Author: Naga Karthik

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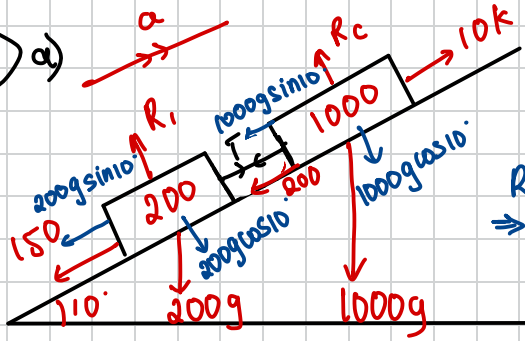
7.6: Connected particles

(1) a)



b)i) $\uparrow = \downarrow \Rightarrow R_1 + R_C = 200g\cos 10° + 1000g\cos 10°$

$R(\nearrow) \Rightarrow F = ma$

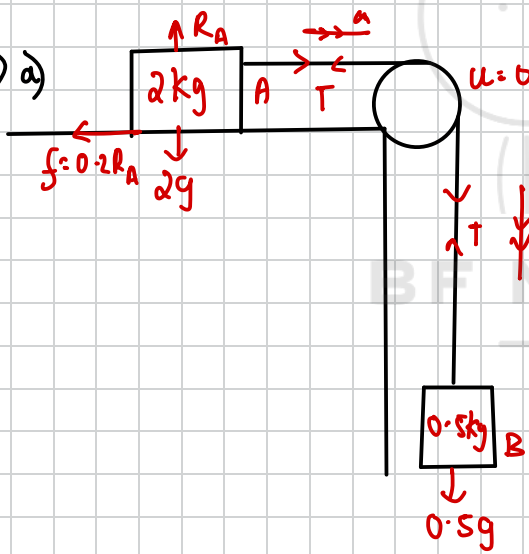
$\Rightarrow 10k - 350 - 200g\sin 10° - 1000g\sin 10° = 1200a$

$\Rightarrow a = 6.34\ ms^{-2}$ (3SF)

ii) $R(\rightarrow) \Rightarrow T - 150 - 200g\sin 10° = 200a \Rightarrow T = 1758.33 \approx 1760N$

c) Acceleration of car and trailer are the same.

(2) a)



b) For A: $\uparrow = \downarrow = R_A = 2g$

$R(\rightarrow) \Rightarrow T - 0.2R_A = 2a$ — (1)

$T = 2a + 0.4g$ — (1)

For B:

$R(\downarrow) \Rightarrow 0.5g - T = 0.5a$ — (2)

$\Rightarrow 0.5g - 0.4g - 2a = 0.5a$

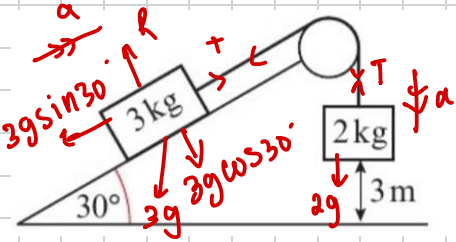
$\Rightarrow 0.1g = 2.5a$

$\Rightarrow a = \frac{1}{25}g\ ms^{-2}$

c) $T = 2\left(\frac{1}{25}g\right) + 0.4g = \frac{12}{25}g\ N$

d) Tension in string is the same on both sides of the pulley.

③



b) For 2kg: $R(\downarrow) \Rightarrow F = ma$

$\Rightarrow 2g - T = 2a \Rightarrow T = 2g - 2a$ — (1)

For 3kg: $R(\nearrow) \Rightarrow F = ma$

$\Rightarrow T - 3g\sin 30^\circ = 3a$.

$\Rightarrow 2g - 2a - 3g\sin 30^\circ = 3a$

$\Rightarrow 2g - 3g\sin 30^\circ = 5a$ $\Rightarrow a = 0.1g\ ms^{-2} \approx 0.98\ ms^{-2}$

$\Rightarrow T = 2g - 0.2g = 1.8g\ N.$

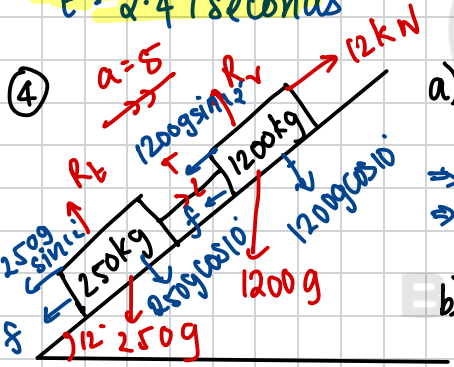
a) $T = 1.8g\ N$ b) $0.1g\ ms^{-2}$

c) Given: $u = 0$ $t = t$ $s = 3$ $a = 0.98$

$s = ut + \frac{1}{2}at^2 \Rightarrow 3 = 0(t) + 0.5(0.98)t^2 \Rightarrow t = \sqrt{\frac{3}{0.5(0.98)}}$

$t = 2.47$ seconds

④



a) $R(\nearrow) \Rightarrow 12000 - R - 1200g\sin 12^\circ - 250g\sin 12^\circ = 1450(5)$

$\Rightarrow R = 12000 - 1200g\sin 12^\circ - 250g\sin 12^\circ - 1450(5)$

$\Rightarrow R = 1800\ N$ (3sf)

b) $f + 3f = 1800 \Rightarrow 4f = 1800 \Rightarrow f = 450$

$R(\nearrow) \Rightarrow T - 250g\sin 12^\circ - 450 = 250(5)$

$\Rightarrow T = 250(5) + 250(9.8)\sin 12^\circ + 450 \Rightarrow T = 2210\ N$ (3sf)

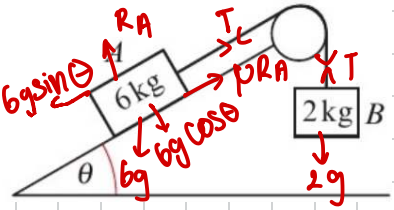
c) $R(\swarrow) \Rightarrow 450 + 250g\sin 12^\circ = 250a \Rightarrow a = 3.84\ ms^{-2}$ (3sf)

Trailer

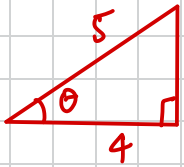
$u = 8$ $v = 0$ $a = -3.84\ ms^{-2}$ $t = t$

$v = u + at \Rightarrow 0 = 8 - 3.84t \Rightarrow t = \frac{8}{3.84} \Rightarrow t = 2.09$ seconds (3sf)

⑤



$\tan\theta = \frac{3}{4}$



$\sin\theta = \frac{3}{5}$

$\cos\theta = \frac{4}{5}$

For A:

a) $\uparrow = \downarrow \Rightarrow R_A = 6g\cos\theta \Rightarrow R_A = \frac{216}{5}N$

For B: $\rightarrow$ $F = ma \Rightarrow T - 2g = 2a \Rightarrow T = 2g + 2a$

$\Rightarrow$ For A: $\rightarrow$ R($\swarrow$) $\Rightarrow$ $F = ma \Rightarrow 6g\sin\theta - (2g + 2a) - \mu R_A = 6a$

$\Rightarrow 35\cdot28 - 2g + 2a - 43\cdot2\mu = 6a$

$\Rightarrow 15\cdot68 - 43\cdot2\mu = 4a.$

for box to slide down: $\rightarrow 6g\sin\theta - 2g - \mu 6g\cos\theta > 0$

$\Rightarrow 3\cdot6g - 2g > 4\cdot8\mu g \Rightarrow 1\cdot6g > 4\cdot8\mu g \Rightarrow \boxed{\mu < \frac{1}{3}}$

b) $\mu = 0\cdot2 \Rightarrow \frac{3\cdot6(9\cdot8) - 2(9\cdot8) - 4\cdot8(0\cdot2)(9\cdot8)}{4} = a$ $\quad a = 1\cdot568$

$u = 0 \quad a = 1\cdot568 \quad t = t \quad v = 5$

$\Rightarrow v = u + at \Rightarrow 5 = 1\cdot568t \Rightarrow t = 3\cdot188\,77551.$

$\Rightarrow 2t \Rightarrow 2(3\cdot18877\ldots) = 6\cdot38$ seconds.

c) Box A does not reach ground; Box B does not reach pulley.

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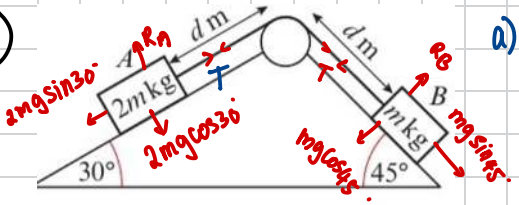

a) $2mg\sin 30^\circ = 2mg\left(\frac{1}{2}\right) = mg \rightarrow$ A

$mg\cos 45^\circ = mg\left[\frac{1}{\sqrt{2}}\right] \Rightarrow \frac{1}{\sqrt{2}}mg \rightarrow$ B

$\Rightarrow \frac{1}{\sqrt{2}}mg < mg$; So block B slides up the slope.

For A:

b) $R(\swarrow) \Rightarrow F=ma \Rightarrow 2mg\sin 30^\circ - T = 2ma \Rightarrow mg - T = 2ma$

$\Rightarrow T = mg - 2ma \quad -①$

$R(\nearrow) \Rightarrow T - mg\sin 45^\circ = ma \Rightarrow T - \frac{1}{\sqrt{2}}mg = ma \Rightarrow T = ma + \frac{\sqrt{2}}{2}mg \quad -②$

$\Rightarrow ma + \frac{\sqrt{2}}{2}mg = mg - 2ma \Rightarrow 3ma = \frac{2-\sqrt{2}}{2}mg$

$\Rightarrow a = \frac{2-\sqrt{2}}{6}g$

Given: $u=0 \quad a=\frac{2-\sqrt{2}}{6}g \quad s=d \quad t=t$

$s = ut + \frac{1}{2}at^2 \Rightarrow d = \frac{1}{2}\left(\frac{2-\sqrt{2}}{6}g\right)t^2 \Rightarrow d = \left(\frac{2-\sqrt{2}}{12}g\right)t^2$

$\Rightarrow \frac{12d}{(2-\sqrt{2}g)} = t^2 \Rightarrow t = \sqrt{\frac{12d}{(2-\sqrt{2}g)}}$