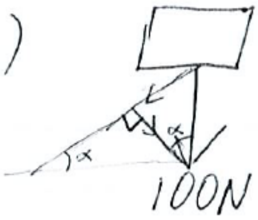
M1 January 2005 (OCR-

① i)



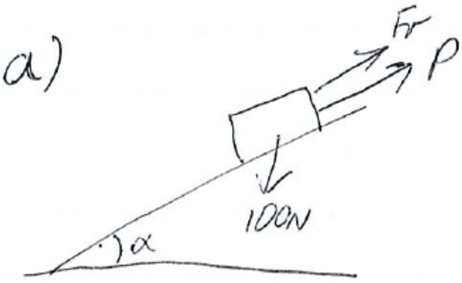
Component of weight acting normal to the plane is

$$100\cos\alpha = 96N$$

Normal reaction force must exactly cancel this out, so $= \underline{96N}$.

(ii) In limiting equilibrium $Fr = \mu . R$
$= 0.25 \times 96$
$= 24N$

(iii) a)

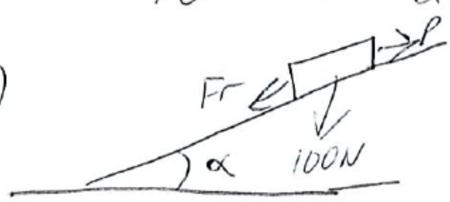


As box is on point of slipping down, friction resists this & acts up the plane.

$$100\sin\alpha = Fr + P = 24 + P$$

So $P = 28 - 24 = \underline{4N}$

b)



Here $100\sin\alpha + Fr = P$

ie $28 + 24 = \boxed{52N = P}$

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② (i) Momentum of A&B before collision

$$= (6 \times 0.4) - (2 \times 1.2) = 0 \text{ Ns}.$$

Conservation of momentum gives that this

$$0 = v \times 0.4 + 1 \times 1.2 = 0.4v + 1.2$$

so $v = \underline{-3ms^{-1}}$ (away from C)

(2) (ii) Momentum of B & C before collision

$= (1 \times 1.2) - (4 \times m)$

And after collision $= -(0.5 \times 1.2) + (2 \times m)$

So Cons. of Mom. gives:- $1.2 - 4m = 2m - 0.6$

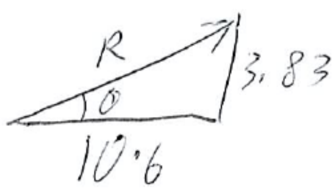
so $1.8 = 6m$

& $\underline{0.3\,kg = m}$

(3) (i) a) $2 \times 8\cos 30 - 5\sin 40 = \underline{10.6N}$ (to 3s.f.)

b) $5\cos 40 = \underline{3.83N}$ (to 3s.f.)

(ii)



$R = \sqrt{10.6^2 + 3.83^2} = \underline{11.3N}$ (to 3s.f.)

$\theta = \tan^{-1}\left(\frac{3.83}{10.6}\right) = \underline{19.8^\circ}$

(anticlockwise from positive x-axis).

(4) (i) $a = \frac{dv}{dt} = \underline{1 + 0.2t}$

(ii) When $a = 2.8ms^{-2}$ $\quad t = \frac{2.8 - 1}{0.2} = 9s$.

$v = \frac{ds}{dt}$, so $s = \int v\,dt = \frac{1}{2}t^2 + \frac{1}{30}t^3 (+C)$

(but $C = 0$ as $s = 0$ when $t = 0$)

So when $a = 2.8ms^{-2}$ $\quad s = \frac{1}{2} \times 9^2 + \frac{1}{30} \times 9^3 = \underline{64.8m}$

5 (i) $s = ut + \frac{1}{2}at^2$, $s_A = \underline{7t - 4.9t^2}$, $s_B = \underline{10.5t - 4.9t^2}$

(ii) $s_B - s_A = \underline{3.5t}$

(iii) A is at maximum height when $v = 0$ & $v = u + at = 7 + 9.8t$

When $v = 0$ $t = 0.714s$, & so

$s_B - s_A = 3.5 \times 0.714 = \underline{2.5m}$

(iv) When $s_B - s_A = 3.5$, $t = 1$, so A has gone beyond its maximum height & is moving <u>downwards</u>.

(v) $s_A = 7 \times 1 - 4.9 \times 1^2 = \underline{2.1m}$

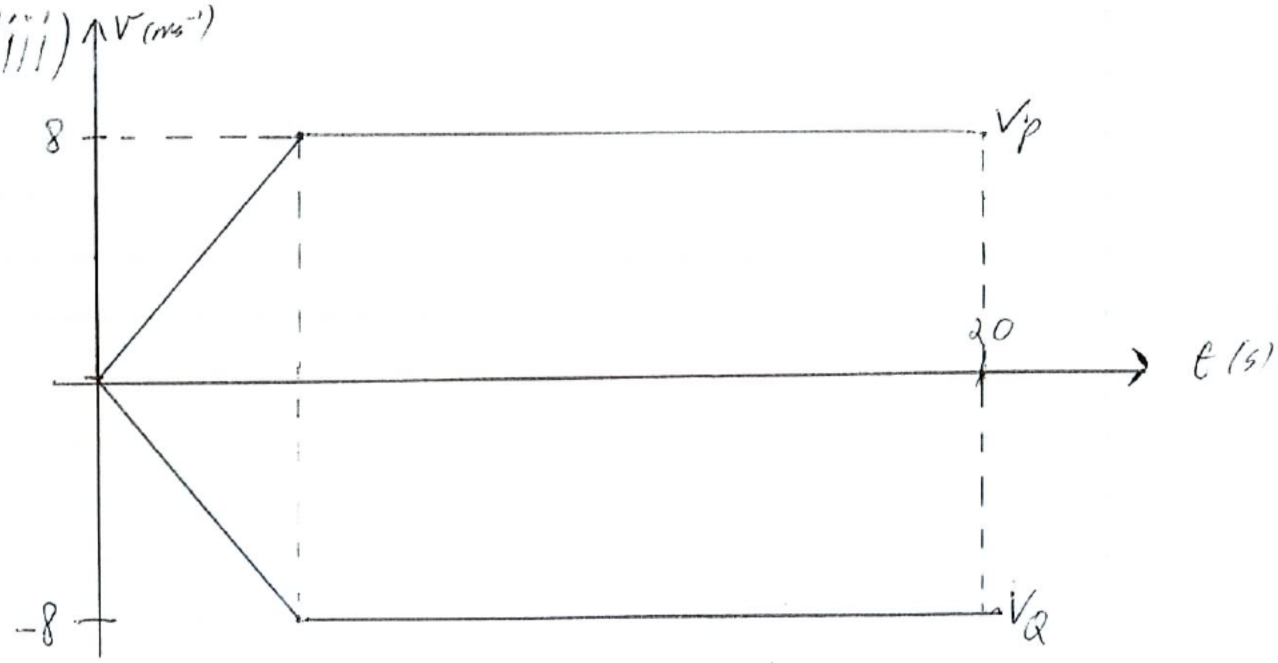
6 (i) $\frac{v-u}{a} = t$ gives $t = 8/2 = \underline{4s}$

(ii) $s = ut + \frac{1}{2}at^2$. Using this twice gives:-

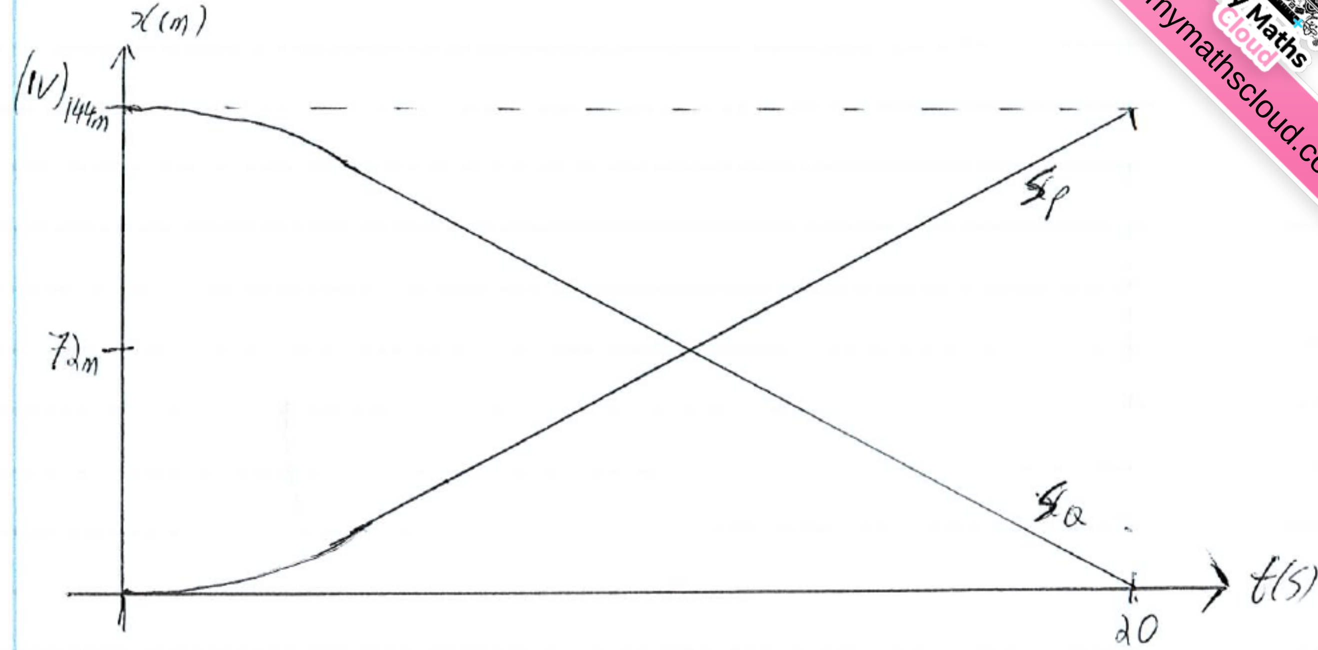
$s = (0 \times 4 + \frac{1}{2} \times 2 \times 4^2) + (8 \times 16 + \frac{1}{2} \times 0 \times 16^2)$

$= 16 + 128 = \underline{144m}$

(iii)

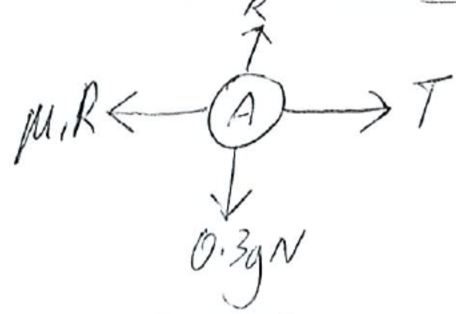


(6) (iv)



(v) After 4s:- $s_P = 16m$ & $s_Q = 144 - 16 = 128$, so $s_Q - s_P = 112m$. After this they move towards each other both at constant speed of $8ms^{-1}$, so it takes a further $\frac{112}{16} = 7s$ for them to meet. So P & Q pass when $t = 7+4 = \underline{11s}$.

(7) (i) Forces on A:-

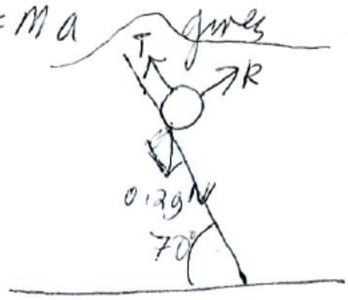


$R = 0.3gN$ & $\mu R = 0.4 \times 0.3g = 1.18N$

Resultant force on A is $\underline{T - 1.18N}$.

Using $F = ma$ gives $a = \frac{10}{3}(T - 1.18)\,ms^{-2}$

Forces on B:-



Parallel to plane:-

$0.2g \sin 70 - T$

$= \underline{1.84 - T}$

(7) (i) (cont) Using $F=ma$ on B:-

$$a = \frac{10}{2} \times (1.84 - T)$$

As A & B accelerate at same rate

$$\frac{10}{3}(T-1.18) = \frac{10}{2}(1.84 - T)$$

Giving $5T = 3\times1.84 + 2\times1.18 = 7.88$

& $\underline{T = 1.58N}$

Thus $a = 5 \times (1.84 - 1.58) = \underline{1.33ms^{-2}}$

(ii) Only horizontal force on A is friction, μR, & this $= 1.18N$

$F=ma$ gives $a = \frac{-1.18}{0.3} = -3.92ms^{-2}$

$$s = \frac{1}{2a}(v^2 - u^2) \quad (\text{from } v^2 = u^2 + 2as)$$

So $s = \frac{1}{2\times(-3.92)}(0^2 - 1.5^2)$ $(u = 1.5,\ v = 0)$

$= \underline{0.287m}$

(iii) Only force on B parallel to plane is the component of its weight, 1.84N.

So $F=ma$ gives $a = \frac{1.84}{0.2} = 9.209$

Using $v = u + at$ on A we get:-

$0 = 1.5 - 3.92t$, so $t = 0.383s$

Then $s = ut + \frac{1}{2}at^2$ on B gives

$s = 1.5\times0.383 + \frac{1}{2}\times9.209\times0.383^2 = \underline{1.25m}$