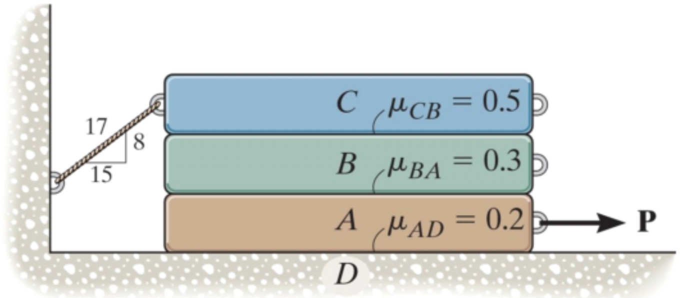
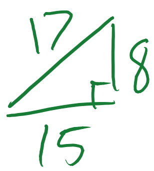
Page 6

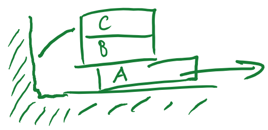
Tuesday, March 28, 2017 6:08 PM



The three bars have a weight $W_A = 20$ lb, $W_B = 40$ lb, $W_C = 60$ lb respectively. If the coefficient of static friction at the surfaces of contact are as shown, determine the smallest horizontal force P needed to move block A.

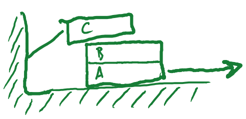


Case 1: A moves, B does not



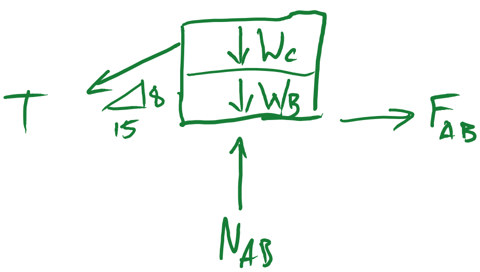
$$\left.\begin{aligned} F_{AD} &= \mu_{AD} \cdot N_{AD} \\ F_{AB} &= \mu_{AB} \cdot N_{AB} \end{aligned}\right\}$$ max. static friction before sliding

Case 2: A & B slide together



$$\left.\begin{aligned} F_{AD} &= \mu_{AD} \cdot N_{AD} \\ F_{BC} &= \mu_{BC} \cdot N_{BC} \end{aligned}\right\}$$ max. static friction before sliding

Case 1



$$\Sigma F_y = 0 \Rightarrow N_{AB} = W_B + W_c + T \cdot \frac{8}{17}$$

$$\Sigma F_x = 0 \Rightarrow F_{AB} = T \cdot \frac{15}{17}$$

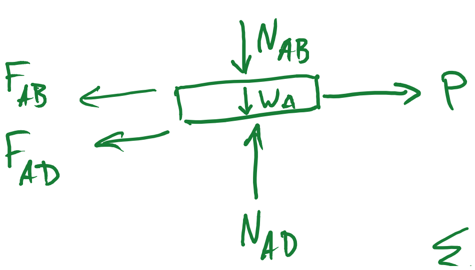
$$\hookrightarrow T = \frac{17}{15} \mu_{AB} \cdot N_{AB}$$

$$T = \frac{17}{15} \mu_{AB} \cdot \left(W_B + W_c + T \cdot \frac{8}{17}\right)$$

$$\Rightarrow T = 40.48 \text{ lb}$$

$$\Rightarrow N_{AB} = 40 \text{ lb} + 60 \text{ lb} + (40.48 \text{ lb}) \frac{8}{17}$$

$$= 119.05 \text{ lb}$$



$$\Sigma F_y = 0 \Rightarrow N_{AD} = W_A + N_{AB}$$

N_{AD}

$$\Sigma F_y = 0 \Rightarrow \boxed{N_{AD} = W_A + N_{AB}}$$

$$= 20\,lb + 119.05\,lb$$

$$\boxed{= 139.05\,lb}$$

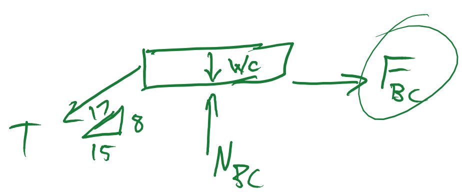
$$\Sigma F_x = 0 \Rightarrow P = F_{AB} + F_{AD}$$

$$P = \mu_{AB} N_{AB} + \mu_{AD} N_{AD}$$

$$= (0.3)(119.05\,lb) + (0.2)(139.05\,lb)$$

$$\underline{P = 63.52\,lb}$$

Now, solve P for case 2



$$\Sigma F_x = 0$$

$$\Rightarrow F_{BC} - T \cdot \frac{15}{17} = 0$$

$$\mu_{BC} \cdot N_{BC} = T \cdot \frac{15}{17} \qquad T = \frac{17}{15} \cdot \mu_{BC} \cdot N_{BC}$$

$$\Sigma F_y = 0$$

$$\Rightarrow N_{BC} - W_C - T \cdot \frac{8}{17} = 0$$

$$N_{BC} = W_C + T \cdot \frac{8}{17}$$

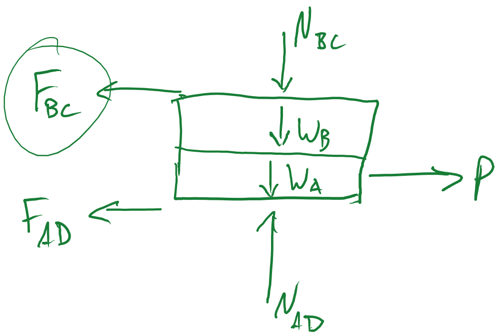
$$N_{BC} = W_C + \frac{8}{\cancel{17}}\left(\frac{\cancel{17}}{15} \cdot \mu_{BC} \cdot N_{BC}\right)$$

$$N_{BC} = W_C + \frac{8}{15} \mu_{BC} \cdot N_{BC}$$

$$N_{BC} \cdot \left(\frac{15}{15} - \frac{8}{15}\mu_{BC}\right) = W_C$$

$$N_{BC}\cdot\left(\frac{15}{15}-\frac{8}{15}\mu_{BC}\right)=W_c$$

$$\boxed{N_{BC}=\frac{15\cdot W_c}{15-8\mu_{BC}}}$$



$$\Sigma F_y=0$$

$$\Rightarrow\quad N_{AD}=N_{BC}+W_B+W_A$$

$$=\left(\frac{15\cdot W_c}{15-8\cdot\mu_{BC}}\right)+W_B+W_A$$

$$\Sigma F_x=0$$

$$\Rightarrow\quad P=F_{AD}+F_{BC}$$

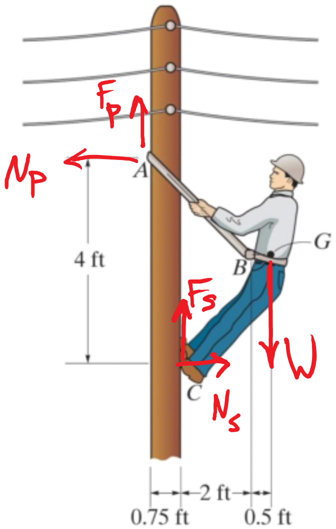
$$P=\mu_{AD}\cdot N_{AD}+\mu_{BC}\cdot N_{BC}$$

$$P=\mu_{AD}\left[\left(\frac{15W_c}{15-8\mu_{BC}}\right)+W_B+W_A\right]+\mu_{BC}\cdot\left(\frac{15\cdot W_c}{15-8\mu_{BC}}\right)$$

$\therefore$ sub. values & solve

Case 2: $\underline{P=69.27\text{ lb}}$

Case 1: $\boxed{P=63.52\text{ lb}}$ ← lower P causes block A to move



If the coefficient of static friction between the man's shoes and the pole is $\mu_s = 0.6$, determine the minimum coefficient of static friction required between the belt and the pole at A in order to support the man. The man has weight of 180 lb and a center of gravity at G.

$W_{man} = 180$ lb

shoes: $\mu_s = 0.6$

FBD of man & belt

$(\Sigma M)_{shoes} = 0$

$-2.5 \cdot W + 4N_p - 0.75 \cdot F_p = 0$

$-2.5 \cdot W + 4N_p - 0.75 \cdot \mu_p \cdot N_p = 0$ ✩

$\Sigma F_y = 0 \Rightarrow F_p + F_s = W$

$\mu_p N_p + \mu_s \cdot N_s = W$ ✩

$\Sigma F_x = 0 \Rightarrow N_p = N_s$ ✩ (call $N_p = N_s = \underline{N}$)

$\mu_p \cdot N + \mu_s \cdot N = W$

$(\mu_p + \mu_s) N = W$

$-2.5W + 4N - 0.75\mu_p \cdot N = 0$

$W = \dfrac{(4 - 0.75\mu_p) \cdot N}{2.5}$

$$2.5$$

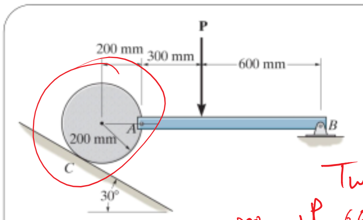
$$(\mu_p+\mu_s)\cancel{N} = \left(\frac{4-0.75\mu_p}{2.5}\right)\cancel{N}$$

$$\mu_p+\mu_s = \frac{4-0.75\mu_p}{2.5}$$

continue to simplify

$$\mu_p = \frac{4-2.5\mu_s}{3.25}$$

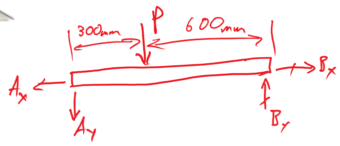
$$\boxed{\mu_p = 0.769}$$



A disk with mass M=35 kg rests on an inclined surface for which $\mu_s = 0.2$. Determine the maximum vertical force **P** that can be applied to bar AB without causing the disk to slip at C. Neglect the mass of the bar.

Two FBD: The disk

The bar



$$(\Sigma M)_B = 0 \Rightarrow 600 \cdot P + 900 \cdot A_y = 0$$

$$A_y = -\frac{2}{3} P$$

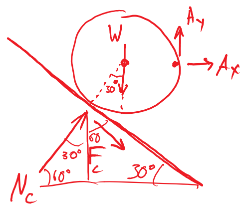
$$\Sigma F_y = 0 \Rightarrow B_y - P - A_y = 0$$

$$B_y = P + A_y$$

$$= P + \left(-\frac{2}{3} P\right)$$

$$= \frac{1}{3} P$$

$$\Sigma F_x = 0 \Rightarrow -A_x + B_x = 0 \Rightarrow A_x = B_x$$



Q: which direction for the friction force?

A) Up the incline

B) Down the incline

friction acts in the direction that resists the impending motion to hold the disk stationary

$$(\Sigma M)_{\text{center of disk}} = 0$$

$$+200\,mm \cdot A_y + 200\,mm \cdot F_c = 0$$

$$\Rightarrow F_c = -A_y = -\left(-\frac{2}{3} P\right)$$

$$F_c = \frac{2}{3} P$$

$$\mu_c N_c = \frac{2}{3} P$$

$$\Sigma F_y = 0$$

$$\Rightarrow -W + A_y + N_c \cdot \sin 60° - F_c \cdot \cos 60° = 0$$

$$-W + \left(-\frac{2}{3} P\right) + N_c \sin 60° - \mu_c \cdot N_c \cos 60° = 0$$

$$-(35\,kg)(9.81\,m/s^2) + \left(\frac{2P}{3\mu_c}\right) \sin 60° - \left(\frac{2P}{3}\right) \cos 60° = 0$$

$$\vdots$$

$$\boxed{P = 181.9\,N}$$