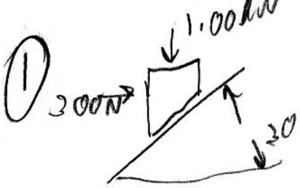
PS9

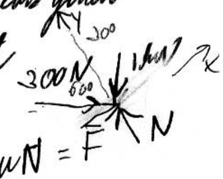
1



$\mu_s = .40$

$\mu_d = .20$

since no dimensions given
treat as point



Normal force = $\cos 60°(300N) + \cos 30°(1.00kN) = 1016.0254N$

shearing component of applied force:

$\Sigma F_x = 0 = F - \sin(30°)(1.00kN) + 300N(\cos 60°)$

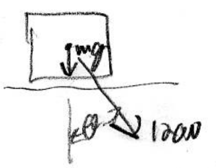
$F = 240.19N$

μ for equilibrium $\leq \mu_s$; $\left|\frac{F}{N}\right| = \frac{240.19N}{1016.0254N} = \boxed{.236 < \mu_s}$

So in equilibrium

frictional force that 240.19 N up slope

2



normal force = $mg + 120N\cos\theta$

shearing force = $120N\sin\theta$

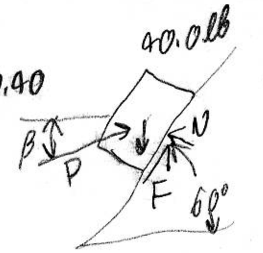
$\mu_s = 0.30$

impending motion at shear $= 120N\sin\theta = \mu_s[mg + 120N\cos\theta]$

a) for $m = 20.0kg$, $\theta = 44.7°$

b) for $m = 35.0kg$, $\theta = 71.97°$

(3) $\mu_s = 0.40$



$$N = 40.0\,lb(\cos 60°) + P\cos(60°+\beta)$$

$$R = \text{shear load} = 40.0\,lb(\sin 60°) - P\sin(60°+\beta)$$

at equilibrium, max shear $= \mu_s(N)$

$$= 0.40\left[40.0\,lb(\cos 60°) + P\cos(60°+\beta)\right]$$

$$\frac{40.0\,lb(\sin 60°) - P\sin(60°+\beta)}{40.0\,lb(\cos 60°) + P\cos(60°+\beta)} = 0.40$$

R has minimum at $\sin(60°+\beta)$ maximum, or $60°+\beta = 90°$

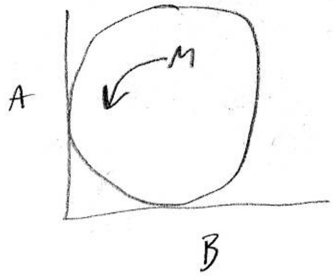
$$\boxed{\text{so } \beta = 30°}$$

thus $40.0\,lb(\sin 60°) - P\underbrace{\sin(90°)}_{1} = .40\left[40\,lb\cos 60° + P\underbrace{\cos 90°}_{0}\right]$

$$P = 40.0\,lb\left[\sin(60°) - .40\cos(60°)\right]$$

$$\boxed{P = 26.64\,lb}$$

(4)

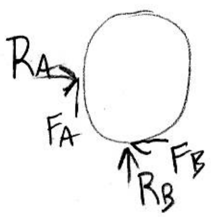


weight = W
radius = r

$$\Sigma M_{center} = M - F_B(r) - F_A(r) = 0$$

$$\Sigma F_y = 0 = R_B + F_A - W$$

$$\Sigma F_x = 0 = R_A - F_B \rightarrow R_A = F_B$$



at break free, $F_A = R_A \mu_{sA}$, $F_B = R_B \mu_{sB}$

so $0 = R_B + R_A \mu_{sA} - W = \Sigma F_y$

and $0 = R_A - R_B \mu_{sB} \rightarrow R_A = R_B \mu_{sB}$

$$0 = R_B + R_B \mu_{sA} \mu_{sB} - W$$

$$R_B = \frac{W}{(1 + \mu_{sA}\mu_{sB})}$$

so for a) $\mu_{sA} = 0$, $\mu_{sB} = 0.20$, $R_B = \frac{W}{1}$

$$F_A = 0$$

$$F_B = W(0.20)$$

$$\rightarrow \boxed{M = F_B r = W(0.20)(r) = \frac{Wr}{5}}$$

for b) $\mu_{sA} = .30$, $\mu_{sB} = .25$

$$R_B = \frac{W}{1 + (.30)(.25)} = \frac{40W}{43}$$

$$F_B = R_B(0.25) = \frac{10W}{43}$$

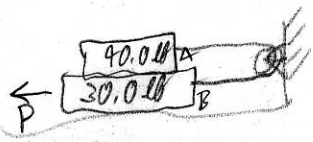
$$R_A = F_B$$

$$F_A = R_A(0.30) = \frac{3W}{43}$$

so $M = F_B(r) + F_A(r) = \frac{10W}{43}(r) + \frac{3W}{43}(r)$

$$\boxed{M = \frac{13Wr}{43}}$$

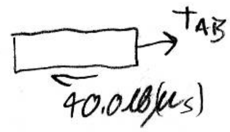
(5)



$\mu_s = 0.30$

(a)

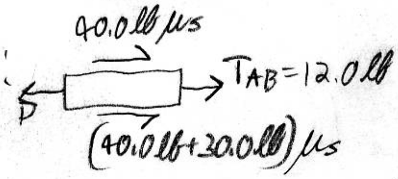
on block "A":



$\Sigma F_x = 0 = T_{AB} - 40.0\,lb(0.20)$

$T_{AB} = 12.0\,lb$

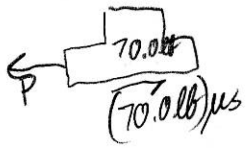
on block "B":



$$\Sigma F_x = 0 = -P + 12.0\,lb + 40.0\,lb(0.30) + 70.0\,lb(0.30)$$

$$\boxed{P = 43.0\,lb}$$

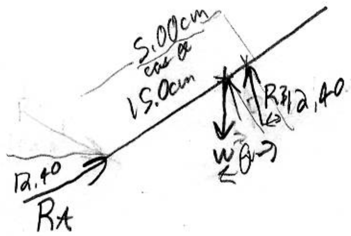
(b)



$$\Sigma F_x = 0 = -P + 70.0(0.30)\,lb$$

$$\rightarrow \boxed{P = 21.0\,lb}$$

(6a) $\mu_s = .22 \Rightarrow \phi_s = \arctan(.22) = 12.4^\circ$



$$\Sigma F_x = R_A \cos(12.4^\circ) - R_B \sin(\theta - 12.4^\circ)$$

$$\Sigma F_y = 0 = R_A \sin(12.4^\circ) - W + R_B \cos(\theta - 12.4^\circ)$$

$$\Sigma M_A = -W\,15.0\text{cm}(\cos\theta) + R_B \cos(12.4^\circ)\left(\frac{5.00\text{cm}}{\cos\theta}\right) = 0$$

from ΣM: $R_B = \dfrac{W\,15.0\text{cm}\,\cos^2\theta}{5.00\text{cm}\,\cos(12.4^\circ)} = \dfrac{3W\cos^2\theta}{\cos(12.4^\circ)}$

from ΣF_x: $R_A = R_B \dfrac{\sin(\theta - 12.4^\circ)}{\cos(12.4^\circ)}$

substitute into

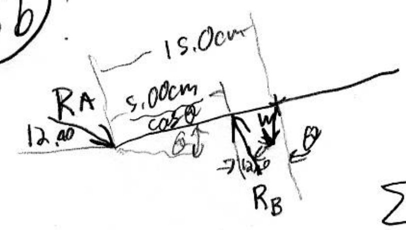
$$\Sigma F_y:\ 0 = R_B \frac{\sin(\theta-12.4^\circ)\sin(12.4^\circ)}{\cos(12.4^\circ)} - W + \frac{3W\cos^2\theta(\cos\theta - 12.4^\circ)}{\cos 12.4^\circ}$$

$$0 = \frac{3W\cos^2\theta\sin(\theta-12.4^\circ)\sin(12.4^\circ)}{\cos^2(12.4^\circ)} - W + \frac{3W\cos^2\theta\cos(\theta-12.4^\circ)}{\cos(12.4^\circ)}$$

comes to $\theta \approx 53.07^\circ$, outside range where center of mass is inside the tube.

NO SOLUTION

(6b):



$$\Sigma F_x = 0 = R_A\cos(12.4°) - R_B\sin(\theta - 12.4°)$$

$$\rightarrow R_A = R_B\frac{\sin(\theta-12.4°)}{\cos(12.4°)}$$

$$\Sigma M_A = 0 = -W\,15.0cm(\cos\theta) + R_B\cos(12.4°)\left(\frac{5.00cm}{\cos\theta}\right)$$

$$\rightarrow R_B = \frac{3W\cos^2\theta}{\cos(12.4°)}$$

$$\rightarrow R_A = \frac{3W\cos^2\theta\sin(\theta-12.4°)}{\cos^2(12.4°)}$$

$$\Sigma F_y = 0 = -W - R_A\sin(12.4°) + R_B\cos(\theta+12.4°)$$

$$0 = -W - \frac{3W\cos^2\theta\sin(\theta-12.4°)\sin(12.4°)}{\cos^2(12.4°)} + \frac{3W\cos^2\theta\cos(\theta+12.4°)}{\cos(12.4°)}$$

$$\rightarrow \boxed{\theta \approx 37.58°}$$