The 50-pound crate shown rests on a rough inclined surface. The horizontal cable attached to the crate at A passes over a frictionless pulley and supports a hanging weight W. Given that the coefficients of friction between the crate and the surface are $\mu_s = 0.20$ and $\mu_k = 0.15$, determine the maximum weight W for which the crate will remain in static equilibrium.

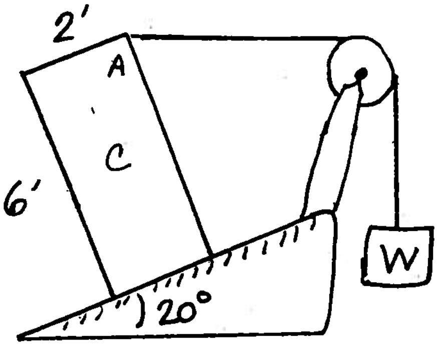
For full credit, consider both tipping and slipping.

Given: $\mu_s = 0.20$

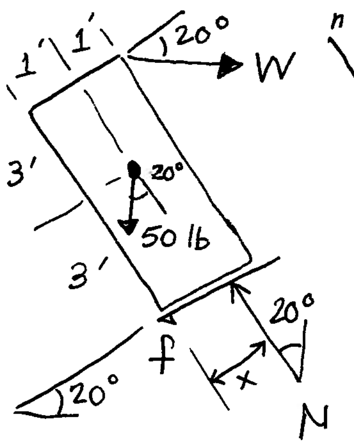
$\mu_k = 0.15$

$W_c = 50$ lb

FIND: W_{max}



Slipping up the incline



$$\overset{+}{\nearrow} \Sigma F_t = 0$$

$$W\cos 20 - 50\sin 20 - f = 0$$

$$f = W\cos 20 - 50\sin 20$$

$$\overset{+}{\nwarrow} \Sigma F_n = 0 = N - 50\cos 20 - W\sin 20$$

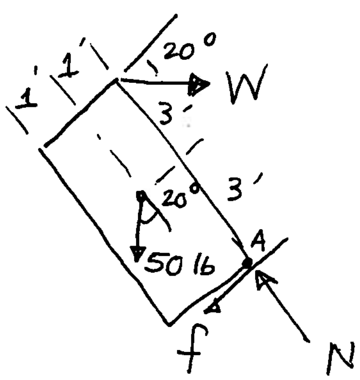
$$N = 50\cos 20 + W\sin 20$$

at slipping $f = f_{max} = \mu N$

$$(W\cos 20 - 50\sin 20) = (0.20)(50\cos 20 + W\sin 20)$$

$$0.8713\,W = 26.498 \qquad W = 30.4 \text{ lb.}$$

Tipping up the incline



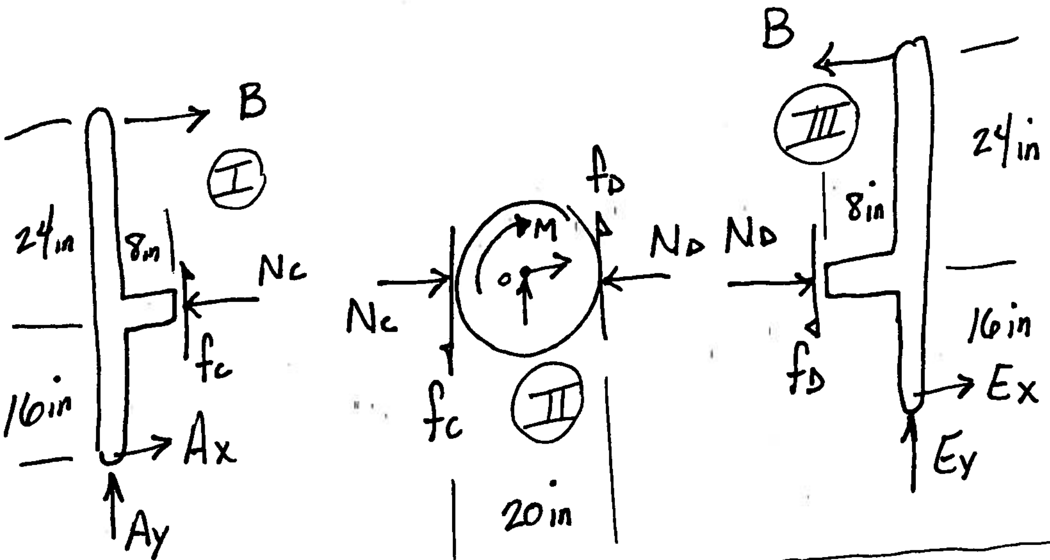
$$\overset{+}{\circlearrowright} \Sigma M_A = 0 = 50\cos 20(1) + 50\sin 20(3) - W\cos 20(6) = 0$$

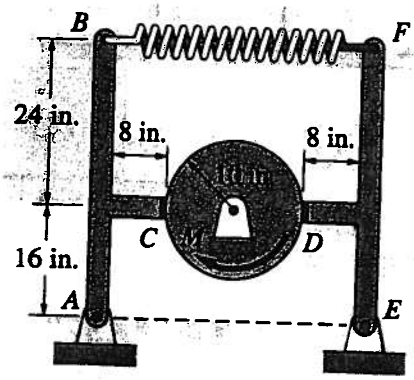
$$W = 17.4 \text{ lb.}$$

$$\boxed{\text{As the weight is increased, the block will tip first.} \quad W = 17.4 \text{ lb}}$$

The brake pads at C and D are pressed against the cylinder by the spring BF. The coefficient of static friction between the pads and the cylinder is 0.2. Find the smallest tension in the spring that would prevent the cylinder from rotating when the clockwise couple $M = 3000$ lb · in. is applied. Neglect the weights of the members.

Given: $\mu = 0.2$, $M = 3000$ lb·in FIND F_{spring}





Note: You CAN NOT assume $f_C = f_D$ OR $N_C = N_D$ (there are pin reactions at the center of the cylinder)

PLAN

I $\Sigma M_A \rightarrow N_C, f_C, B$

II $\Sigma M_O \rightarrow f_D, f_C$

III $\Sigma M_E \rightarrow N_D, f_D, B$

Slips at C and D at the same time so both friction forces will reach their max. values just as equilibrium is disturbed

$f_C = 0.2\,N_C$, $f_D = 0.2\,N_D$

5 equations - 5 unknowns - solvable!

II ΣM_O $\quad f_D(10) + f_C(10) - 3000 = 0 \qquad .2N_C + .2N_D = 300$

$N_D = 1500 - N_C$

I $\Sigma M_A = -B(40) + N_C(16) + (.2N_C)(8) = 0$

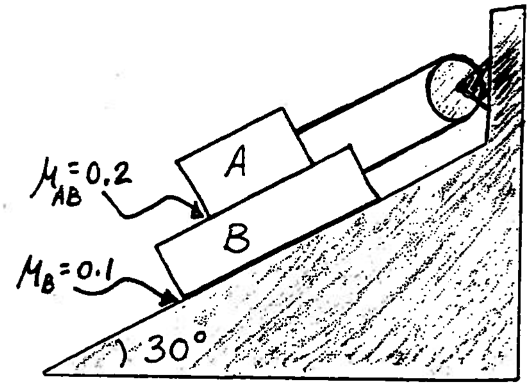
$B = 0.44\,N_C \qquad N_C = 2.27\,B \qquad N_D = 1500 - 2.27\,B$

III $\Sigma M_E = B(40) - N_D(16) + (.2N_D)(8) = 0$

$40B - 14.4(1500 - 2.27B) = 0$

$72.69\,B = 21600 \qquad \boxed{B = 297 \text{ lb}}$

In the diagram shown, blocks A and B are attached to each other by a cable that runs parallel to the incline over a frictionless pulley. Given that A weighs 50 lbs, what is the minimum weight of block B required to keep the system in equilibrium? (The coefficient of static friction between the blocks is $\mu_{AB} = 0.2$ and the coefficient of static friction between block B and the incline is $\mu_B = 0.1$)

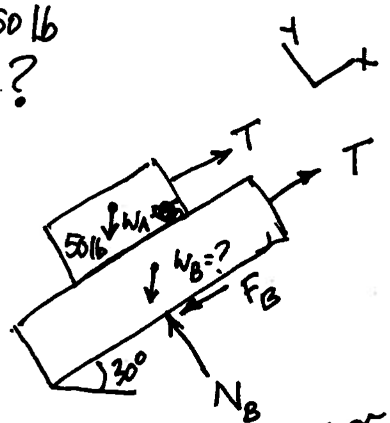


$W_A = 50$ lb

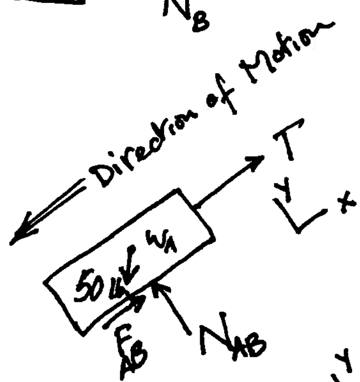
$W_B = ?$

FBD's

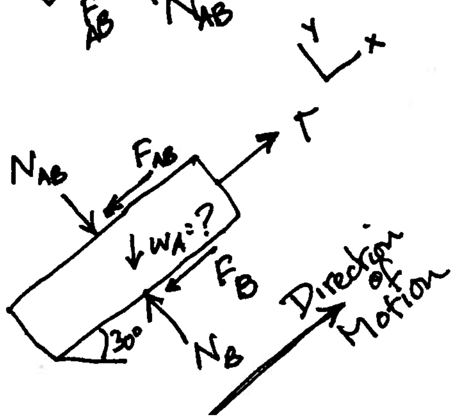
I



II



III



unknowns
N_B
F_B
W_B
T
N_{AB}
F_{AB}

\# eqs
4 SEE's
2 impending sliding
⇓
assume impending sliding at both surfaces.
⇓

$\therefore$ $\boxed{F_{AB} = \mu_{AB} N_{AB} = 0.2 N_{AB}}$

$\boxed{F_B = \mu_B N_B = 0.1 N_B}$

Plan

II $\uparrow + \quad \Sigma F_y = 0 \Rightarrow N_{AB}$

II $+\nearrow \quad \Sigma F_x = 0 \Rightarrow F_{AB}, T$

I $\uparrow + \quad \Sigma F_y = 0 \Rightarrow N_B, W_B$

I $+\nearrow \quad \Sigma F_x = 0 \Rightarrow F_B, W_B, T$

$\therefore$ 6 eq. and 6 unknowns

II $\Sigma F_y = 0 = N_{AB} - 50 \cos 30° \Rightarrow \boxed{N_{AB} = 43.3 \text{ lb}}$

II $\Sigma F_x = 0 = -50 \sin 30° + 0.2 \overset{43.3}{\cancel{N_{AB}}} + T \Rightarrow \boxed{T = 16.34 \text{ lb}}$

I $\Sigma F_y = 0 = -50 \cos 30° - W_B \cos 30° + N_B$

I $\Sigma F_x = 0 = 2T - 0.1 N_B - W_B \sin 30° - 50 \sin 30°$

[solve simultaneously]

multiply by (0.1)

$0.1 W_B (\cos 30°) - (0.1) N_B = -50(0.1) \cos 30°$

$W_B \sin 30° + (0.1) N_B = 2(16.34) - 50 \sin 30°$

$\therefore W_B (0.5866) = 3.35 \Rightarrow \boxed{W_B = 5.71 \text{ lb}}$

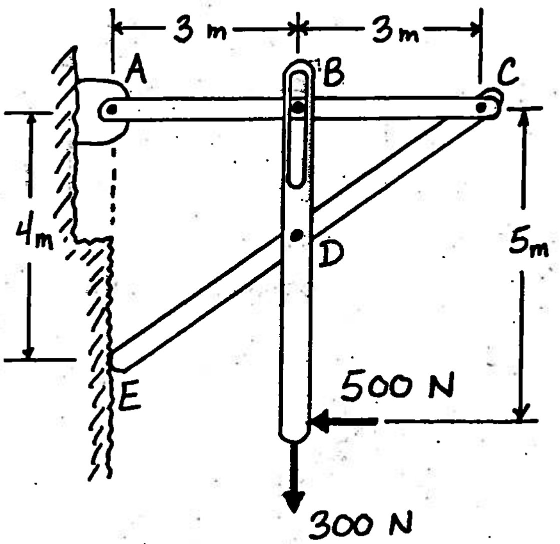
$W_B =$ 5.71 lb

Could solve in just 3 steps.

I $\Sigma M_A \rightarrow N_E$ I $\Sigma F_y \rightarrow f_E$ loads

II $\Sigma M_c \rightarrow A_y$

The frame shown is held together by pins at C and D and a frictionless slot at B. It is connected to the wall by a pin at A and rests on a rough surface at E. Under the load shown, determine if this structure will remain in static equilibrium given a static coefficient of friction between the frame and the wall at E of 0.40. Your answer MUST be supported by numerical equilibrium calculations and a clear explanation to receive credit.



Given $\mu_E = 0.4$ FIND: Equilibrium?

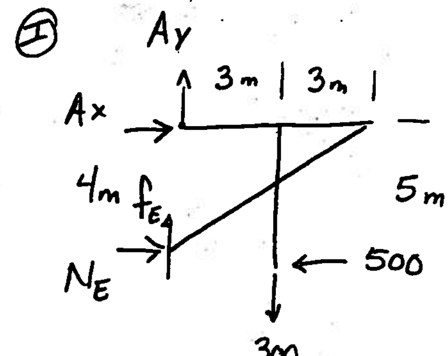
To answer the question we need values for N_E and f_E to compare with $f_{max} = \mu N_E$

IV ΣM_D: Bx
ΣM_B: Dx 1
ΣF_y: Dy 2

II ΣM_A: Cy

I ΣM_A N_E 3

III ΣM_C: Dx Dy N_E f_E 4

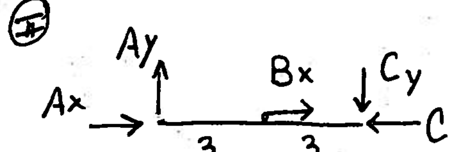


Solve

IV $\Sigma M_B = 0 = Dx(2) - 500(5)$ $Dx = 1250$

$\Sigma F_y = 0$ $Dy - 300 = 0$ $Dy = 300$

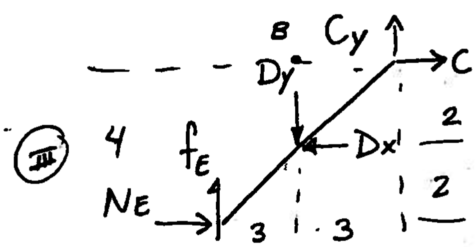
I $\Sigma M_A = N_E(4) - 300(3) - 500(5)$ $N_E = 850$

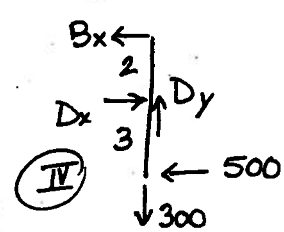


III $\Sigma M_C = 300(3) - 1250(2) + 850(4) - f_E(6)$

$f_E = 300$

$f_{max} = 0.4(850) = 340 > f$

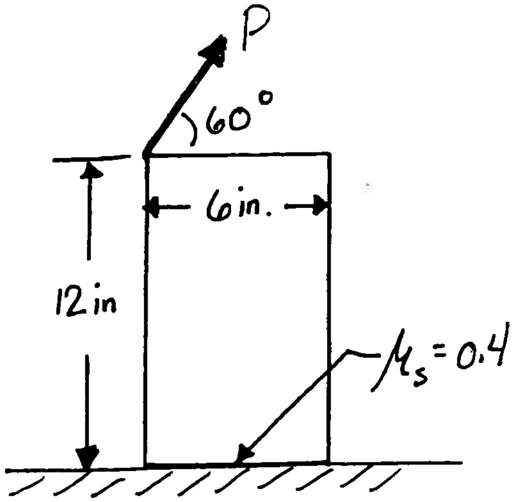


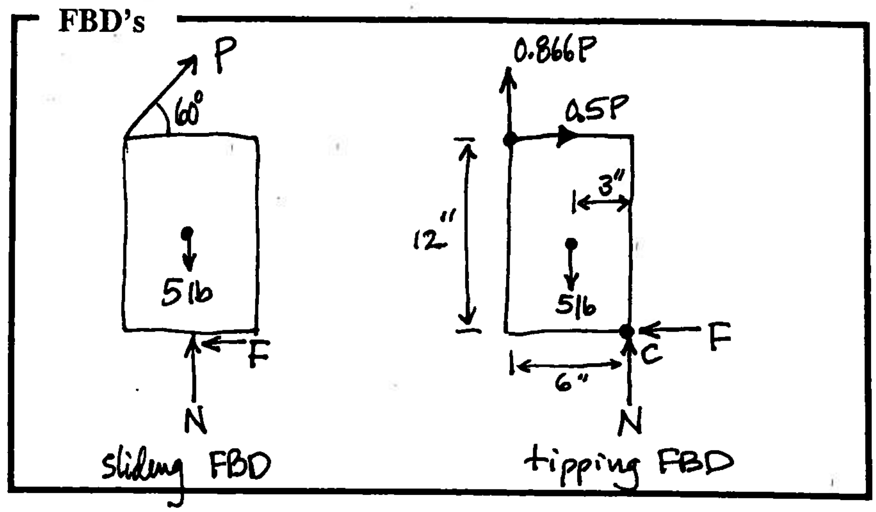


Static Equilibrium? YES or NO (circle one) Explain why based on your calculations shown above.

f required for equilibrium is less than f max

A 5 lb homogeneous rectangular block rests on a rough surface as shown. Determine the largest force P that can be applied for the block to remain in static equilibrium in the position shown.
Note: You must prove your answer by considering ALL possible motions of the block.





test for ① impending sliding to right
② tipping about corner C

① Impending sliding

$$F_{max} = \mu_s N = 0.4N$$

$$\Sigma F_x = 0 = 0.5P - F$$
$$\Sigma F_y = 0 = N - 5 + 0.866P \Rightarrow N = 5 - 0.866P$$

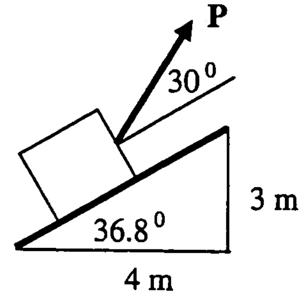
$$\therefore P = 2F = 2(0.4N) = 2(0.4)(5 - 0.866P)$$
$$P = 4 - 0.693P$$
$$\boxed{P = 2.36 \text{ lb}}$$ for impending sliding

② At impending tipping at corner C

$$\circlearrowleft + \ \Sigma M_c = 0 = 5(3) - \underbrace{0.866}_{\sin 60^\circ}P(6) - \underbrace{0.5}_{\cos 60^\circ}P(12)$$
$$\boxed{P = 1.34 \text{ lb}}$$ for impending tipping

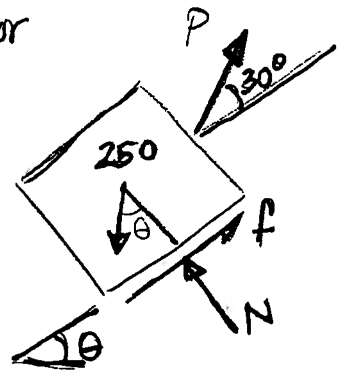
P max = 1.34 lb

A force **P** acting at a 30 deg angle (with respect to the incline plane) is applied to the 250 lb block, as shown. The coefficient of static friction between the block and the incline is $\mu_s = 0.4$.



Find the range of values for the applied force **P** for which the block will be in static equilibrium.

FIND: Range of P for static equilib.



To keep from slipping down.

$$\nwarrow^{+} \; \Sigma F_N = 0 = N - 250\cos 36.8 + P\sin 30 \qquad (\cos 36.8 = 4/5,\ \sin 30 = 1/2)$$

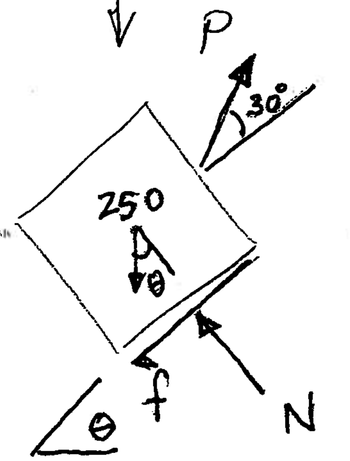
$$N = 200 - \tfrac{1}{2}P$$

$$\nearrow^{+} \; \Sigma F_T = 0 = P\cos 30 - 250\sin 36.8 + f \qquad (\sin 36.8 = 3/5)$$

$$f = 150 - 0.866P \le (0.4)(200 - \tfrac{1}{2}P)$$

$$150 - 80 \le (0.866 - 0.2)P$$

$$105.1 \le P$$



To keep from slipping up

$$\Sigma F_N = 0 \quad = \text{same} \quad N = 200 - 0.5P$$

$$\nearrow^{+} \; \Sigma F_T = 0 = P\cos 30 - 250\sin 36.8 - f$$

$$f = 0.866P - 150 \le (0.4)(200 - 0.5P)$$

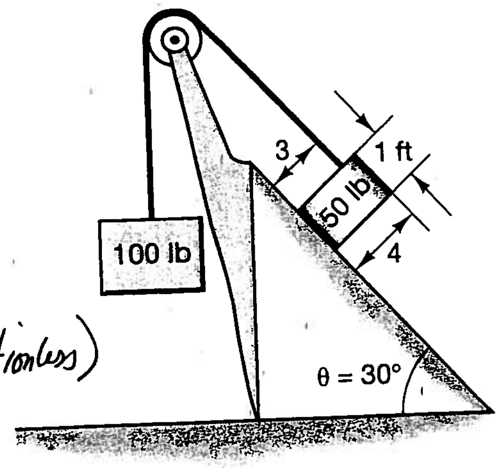
$$(0.866 + 0.2)P \le 150 + 80$$

$$P \le 215.8$$

P_{MIN} = 105 lb

P_{MAX} = 216 lb.

Is the system shown in equilibrium? Assume the weight of each crate acts in it's geometric center and the pulley is frictionless. The coefficients of static friction between the 50 lb crate and the incline are $\mu_s = 0.6$ and $\mu_k = 0.5$.



Given: $\mu_s = 0.6$, $\mu_k = 0.5$

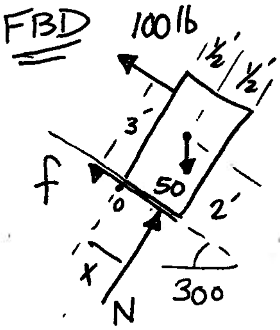
Assume: pulley is frictionless

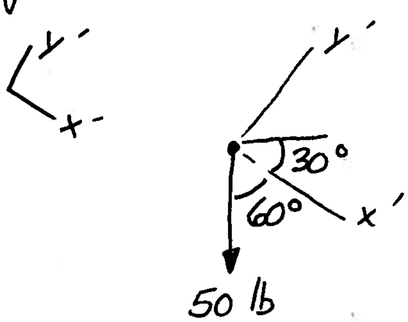
Find: Is the system in equilibrium?

Check both sliding and tipping

Tension in the rope is 100 lb (because pulley is frictionless)

FBD





assumed direction of impending motion

$+\searrow \quad \Sigma F_{x'} = 50\cos 60° - 100 - f = 0$

$f = -75$ lb

(neg. means impending motion is actually up the incline)

A friction force of 75 lb is required to maintain equilibrium

$+\nearrow \quad \Sigma F_{y'} = N - 50\sin 60 = 0$

$N = 43.3$ lb.

$f_{max} = \mu N = (0.6)(43.3)$

$f_{max} = 26.0$ lb

$f > f_{max} \rightarrow$ the block will slide under this load

$\circlearrowleft \quad \Sigma M_o = N(x) + 100(3) - 50\cos 60(2) - 50\sin 60(½) = 0$

$x = -5.27$ ft.

(the block will tip under this load)

NO. this system is **NOT** in equilibrium