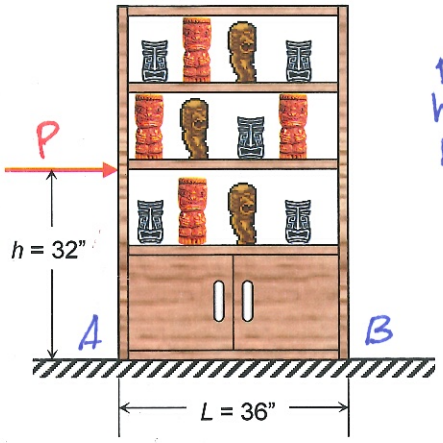
Example

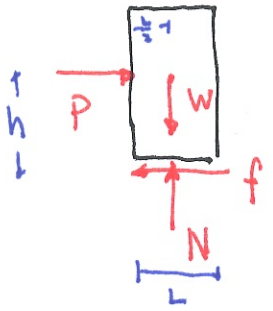
Sid Gupta's legendary Tiki mug collection is displayed in a cabinet with a total weight of W_{cab} = 120 lb. A force P is applied to the cabinet at a height of h = 32 in as shown in the figure. If the coefficient of static friction between the cabinet and the floor is μ_s = 0.30,

SHAG CARPET

a) find the minimum force P that results in the cabinet moving.
b) Repeat a) if μ_s = 0.20. 0.60



a) FBD



$\Sigma F_y = 0 = -W + N \quad N = W = 120\,lb$

$\Sigma F_x = 0 = P - f \quad P = f$

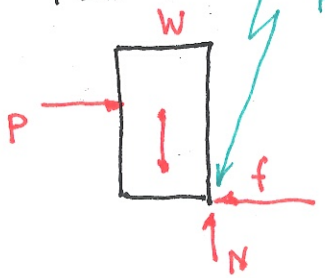
FOR IMPENDING MOTION: $f = \mu_s N$

$\therefore P = \mu_s N = \mu_s W = (0.3)(120\,lb)$

$= 36\,lb$

BUT IT COULD TIP COULDN'T IT?! WHAT'S THE FBD LOOK LIKE?

FBD



$\Sigma F_y = 0 = -W + N \quad N = W = 120\,lb$

$\Sigma F_x = 0 = P - f \quad P = f \stackrel{?}{=} \mu_s N$. DON'T KNOW!!!

$\circlearrowleft \Sigma M_B = 0 = -hP + \frac{L}{2}W = 0$

$P_{TIP} = \frac{L}{h2}W = \frac{36"}{(32")(2)}(120\,lb) = 67.5\,lb$

$P_{SLIP} < P_{TIP} \Rightarrow$ IT SLIPS FIRST $\therefore$ **$P_{MIN} = 36\,lb$**

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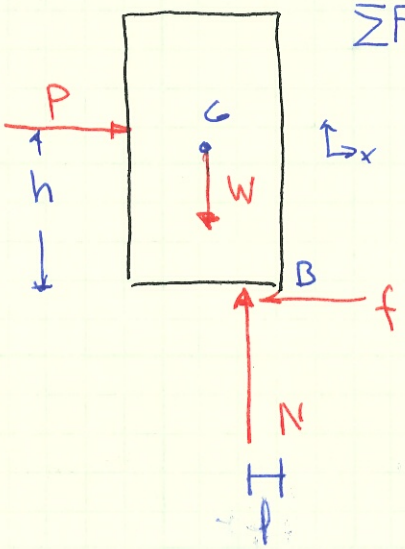
b) TIPPING THE SAME.

SLIPPING:

$P_{SLIP} = \mu_s W = (0.6)(120\,lb) = 72\,lb$

$P_{TIP} < P_{SLIP} \Rightarrow$ IT TIPS FIRST $\therefore$ **$P_{MIN} = 67.5\,lb$**

c). NEW!! IF $P = 30\,lb$ & $\mu_s = 0.3$ (AS IN a)) FIND f & LOCATION of NORMAL FORCE FROM FLOOR.



$\Sigma F_x = 0 = P - f$ $\boxed{f = P = 30\,lb}$ $\neq \mu_s N$!!

$\Sigma F_y = 0 = -W + N$

$N = W = 120\,lb$

$\circlearrowleft \Sigma M_B = 0 = -hP + \frac{L}{2}W - fN = 0$

$f = \dfrac{\frac{L}{2}W - hP}{N}$

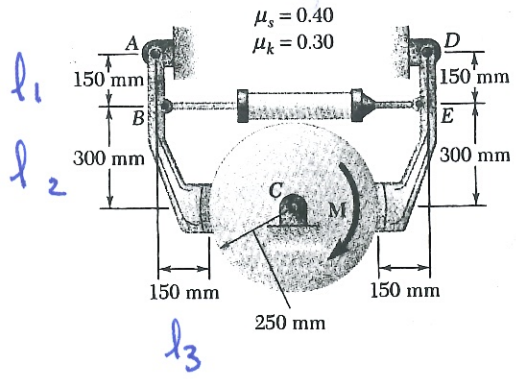
$= \dfrac{\frac{L}{2}W - hP}{W} = \frac{L}{2} - h\frac{P}{W}$

$= 19'' - (32'')\dfrac{(30\,lb)}{(120\,lb)}$

$= \boxed{10''}$ FROM RIGHT EDGE.

AS P INCREASES N KEEPS SHIFTING RIGHT.

Given:



l_1

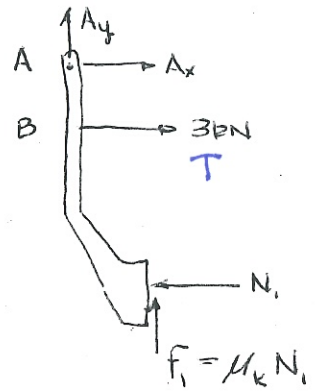
l_2

l_3

Find: M TO KEEP DRUM ROTATING CLOCKWISE @ CONST. SPEED.

Soln:

FBD AB



$\circlearrowleft + \sum M_A = 0 \quad -(l_1+l_2) \quad l_3\ \mu_k N_1$

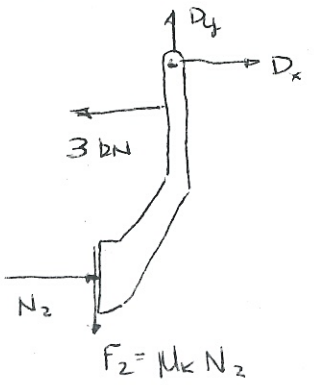
$l_1 \quad T$

$+(150)(3) - (450)(N_1) + (150)(\mu_k N_1) = 0$

$(450)(3) - (450)(N_1) + (150)(0.3)N_1 = 0$

$N_1 = 1.11$ kN

FBD DE



$\circlearrowleft + \sum M_D = 0$

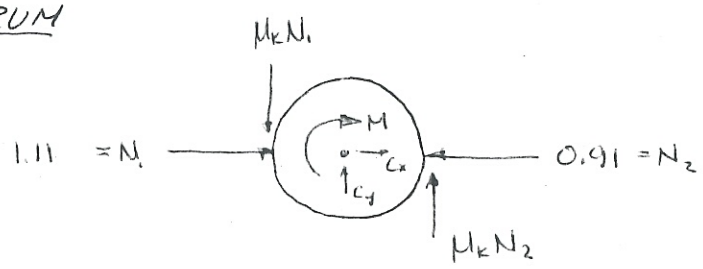
$-l_1 \quad + (l_1+l_2) \quad + \quad l_3\ \mu_k N_2$

$-(150)(3) + (450)(N_2) + (150)(\mu_k N_2) = 0$

$-(150)(3) + (450)(N_2) + (150)(0.3)N_2 = 0$

$N_2 = 0.91$ kN

FBD DRUM



$\circlearrowleft \Sigma M_c = 0$

$$-M + (\mu_k N_2)(250) + (\mu_k N_1)(250) = 0$$

(R) (R)

$$-M + (0.3 * 0.91)(250) + (0.3 * 1.11)(250) = 0$$

$$M = 152 \text{ N-mm} * \left\langle \frac{1000 \text{ N}}{\text{kN}} \right\rangle \left\langle \frac{\text{m}}{1000 \text{ mm}} \right\rangle$$

$$\boxed{M = 152 \text{ N-m}}$$