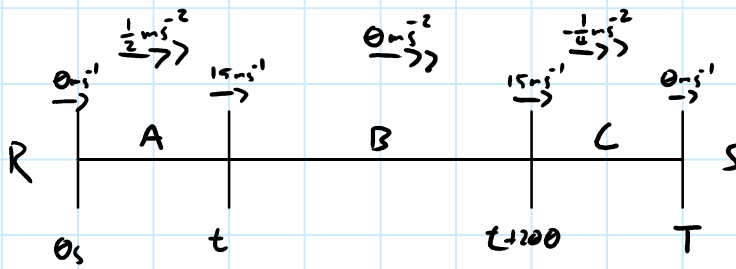


January 2017 (IAL) MA - M1

1)

a)



$$15 \text{ m s}^{-1} = 0 + \frac{1}{2} t$$

$$t = 30 \text{ s}$$

$$T = 30 + 200 + 60$$

$$0 \text{ m s}^{-1} = 15 - \frac{1}{4} t$$

$$= 240 \text{ s}$$

$$t = 60 \text{ s}$$

b)

(A) S —

$$U \ 0 \text{ m s}^{-1}$$

$$V \ 15 \text{ m s}^{-1}$$

$$A \ \frac{1}{2} \text{ m s}^{-2}$$

$$T \ 30 \text{ s}$$

(B) S —

$$U \ 15 \text{ m s}^{-1}$$

$$V \ 15 \text{ m s}^{-1}$$

$$A \ 0 \text{ m s}^{-2}$$

$$T \ 200 \text{ s}$$

(C) S —

$$U \ 15 \text{ m s}^{-1}$$

$$V \ 0 \text{ m s}^{-1}$$

$$A \ -\frac{1}{4} \text{ m s}^{-2}$$

$$T \ 60 \text{ s}$$

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

$$s = \left(\frac{0+15}{2} \right) 30$$

$$s = 225 \text{ m}$$

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

$$s = 15(200) + 0$$

$$s = 3000 \text{ m}$$

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

$$s = \left(\frac{15+0}{2} \right) 60$$

$$s = 450$$

$$|\vec{RS}| = 3,675 \text{ m}$$

1)

$$c) \quad \overline{\text{Speed}} = \frac{\text{distance}}{\text{time}}$$

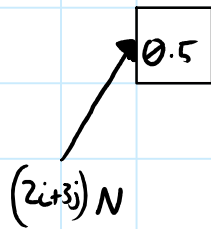
$$\bar{s} = \frac{d}{t}$$

$$\bar{s} = \frac{3675}{290}$$

$$\bar{s} = 12.7 \text{ m s}^{-1} \quad (3 \text{ s.f.})$$

2)

a)



$$F = ma$$

$$2i + 3j = \frac{1}{2} a \quad \therefore a = (4i + 6j) \text{ m s}^{-2}$$

b)

$$V_t = 4i + 0j + t(4i + 6j)$$

$$V_t = (4 + 4t)i + 6tj$$

$$|V_3| = |4 + 12i + 18j|$$

$$|V_3| = \sqrt{16^2 + 18^2}$$

$$|V_3| = \sqrt{580}$$

$$= 24.1 \text{ m s}^{-1} \quad (3 \text{ s.f.})$$

c)

$$V_T = k(2i + j)$$

$$2k = 4 + 4T$$

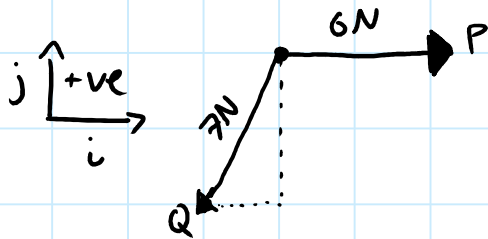
$$k = 6T$$

$$\therefore 12T = 4 + 4T$$

$$8T = 4$$

$$T = 0.5 \text{ s}$$

3)



Let i be a horizontal vector, parallel to the line of action of P
 Let j be a vertical vector, perpendicular to the line of action of P

$$P = 6i$$

$$Q = 7\cos(-120^\circ)i + 7\sin(-120^\circ)j$$

(note: angles for unit vectors are done anti-clockwise, hence the negative sign seen here)

$$R = \left(6 + 7\left(-\frac{1}{2}\right)\right)i + 7\left(-\frac{\sqrt{3}}{2}\right)j$$

$$R = \frac{5}{2}i - \frac{7\sqrt{3}}{2}j$$

$$i) \quad |R| = \sqrt{\left(\frac{5}{2}\right)^2 + \left(\frac{-7\sqrt{3}}{2}\right)^2}$$

$$|R| = \sqrt{43}$$

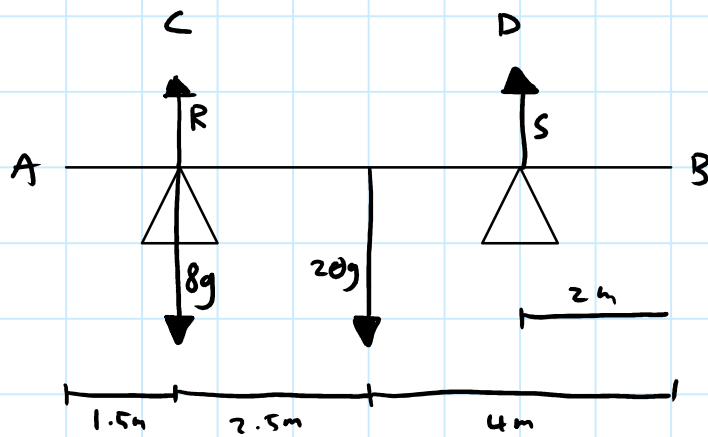
$$|R| = 6.56 \text{ N (3sf)}$$

$$ii) \quad \arg(R) = \tan^{-1}\left(\frac{-\frac{7\sqrt{3}}{2}}{\frac{5}{2}}\right)$$

$$= -67.6^\circ \text{ anticlockwise}$$

4)

a)



$$R + S = 8g + 20g$$

moments around C $(\uparrow) = (\downarrow)$

$$0 = 2.5(-20g) + 4.5(S)$$

$$490 = 4.5S$$

$$S = \frac{980}{9}$$

i)

$$S = 109 \text{ (3sf)}$$

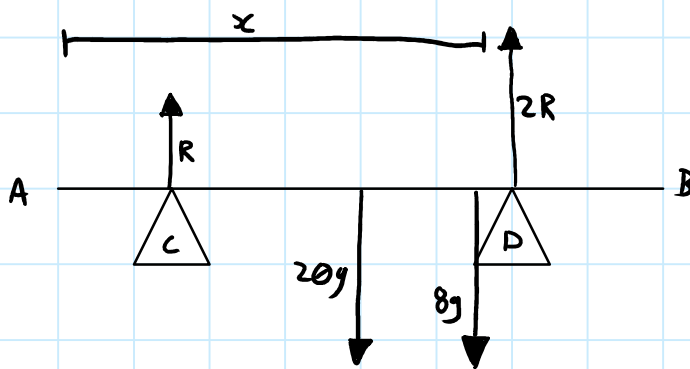
$$R + 109 = 274.4$$

ii)

$$R = 166 \text{ N (3sf)}$$

4)

b)



$$R + 2R = 20g + 8g$$

moments around A ($\sum \tau = 0$)

$$0 = 1.5R + 4(-20g) + x(-8g) + 6(2R)$$

$$80g + 8xg = 13.5R$$

$$240g + 24xg = 13.5(3R)$$

$$240g + 24xg = 13.5(28g)$$

$$240 + 24x = 378$$

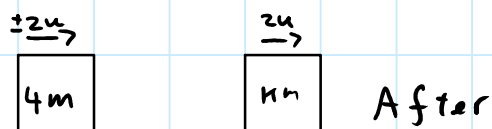
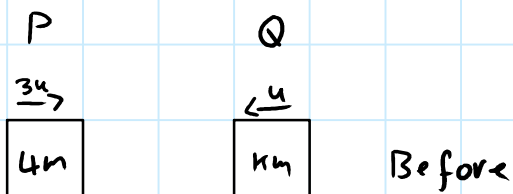
$$24x = 138$$

$$x = 5.75\text{m}$$

c)

The weight of the package acts directly on the point stated (C or E)

5)



a) $-u(km) + I = 2u(km)$

$$I = 3ukm$$

b)

Momentum is conserved

Total momentum before = total momentum after

$$3u(4m) + -u(km) = 2u(4m) + 2u(km)$$

$$12um - kum = 8um + 2kum$$

$$4um = 3kum$$

$$k = \frac{4}{3}$$

OR

$$3u(4m) + -u(km) = -2u(4m) + 2u(km)$$

$$12um - kum = -8um + 2kum$$

$$20um = 3kum$$

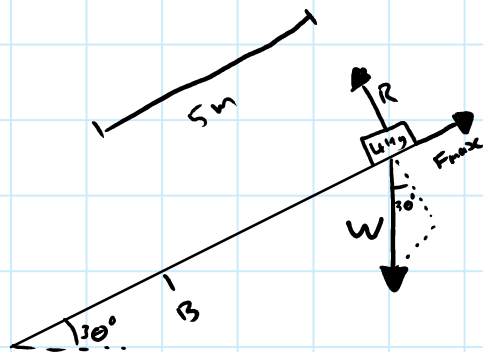
$$k = \frac{20}{3}$$

The question states the **speed** of both particles is $2u$, but only mentions the direction of this speed for Q , leaving P 's velocity ambiguous. The 2 values of K are for when P is moving towards Q ($k = 4/3$) and away from Q ($20/3$)

6)

a)

$$\mu = 0.3$$



$$R = 4g \cos(30^\circ)$$

$$= \frac{98\sqrt{3}}{5}$$

$$F_{\max} = \mu R$$

$$= 0.3 \frac{98\sqrt{3}}{5}$$

$$= 10.2 \text{ N (3 sf)}$$

$$W(\perp) = 4g \sin(30^\circ)$$

$$= 19.6 \text{ N}$$

$$19.6 - 10.2 = 9.42 \text{ N (3 sf)}$$

$$F = ma$$

$$9.42 = 4a \quad \therefore a = 2.35 \text{ m/s}^2$$

$$S \quad 5 \text{ m}$$

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

$$U \quad 0 \text{ m/s}$$

$$V \quad \text{—}$$

$$v^2 = 0 + 23.5$$

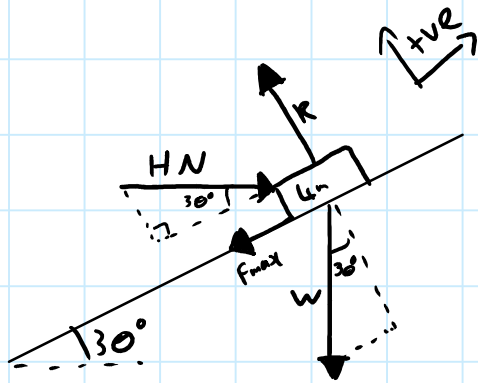
$$A \quad 2.35 \text{ m/s}^2$$

$$|v| = 4.85 \text{ m/s (3 sf)}$$

$$T \quad \times$$

6)

b)



$$R = 4g \cos(30^\circ) + H \sin(30^\circ)$$

$$F_{\max} = 0.3 \left[33.9 + \frac{1}{2} H \right]$$

$$= 10.2 + \frac{3}{20} H$$

Forces parallel to R

$$H \cos(30^\circ) - 4g \sin(30^\circ) - F_{\max} = 0$$

Forces perpendicular to R

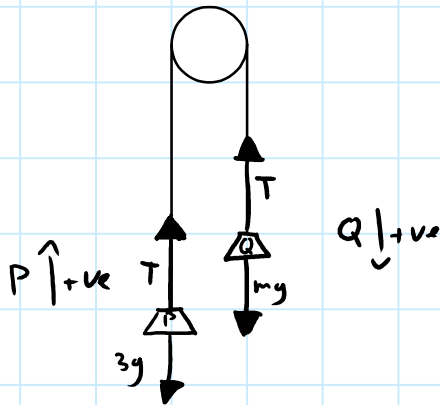
$$\frac{\sqrt{3}}{2} H - 2g - 10.2 - \frac{3}{20} H = 0$$

$$10\sqrt{3} H - 3H = 595.7$$

$$H(10\sqrt{3} - 3) = 595.7$$

$$H = 41.6 \text{ N}$$

7)



a) P: $T - 3g = 3a$

$$33.6 - 29.4 = 3a$$

$$4.2 = 3a$$

$$a = 1.4 \text{ m s}^{-2}$$

b)

Q: $mg - T = ma$

$$4.8m - 33.6 = 1.4m$$

$$8.4m = 33.6$$

$$m = 4 \text{ kg}$$

c) Q: $s = 10.5 \text{ m}$ $s = ut + \frac{1}{2}at^2$

$u = 0 \text{ m s}^{-1}$ $10.5 = 0 + 0.7t^2$

$v = x$ $t^2 = 15$

$a = 1.4 \text{ m s}^{-2}$ $t = \pm \sqrt{15}$

$T = -$ $t > 0 \therefore t = 3.87 \text{ (3 s.f.)}$

7)

Speed of particles when Q hits the ground

1)

$$S \ 10.5m \quad v^2 = u^2 + 2as$$

$$U \ 0 \quad v^2 = 0^2 + 2 \cdot 9.8 \cdot 4$$

$$V \ \underline{\quad} \quad v = 5.42 \text{ m s}^{-1}$$

$$A \ 1.4 \text{ m s}^{-2}$$

$$T \ x$$

$$S \ x \quad v = u + at$$

$$U \ 5.42 \text{ m s}^{-1} \quad 0 = 5.42 - 9.8t$$

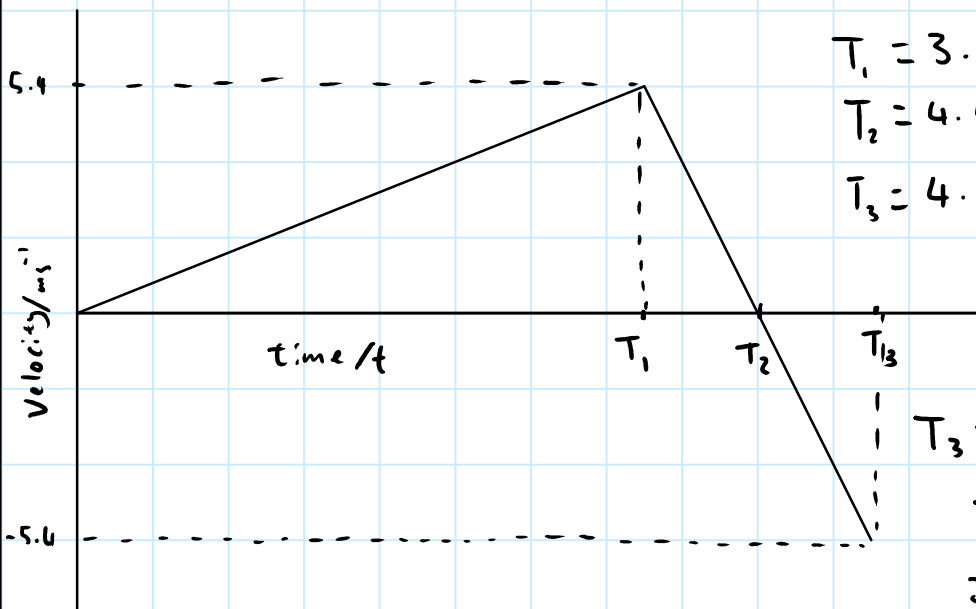
$$V \ 0 \text{ m s}^{-1} \quad 9.8t = 5.42$$

$$A \ -9.8 \text{ m s}^{-2} \quad t = 0.553 \text{ s}$$

$$T \ \underline{\quad}$$

$$T_2 = 3.87 + 0.553 = 4.43 \text{ s}$$

e)



$$T_1 = 3.87 \text{ s}$$

$$T_2 = 4.42 \text{ s}$$

$$T_3 = 4.98 \text{ s}$$

$$\begin{aligned} T_3 &= T_2 + (T_2 - T_1) \\ &= \frac{8\sqrt{5}}{7} + \frac{8\sqrt{5}}{7} - \sqrt{5} \\ &= \frac{9\sqrt{5}}{7} \end{aligned}$$