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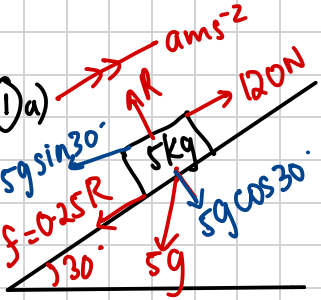
7.5: Dynamics and inclined planes

(1) a)



b) $F = ma$ (y-axis)

$\uparrow : \downarrow \Rightarrow R = 5g\cos 30°$ (as the box is not moving up and down, so $\uparrow = \downarrow$)

$\Rightarrow R = 42.43$ $\quad R = 42.4\,N$ (3SF)

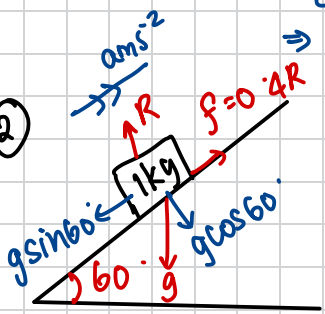
c) $F = ma$ (x-axis)

$R(\nearrow) \Rightarrow 120 - 0.25R - 5g\sin 30 = 5a$

$\Rightarrow \left[120 - 0.25\left(\frac{49\sqrt{3}}{2}\right) - 5g\sin 30°\right] \div 5 = a$

$\Rightarrow a = 16.97\ldots$ $\quad a = 17.0\,ms^{-2}$ (3SF)

(2)



a) Rest $= \uparrow : \downarrow$; $\rightarrow = \leftarrow$

$\uparrow : \downarrow \Rightarrow R = g\cos 60°$; $f = 0.4(g\cos 60°)$

$f = 1.96\,N$ up the slope

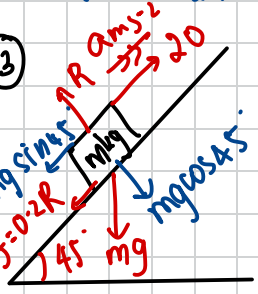
b) $g\sin 60° = 8.48704\ldots$ $\quad f = 1.96$ $\quad \Rightarrow 8.49 > 1.96$

$\Rightarrow$ as the force is greater than the friction it will start to slide down

$\Rightarrow$ c) $R(\downarrow) \Rightarrow F = ma$ (x-axis) $\Rightarrow g\sin 60 - 0.4(g\cos 60) = a$ (1)

$\Rightarrow a = 6.527$ $\quad \Rightarrow a = 6.53\,ms^{-2}$ (3sf)

(3)



$a = 2$ $\quad F = ma$ (y-axis)

$\uparrow : \downarrow \Rightarrow R = mg\cos 45°$

$F = ma$ (x-axis)

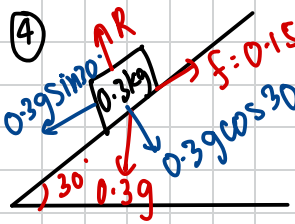
$R(\nearrow) \Rightarrow 20 - 0.2R - mg\sin 45° = 2m$

$\Rightarrow 20 - 0.2\left(\frac{49\sqrt{2}}{10}\right)m - \left(\frac{49\sqrt{2}}{10}\right)m = 2m$

$\Rightarrow 20 - \frac{49\sqrt{2}m}{50} - \frac{49\sqrt{2}}{10}m = 2m$ $\quad \Rightarrow 20 = 2m + \frac{49\sqrt{2}m}{50} + \frac{49\sqrt{2}m}{10}$

$\Rightarrow 20 = 10.31\ldots m$ $\quad m = \frac{20}{10.31\ldots} = 1.9388\ldots$ $\quad \Rightarrow m = 1.94$ (3sf)

④



$s = 5 \quad u = 0 \quad a = a \quad t = t$

Rest = $\uparrow = \downarrow$,

$\Rightarrow R = 0.3g\cos 60° \quad -①$

$\Rightarrow F = ma$ (x- axis) $\Rightarrow 0.3g\sin 30° - 0.15R = 0.3a$

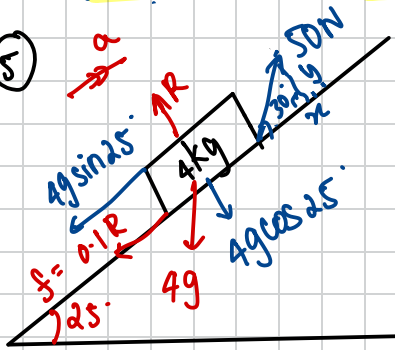
$\Rightarrow [0.3g\sin 30° - 0.15(0.3g\cos 30°)] \div 0.3 = a$

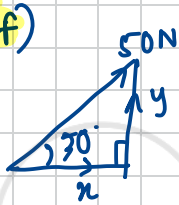
$\Rightarrow a = 3.626942656\ ms^{-2}$

$\Rightarrow$ To find t: $s = ut + \frac{1}{2}at^2 \Rightarrow 5 = \frac{1}{2}(a)t^2 \Rightarrow \sqrt{\frac{10}{a}} = t$

$t = 1.66$ seconds (3sf)

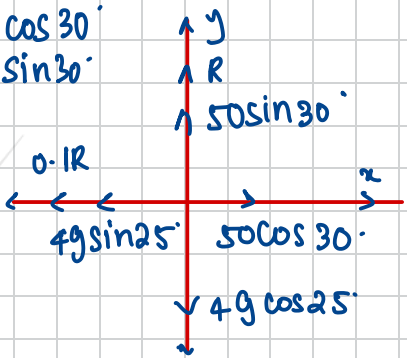
⑤





$x = 50\cos 30°$

$y = 50\sin 30°$



a) $\downarrow = \uparrow$ (as there is movement in y-axis)

$\Rightarrow R + 50\sin 30° = 49\cos 25° \Rightarrow R = 49\cos 25° - 50\sin 30° \quad -①$

$\Rightarrow F = ma$ (x-axis) $\Rightarrow R(\nearrow) \Rightarrow 50\cos 30° - 49\sin 25° - 0.1R = 4a$

$\Rightarrow 25.6819078 = 4a \Rightarrow a = 6.42\ ms^{-2}$

b) Find $a \Rightarrow R(\nearrow) \Rightarrow 49\sin 25 + 0.1(49\cos 25) = 4a \Rightarrow a = 5.02984$

$\Rightarrow s = S \quad u = 0 \quad a = 6.42 \quad t = 3$

$\Rightarrow s = ut + \frac{1}{2}at^2 \Rightarrow s = 26.0796...$

$s = 26.0796... \quad v = v$

$a = 6.42 \quad u = 0$

$\Rightarrow v = u + at \Rightarrow v = 19.26...$

$v = 0 \quad u = 19.26... \quad a = -5.029 \quad t = t$

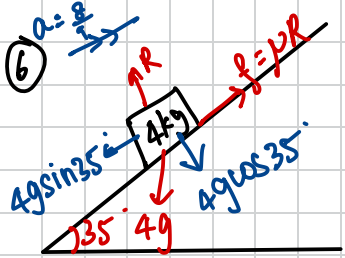
$\Rightarrow v = u + at \Rightarrow 0 = 19.26 - 5.029...t \Rightarrow t = \frac{-19.26}{-5.029} \Rightarrow 3.829$

$t = 3.83$ sec (3sf)

c) $R(\nearrow) \Rightarrow F = ma \Rightarrow 49\sin 25 = 16.56N \Rightarrow f = \mu R = 3.552726525$

$\Rightarrow 16.56 > 3.552...$, so it will slide down.

(6)



Given: $s = 4$ $u = 0$ ~~v~~ $a = ?$ $t = 3$

$\Rightarrow s = ut + \frac{1}{2}at^2 \Rightarrow 4 = 0t + \frac{1}{2}(a)(3)^2$

$\Rightarrow \frac{8}{9} = a$ $\quad a = \frac{8}{9} ms^{-2}$

$\uparrow = \downarrow$ (as there is no movement in y-axis)

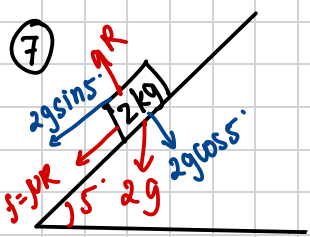
$\Rightarrow R = 4g \cos 35° \quad$ — (1)

$- F = ma$ (x-axis) $\Rightarrow R(\swarrow) \Rightarrow 4g \sin 35° - \mu R = 4\left(\frac{8}{9}\right)$

$\Rightarrow 4g \sin 35 - \mu(4g \cos 35°) = \frac{32}{9}$ $\quad \Rightarrow \mu = 0.58948...$

$\Rightarrow \mu = 0.589.$

(7) $\rightarrow$ (6-2)



Given: ~~s~~ $u = 4$ $v = 0$ $a = ?$ $t = 4$

$\Rightarrow v = u + at \rightarrow 0 = 4 + a(4) \Rightarrow -4 = 4a \Rightarrow \boxed{a = -1}$

$a = -1$

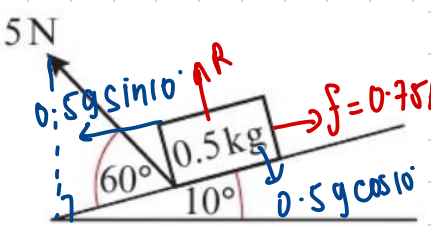
$\uparrow = \downarrow$ (as there is no movement in y-axis)

$\Rightarrow R = 2g \cos 5°$

$\Rightarrow F = ma$ (x-axis) $\Rightarrow R(\rightarrow) \Rightarrow \mu(2g \sin 5° + \mu R) = \mu \times 2$

$\Rightarrow (2 - 2g \sin 5°) \div 2g \cos 5° = \mu \Rightarrow \mu = 0.0149$ (3sf)

(8)



Given: $a = a$ $v = 30$ $u = 0$ $t = t$

$\uparrow = \downarrow$ (as there is no movement in y-axis) $\Rightarrow R = 0.5g \cos 10° - 5 \sin 60°$

$\Rightarrow F = ma$ (x-axis) $: R(\swarrow)$

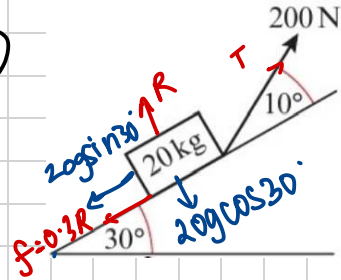
$\Rightarrow 0.5g \sin 10° + 5 \cos 60° - 0.75R = 0.5a$

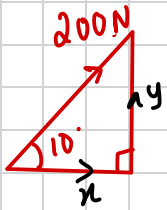
$\Rightarrow a = 5.9586...$

$\Rightarrow v = u + at$

$30 = 0 + at \quad t = \frac{30}{5.986...} = 5.03$ seconds

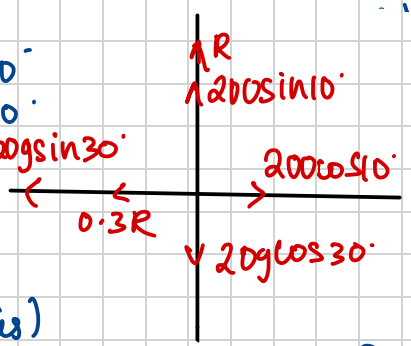
(9)





$y = 200\sin 10°$

$x = 200\cos 10°$



$\uparrow = \downarrow$ (as there is no movement in y-axis)

$\Rightarrow R + 200\sin 10° = 20g\cos 30° \Rightarrow R = 20g\cos 30° - 200\sin 10°$ — (1)

$R(\rightarrow)$: $\rightarrow F = ma \Rightarrow 200\cos 10° - 20g\sin 30° - 0.3R = 20(a)$

$$\Rightarrow \frac{200\cos 10° - (20g\sin 30° + 0.3(20g\cos 30° - 200\sin 10°))}{20} = a$$

$\Rightarrow a = 2.922907376$.

Given: $u = 0$ $a = 2.922907376$ $v = v$ $t = 10$

$v = u + at = v = 0 + 2.922907376(10) \Rightarrow v = 29.22907376$

As the rope snaps, there is no tension.

$\uparrow = \downarrow = R = 20g\cos 30°$ $R(\uparrow) \Rightarrow F = ma \rightarrow -(20g\sin 30° + 0.3R) = 20a$

$$\Rightarrow a = -\frac{(20g\sin 30° + 0.3(20g\cos 30°)}{20} = a = -7.446\ ms^{-1}$$

$u = 0$ $v = 29.229\ldots$ $a = 7.446\ldots$ $s = s$

$v^2 = u^2 + 2as \Rightarrow \frac{(29.229\ldots)^2}{2(7.446)} = s \Rightarrow s = 57.4\ m$ (3sf)

∴ The sled will travel 57.4 m before coming to rest. Therefore sled will not reach B.