Statics Topic Friction Date 12/2/13
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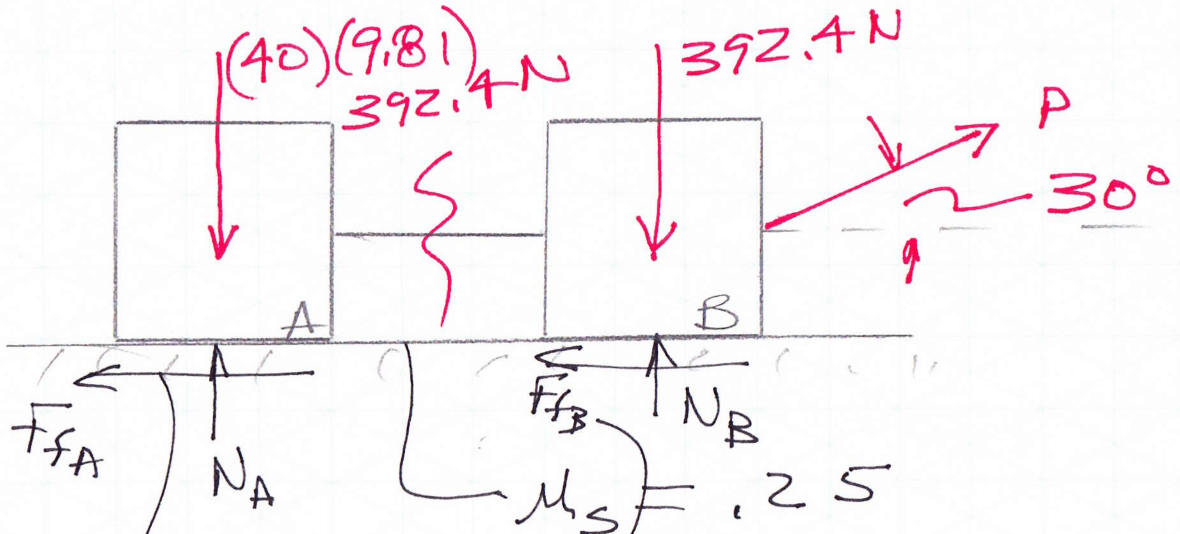
Two 40-kg crates are resting on a flat surface as shown. The coefficient of static friction between the surface and the crates is 0.25. It is assumed that the two crates are connected with an inextensible cord as shown such that if crate B moves, crate A must also move. Determine the maximum force, P, that can be applied to the system without initiating motion.



$F_{fB} = .25 N_B$

$F_{fA} = .25 N_A$

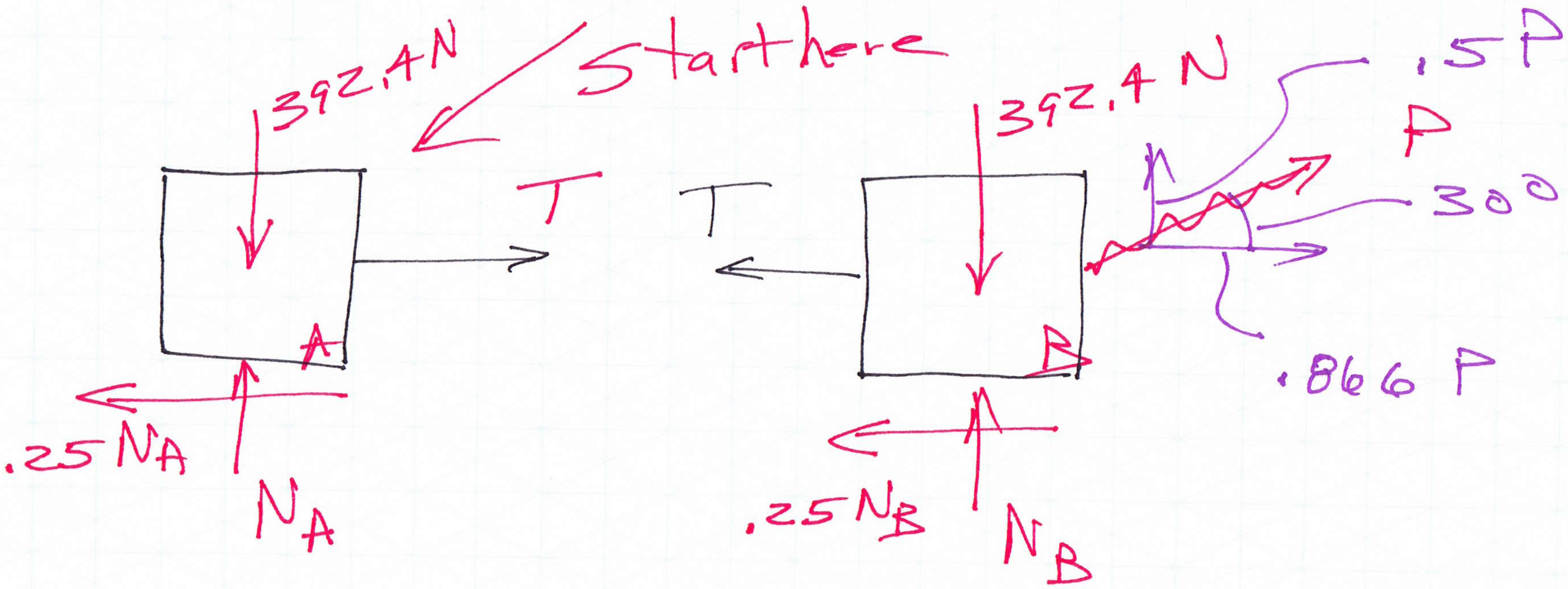
Impending Motion Problem

3 unknown forces

2 Equations.

$\xrightarrow{+} \Sigma F_x = 0$

$+\uparrow \Sigma F_y = 0$



N_A, T, N_B, P

4 unknowns

Crate A

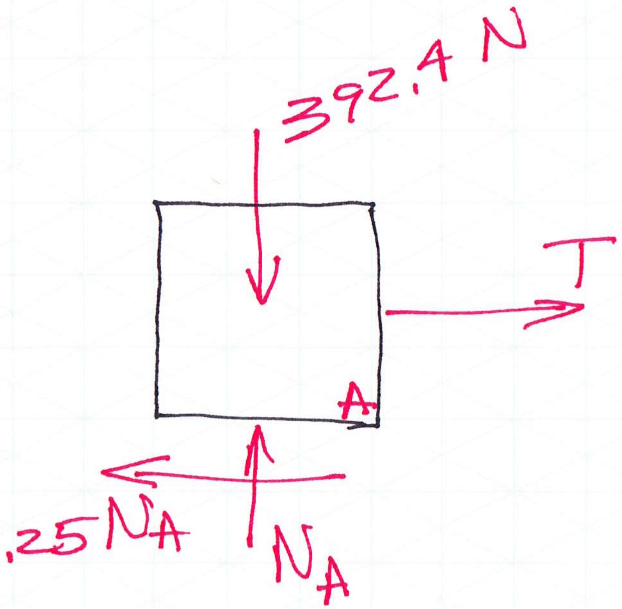
$\xrightarrow{+} \Sigma F_x = 0$

$+\uparrow \Sigma F_y = 0$

Crate B

$\xrightarrow{+} \Sigma F_x = 0$

$\uparrow \Sigma F_y = 0$



$$+\uparrow \sum F_y = 0$$

$$-392.4 + N_A = 0$$

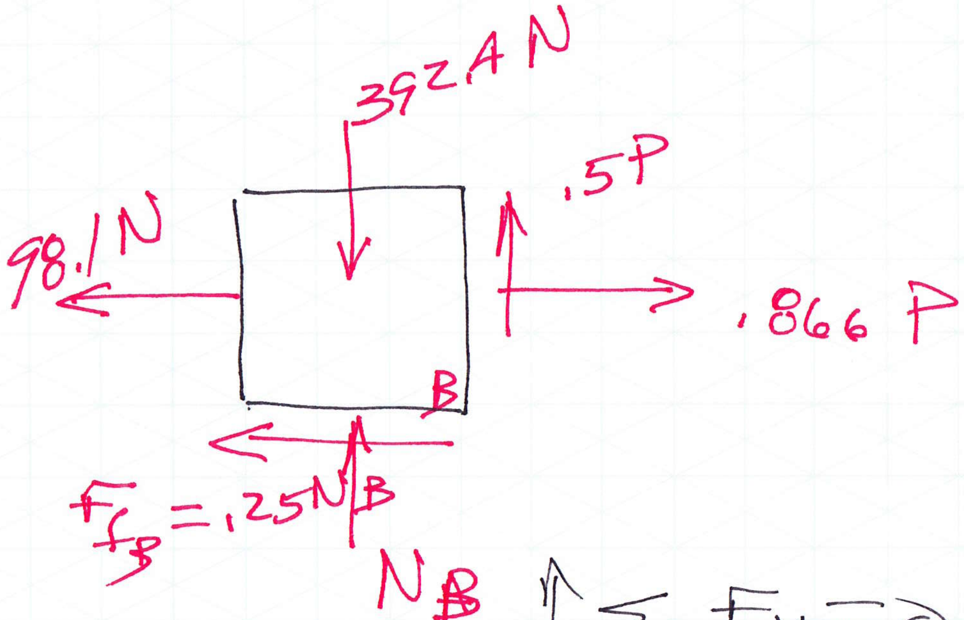
$$\underline{N_A = 392.4 \text{ N} \uparrow \text{ as shown}}$$

$$\xrightarrow{+} \sum F_x = 0$$

$$T - .25 \cancel{N_A}^{\,392.4} = 0$$

$$\underline{T = 98.1 \text{ N} \rightarrow \text{ as shown}}$$

$$\underline{F_{f_A} = .25 \cancel{N_A}^{\,392.4} = 98.1 \text{ N} \leftarrow \text{ as shown}}$$



$\xrightarrow{+} \Sigma F_x = 0$

$-98.1 + .866P - .25N_B = 0$

$.25N_B = .866P - 98.1$

$N_B = 3.464P - 392.4$

$+\uparrow \Sigma F_y = 0$

$-392.4 + .5P + N_B = 0$

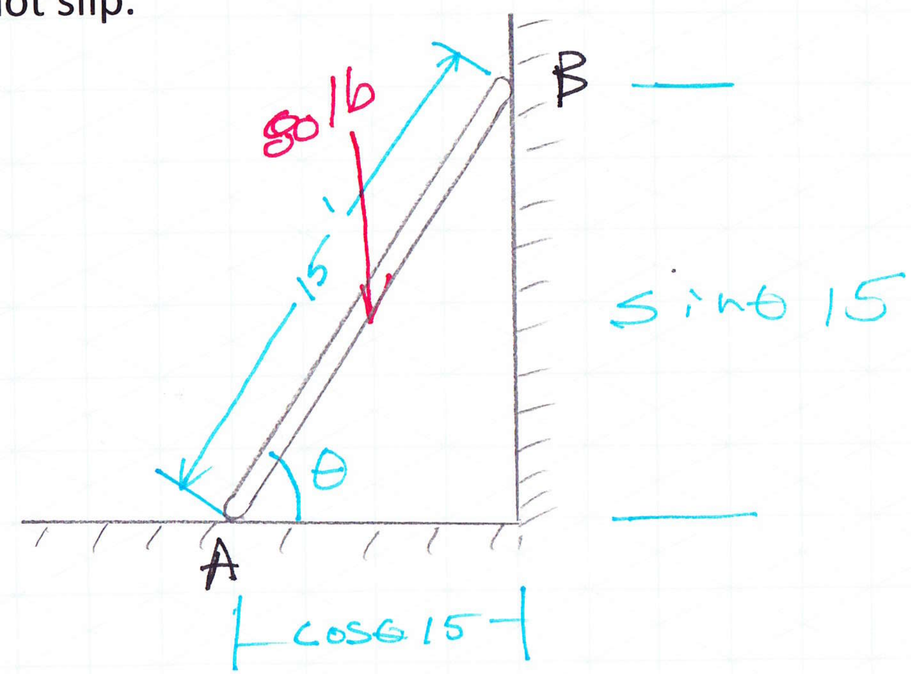
$N_B = 392.4 - .5P$

$392.4 - .5P = 3.464P - 392.4$

$784.8 = 3.964P$

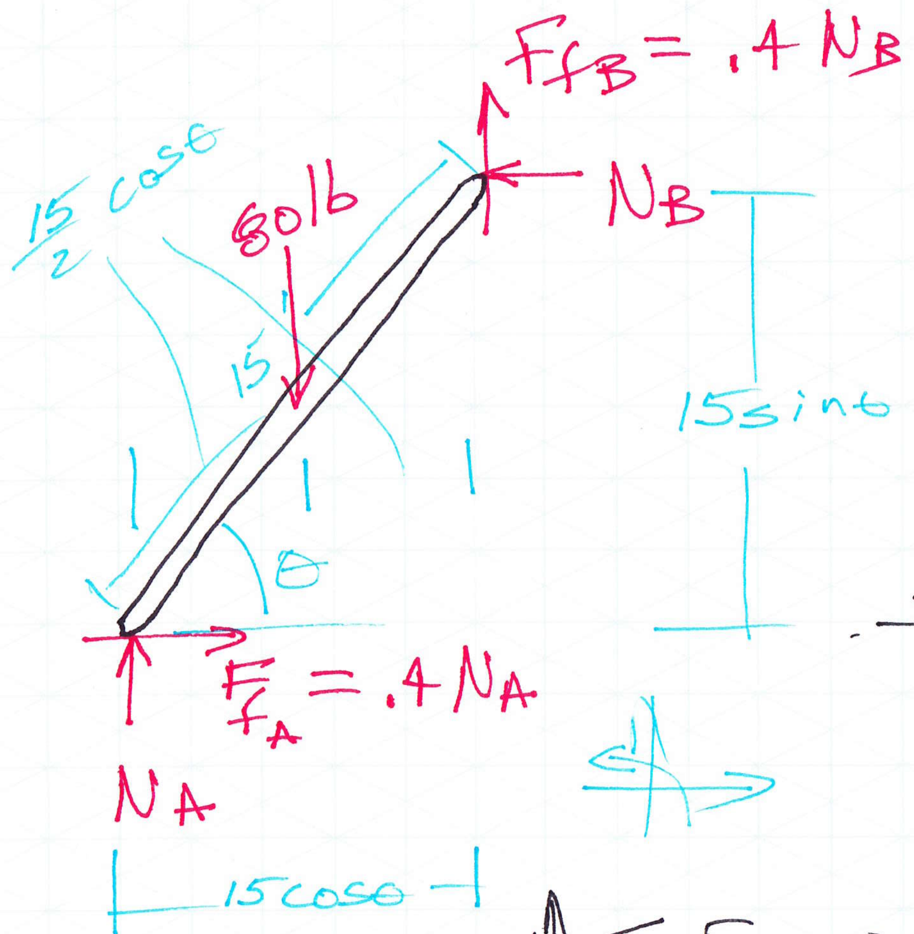
$P = 198.0\ N$ as shown 30°

An 80 lb ladder is positioned against a horizontal surface and a vertical wall as shown. The static coefficient of friction is 0.40 for all contacting surfaces. Determine the minimum angle between the ladder and the horizontal for which the ladder will not slip.



Impending motion

A cannot slide unless B also slides



3 unknowns

N_A, N_B, θ

3 equations of equilibrium

$\overset{+}{\rightarrow} \Sigma F_x = 0$

$.4 N_A - N_B = 0$

$N_B = .4 N_A$

$+\uparrow \Sigma F_y = 0$

$N_A - 80 + .4 N_B = 0$

$.4 N_B = 80 - N_A$

$N_B = 200 - 2.5 N_A$

$$.4 N_A = 200 - 2.5 N_A$$

$$2.9 N_A = 200$$

$$N_A = \underline{68.97 \text{ lb}}$$

$$N_B = .4(68.97) = \underline{27.59 \text{ lb}}$$

or

$$N_B = 200 - 2.5(68.97) = \underline{27.58 \text{ lb}}$$

Good check

$$\circlearrowleft + \ \Sigma M_B = 0$$

$$80\left(\frac{\cancel{15}\cos\theta}{2}\right) + .4\,N_A(\cancel{15}\sin\theta) - N_A\,\cancel{15}\cos\theta = 0$$

$$40\cos\theta + .4(68.97)\sin\theta - 68.97\cos\theta = 0$$

$$27.59\sin\theta = 28.97\cos\theta$$

$$\frac{\sin\theta}{\cos\theta} = \frac{28.97}{27.59}$$

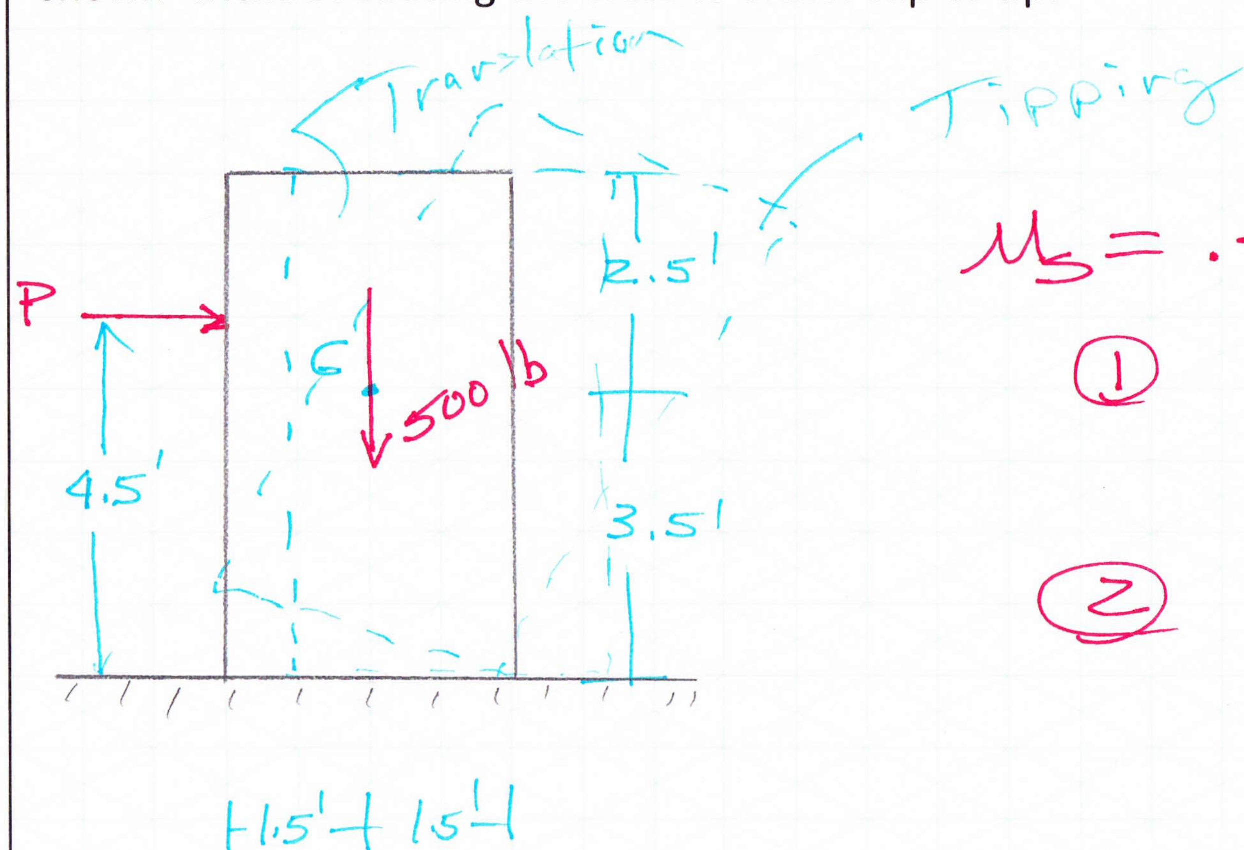
$$\tan\theta = 1.05$$

$$\boxed{\theta = 46.4^\circ}$$

$\theta \geq 46.4^\circ$

otherwise the ladder will become unstable.

A 500 lb crate is resting on a horizontal surface as shown. The location of the centroid of the crate is as shown. The static coefficient of friction for all contacting surfaces is 0.40. Determine the maximum force that can be applied to the crate as shown without causing the crate to either slip or tip.

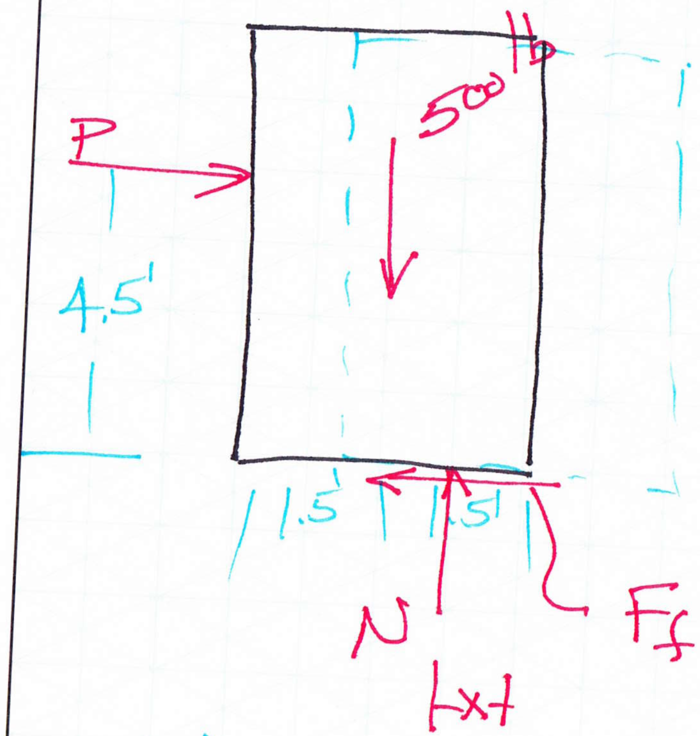


$\mu_s = .40$

1. Impending Slippage
   P_{slip}

2. Impending tipping
   $P_{tipping}$

Check Slipping



$F_f = .4N$

Impending slippage

Unknowns — P, N

$+\uparrow \sum F_y = 0$

$-500 + N = 0$

$N = 500\,lb$

$F_f = .4\,\cancel{N}^{500} = 200\,lb$

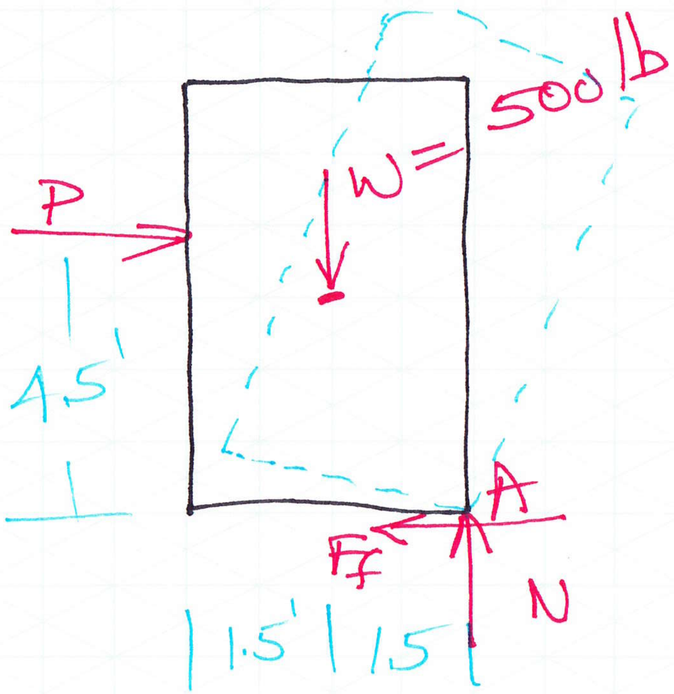
$\overset{+}{\rightarrow} \sum F_x = 0$

$P - \cancel{F_f}^{200} = 0$

$P_{max} = 200\,lb$

This might be the answer???

Check Tipping



$$\circlearrowleft + \quad \sum M_A = 0$$

$$-P(4.5) + 500(1.5) = 0$$

$$P = \frac{500(1.5)}{4.5}$$

$$P = 166.7 \text{ lb}$$

This may be the answer

$P_{slip} = 200$ lb , $P_{Tip} = 166.7$ lb

$$\boxed{\therefore P_{max} = 166.7 \text{ lb}}$$