Specimen (IAL) MA - M1

1)

Let r_t be the position of P at time t

$$r_t = ai + bj + (-3i + 2j)t$$

we know

$$r_6 = -4i - 7j$$

$$\therefore [a + 6(-3)]i = -4i$$

$$a = 14$$

$$\& \ [b + 6(2)]j = -7j$$

$$b = -19$$

$$r_2 = 14i - 19j + 2(-3i + 2j)$$

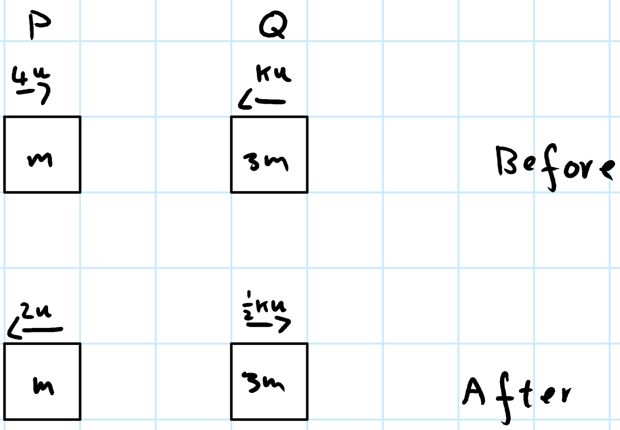
$$= 8i - 15j$$

$$|r_2| = \sqrt{8^2 + (-15)^2}$$

$$= \sqrt{289}$$

$$= 17 \text{ m}$$

2)



Total momentum before = Total momentum after

$$4um + (-ku)3m = (-2u)m + \left(\tfrac{1}{2}ku\right)3m$$

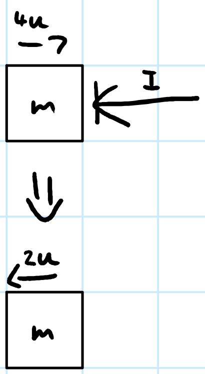
$$4\cancel{um} - 3k\cancel{um} = \tfrac{3}{2}k\cancel{um} - 2\cancel{um}$$

$$4 - 3k = \tfrac{3}{2}k - 2$$

$$6 = \tfrac{9}{2}k$$

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

b)



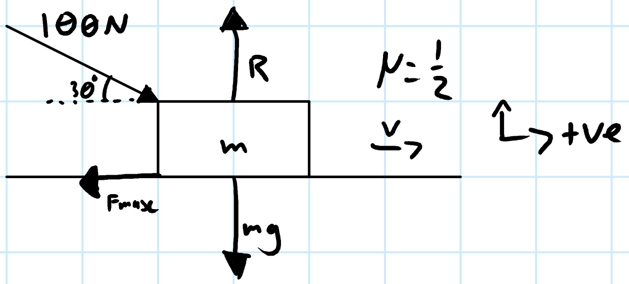
$$4um + I = -2um$$

$$I = -6um \text{ Ns}$$

Question ask for the magnitude so :

$$|I| = 6um \text{ Ns}$$

3)



$R = mg + 100\sin(30°)$

$= mg + 50\text{ N}$

$F_{max} = \mu R$

$= \frac{1}{2}(mg + 50)$

$= \frac{1}{2}mg + 25\text{ N}$

Constant speed therefore no acceleration. (Forces are balanced)

Forces (→)

$100\cos(30°) - F_{max} = 0m$

$50\sqrt{3} - \frac{1}{2}mg - 25 = 0$

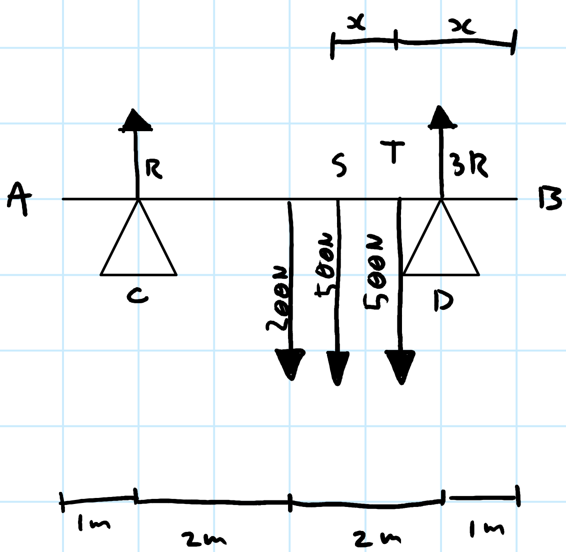
$50\sqrt{3} = \frac{1}{2}mg + 25$

$100\sqrt{3} = mg + 50$

$\frac{100\sqrt{3} - 50}{g} = m$

$m = 12.6\text{ kg}$ (3sf)

4)



Forces in equilibrium

$R + 3R = 200 + 500 + 500$

$4R = 1200\,N$

$R = 300\,N$

Moments in equilibrium

moments ↻ = moments ↺

moments around B

$1(900) + x(-500) + 2x(-500) + 3(-200) + 5(300) = 0$

$900 - 1500x - 600 + 1500 = 0$

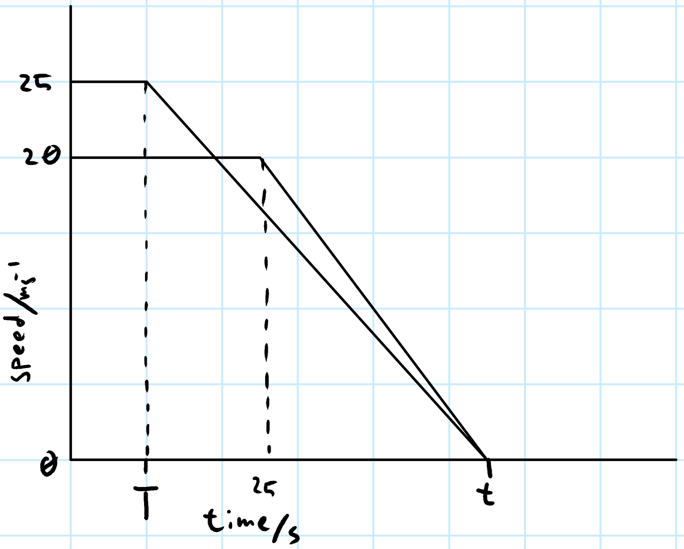
$1800 = 1500x$

$\frac{6}{5} = x$

$x = 1.2\,m$

5)

a)



b)

Area under a speed time graph is the distance travelled. Since both cars arrive at the same place at the same time, the area under both lines is measured at 800m (assuming the cars travel in a straight line)

$(25T) + \frac{1}{2}25(t-T) = 800$ (P)

$20(25) + \frac{1}{2}20(t-25) = 800$ (Q)

$50T + 25t - 25T = 1600$ (P)

$t + T = 64$

$t = 64 - T$

Plug into (Q)

$500 + 10(64 - T - 25) = 800$ (Q)

$890 - 10T = 800$

$90 = 10T$

$T = 9s$

6)

a)

S —
U $14.7ms^{-1}$
V $0 ms^{-1}$
A $-9.8ms^{-2}$
T ×

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

$0 = 216.09 - 19.6S$

$S = \frac{216.09}{19.6}$

$S = 11.025m$

total height $= 49 + 11.025$

$= 60.0m$ (3sf)

b)

S $-49m$
U $14.7ms^{-1}$
V —
A $-9.8ms^{-2}$
T —

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

$v^2 = 14.7^2 + 960.4$

$v^2 = 1176.49$

$|v| = 34.3ms^{-1}$ (3sf)

c)

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

$-49 = 14.7t + \frac{1}{2}(-9.8)t^2$

$4.9t^2 - 14.7t - 49 = 0$

$\frac{14.7 \pm \sqrt{14.7^2 - -960.4}}{9.8} = \frac{14.7 \pm 34.3}{9.8}$

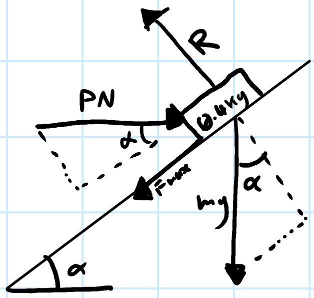
$t = 5s, -2s$

$t > 0 \therefore$ $t = 5s$

7)

a)

b)



$N = \frac{1}{3}$

$\tan(\alpha) = \frac{3}{4}$ $\therefore \sin(\alpha) = \frac{3}{5}$

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

$R = mg\cos(\alpha) + P\sin(\alpha)$

$R = 3.136 + \frac{3}{5}P$

$F = ma$ (Forces up the plane)

$P\cos(\alpha) - F_{max} - mg\sin(\alpha) = 0$

$\frac{4}{5}P - \frac{1}{3}(3.136 + \frac{3}{5}P) - 2.352 = 0$

$\frac{4}{5}P - 1.045\bar{3} - \frac{1}{5}P - 2.352 = 0$

$\frac{3}{5}P = \frac{1274}{375}$

$P = \frac{1274}{225}$

$P = 5.66\text{ N}$ (3sf)

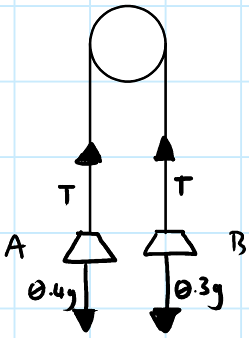
$R = 3.136 + \frac{3}{5}(5.66)$

$R = \frac{48}{15}$

$R = 6.53\text{ N}$ (3sf)

8)

a)



$0.4g - T = 0.4a \Rightarrow g - \frac{5}{2}T = a$

$T - 0.3g = 0.3a \qquad \frac{10}{3}T - g = a$

$g - \frac{5}{2}T = \frac{10}{3}T - g$

$2g = \frac{35}{6}T$

$T = 3.36N$

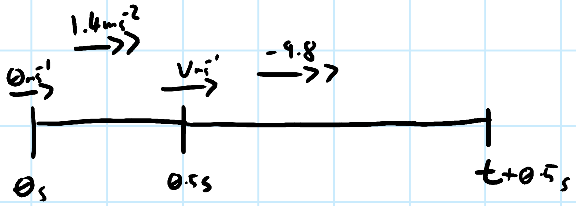
b) $\frac{10}{3}T - g = a$

$11.2 - 9.8 = a$

$a = 1.4 ms^{-2}$

8)

c)



S —
U $0ms^{-1}$
V —
A $1.4ms^{-2}$
T $0.5s$

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

$S = 0 + \frac{1}{2}1.4(0.5^2)$

$S = 0.175m$

$V = u + at$

$V = 0 + 1.4 \times 0.5$

$V = 0.7ms^{-1}$

When the string breaks, B is 0.175m above where it started, (1.175m off the ground in total) and has a speed of $0.7ms^{-1}$ against the direction of gravity.
We want the time taken for it to hit the ground from this state.

S $-1.175m$
U $0.7ms^{-1}$
V X
A $-9.8ms^{-2}$
T —

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

$-1.175 = 0.7t - 4.9t^2$

$4.9t^2 - 0.7t - 1.175 = 0$

$\frac{0.7 \pm \sqrt{0.49 - -23.03}}{9.8} = \frac{0.7 \pm 4.85}{9.8}$

$t = 0.566, -0.423$

$t > 0 \therefore t = 0.566s$ (3sf)