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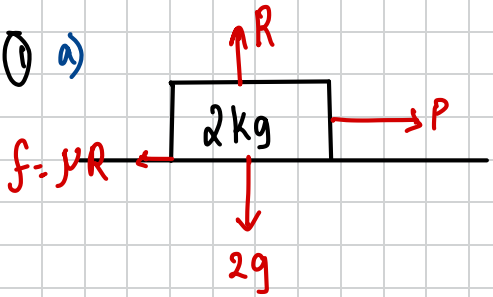
7.3 - Friction and static particles

(1) a)

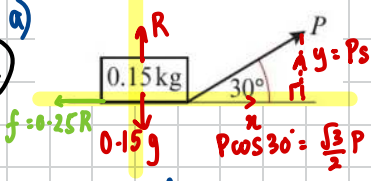


b) Rest = $\rightarrow = \leftarrow$; $P = \mu R$ — (1)

$\uparrow = \downarrow$; $R = 2g \Rightarrow P = 0.2(2g) = 3.92$

$P = 3.92$ N

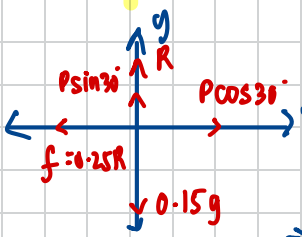
(2) a)



Resolve P:

$y = P\sin 30 = \frac{1}{2}P$

$y = P\cos 30 = \frac{\sqrt{3}}{2}P$



Rest = equilibrium

b) $\uparrow = \downarrow \Rightarrow R = 0.15g - P\sin 30 \Rightarrow R = 1.47 - \frac{1}{2}P$ — (1)

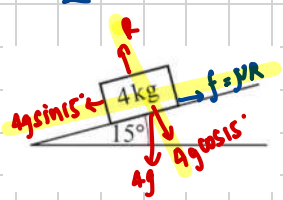
$\rightarrow = \leftarrow \Rightarrow 0.25R = P\cos 30 \Rightarrow R = \frac{\sqrt{3}}{2}P \div 0.25$ — (2)

(1) = (2)

$\Rightarrow 1.47 - \frac{1}{2}P = 2\sqrt{3}P \Rightarrow 1.47 = 2\sqrt{3}P + \frac{1}{2}P$

$\Rightarrow \frac{1+4\sqrt{3}}{2}P = 1.47 \Rightarrow P = 0.371$ N (3 sf)

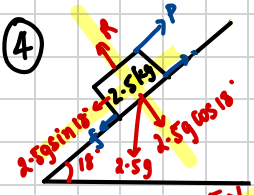
(3)



a) equilibrium ($\uparrow = \downarrow$) $\Rightarrow R = 49\cos 15 = \frac{49\sqrt{6}+49\sqrt{2}}{5} = 37.9$N (3sf)

b) $\rightarrow = \leftarrow \Rightarrow 49\sin 15 = \mu\left(\frac{49\sqrt{6}+49\sqrt{2}}{5}\right) = 2-\sqrt{3} = 0.268$ (3sf)

(4)

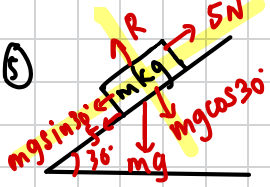


equilibrium ($\uparrow = \downarrow$; $\rightarrow = \leftarrow$)

a) $R = 2.5(9.8)\times\cos 18 = 23.3$ N (3sf)

b) $P = 2.5g\sin 18 + \mu R \Rightarrow P = 14.6$N (3sf)

(5)



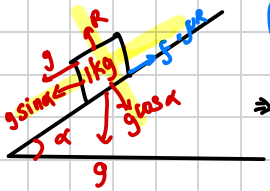
$R = \frac{49\sqrt{3}}{10}m$ — (1)

$5 = 4.9m + 0.4R \Rightarrow 5 = 4.9m + 0.4\left(\frac{49\sqrt{3}}{10}m\right)$

$\Rightarrow 5 \div \left(4.9 + 0.4\left(\frac{49\sqrt{3}}{10}\right)\right) = m \Rightarrow m = 0.603$ (friction in $\rightarrow x$)

$\Rightarrow 5 = 4.9m - 0.4R \Rightarrow m = 3.32$ (friction in $\leftarrow x$)

(6)

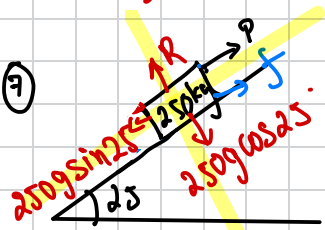


$R(\nwarrow): R = g\cos\alpha$ $R(\nearrow): \mu R = g\sin\alpha + g \Rightarrow \mu R = g(1+\sin\alpha)$

$\Rightarrow \mu \times g\cos\alpha = g(1+\sin\alpha)$

$\Rightarrow \mu = \frac{g(\sin\alpha+1)}{g\cos\alpha} \Rightarrow \mu = \frac{\sin\alpha + 1}{\cos\alpha}$

(7)



equilibrium $\uparrow = \downarrow$; $\rightarrow = \leftarrow$

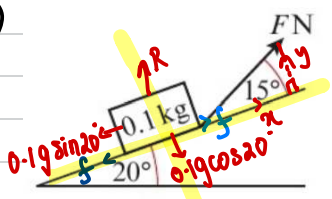
$R = 250g\cos25° \text{ -①}$ $P + \mu R = 250g\sin25°$

$\Rightarrow P = 250g\sin25° - 0.15(250g\cos25°)$

$P = 702 \text{ (3sf)}$

b) valid air resistance not a factor in static situation; rotational forces unlikely to affect solution

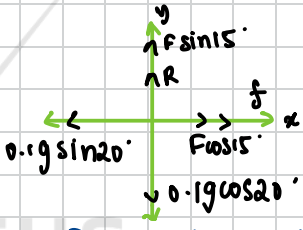
(8)



Resolve FN:

$y = F\sin15°$

$x = F\cos15°$



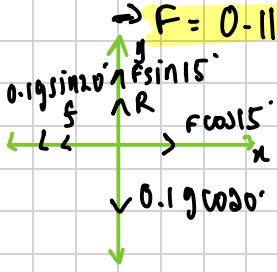
$F\sin15° + R = 0.1g\cos20° \text{ -①}$ $0.25R + F\cos15° = 0.1g\sin20° \text{ -②}$

$\Rightarrow 0.25(0.1g\cos20° - F\sin15°) + F\cos15° = 0.1g\sin20$

$\Rightarrow 0.245\cos20° - 0.25F\sin15° + F\cos15° = 0.1g\sin20$

$\Rightarrow F(\cos15° - 0.25\sin15°) = 0.1g\sin20° - 0.245\cos20°$

$\Rightarrow F = 0.116$



$\Rightarrow R = 0.1g\cos20° - F\sin15° \text{ -①}$ $F\cos15° = 0.25R + 0.1g\sin20$

$\Rightarrow F\cos15° = 0.245\cos20° - 0.25F\sin15° + 0.1g\sin20$

$F(\cos15° + 0.25\sin15°) = 0.1g\sin20° + 0.245\cos20°$

$F = 0.549$ $0.116 \leq F \leq 0.549$ (3sf)