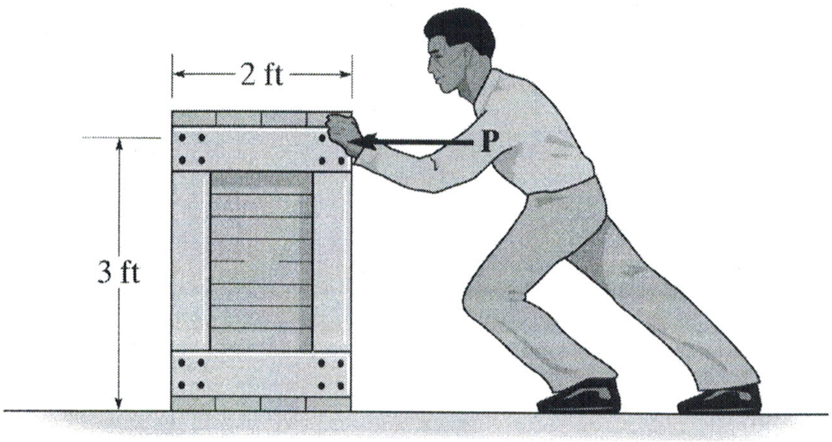
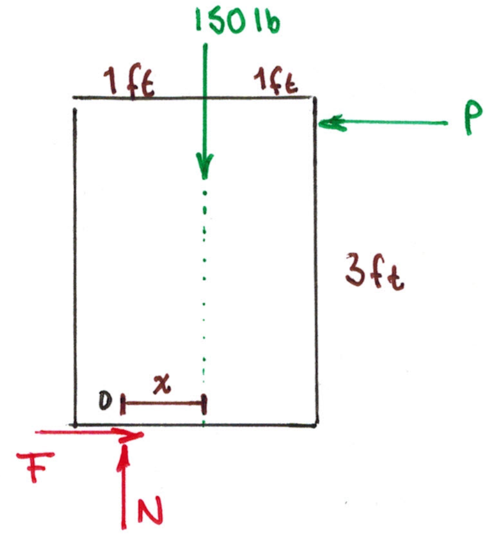
Determine the smallest force $P$ that must be applied in order to cause the 150-lb uniform crate to move. The coefficent of static friction between the crate and the floor is $\mu_s = 0.5$.




Equations of Equilibrium

$\Sigma F_x = 0 \qquad F - P = 0 \qquad (1)$

$\Sigma F_y = 0 \qquad N - 150 = 0 \qquad N = 150 \text{ lb}$

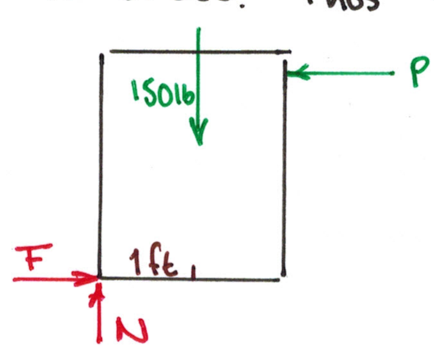
$\Sigma M_O = 0 \qquad P(3) - 150x = 0 \qquad (2)$

Assuming the crate slides $F = \mu N = 0.5(150) = 75$ lb

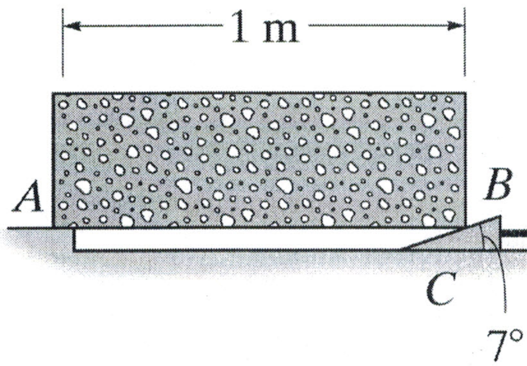
Sub in (1) and (2), $\quad P = F = 75$ lb

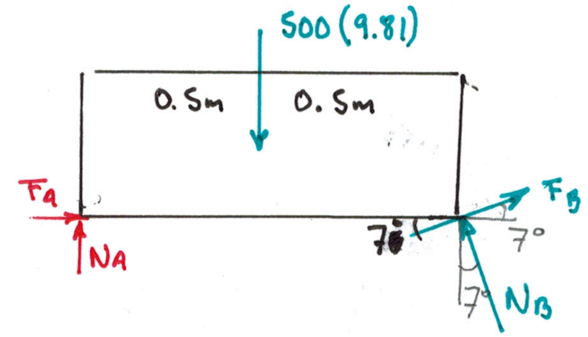
$$x = \frac{75(3)}{150} = 1.5 \text{ ft}$$

Since $x > 1$ ft, where $1 \text{ ft} = b/2$ (b width of base), the crate tips before it slides. Thus the correct FBD



The uniform stone shown below has a mass of 500 kg and is held in the horizontal position using a wedge at B. If the coefficient of static friction is $\mu_s = 0.3$ at the surfaces of contact, determine the minimum force P needed to remove the wedge. Assume that the stone does not slip at A.



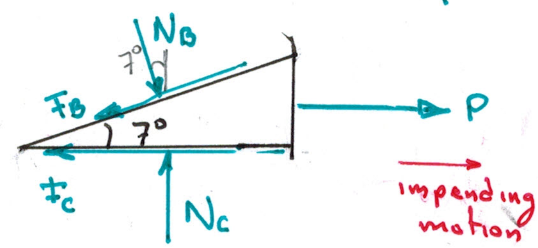




Minimum force P happens when

$F = \mu N$

$F_B = 0.3 N_B$

$F_C = 0.3 N_C$




Stone FBD

$\Sigma M_A = 0$ $\quad -500(9.81)(0.5) + N_B \cos(7)(1) + F_B \sin(7)(1) = 0$

Since $F_B = 0.3 N_B$ $\quad -500(9.81)(0.5) + N_B \cos(7) + 0.3 N_B \sin(7) = 0$

$N_B = 2383 N$

Wedge FBD

$\Sigma F_y = 0$ $\quad N_C - N_B \cos(7) - F_B \sin(7) = 0$

$N_C = N_B(\cos(7) - 0.3 \sin(7)) =$

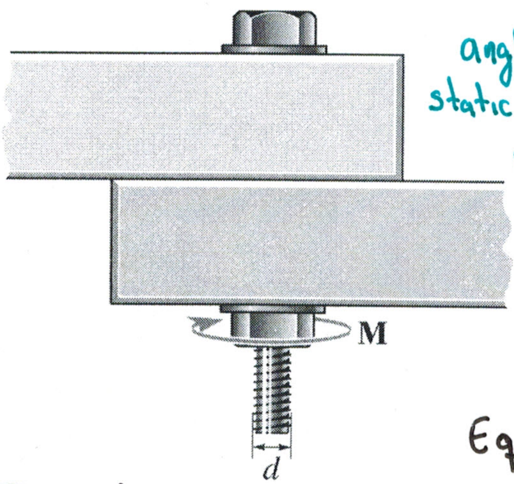
$2383(\cos(7) - 0.3 \sin(7)) = 2452 N$

$\Sigma F_x = 0$ $\quad P - F_C - F_B \cos(7) + N_B \sin(7) = 0$

$P = 0.3 N_C + 0.3 N_B \cos(7) - N_B \sin(7)$

$= 0.3(2452) + 2383(0.3\cos(7) - \sin(7)) = 1155 N$

The square-threaded bolt is used to join two plates together. If the bolt has a mean diameter of $d = 20$ mm and a lead of $l = 3$ mm, determine the smallest torque **M** required to loosen the bolt if the tension in the bolt is T = 40 kN. The coefficient of static friction between the threads and the bolt is $\mu_s = 0.15$.




Check if bolt is self locking $\phi_s > \theta$

angle of static friction $\phi_s = \tan^{-1}(\mu_s) = \tan^{-1}(0.15) = 8.53°$

lead angle $\theta = \tan^{-1}\left(\frac{l}{2\pi r}\right) = \tan^{-1}\left(\frac{3}{2\pi(10)}\right) = 2.734°$

Since $\phi_s > \theta$, we have self-locking bolt

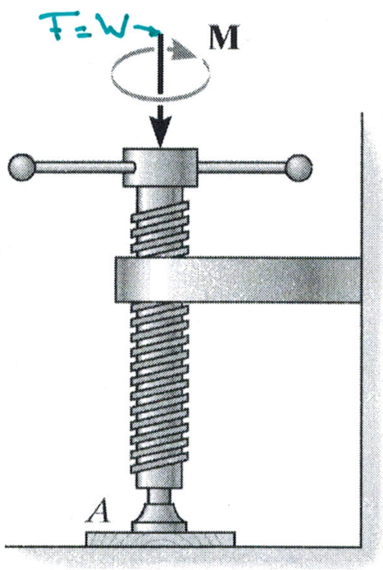
$T = W$

Equation for loosening (downward)

$$M = r W \tan(\phi_s - \theta)$$
$$= (0.01)(40\,000)\tan(8.53 - 2.734)$$

$$M = 40.6 \text{ N·m}$$

Determine the clamping force on the board A if the screw is tightened with a torque of M = 8 N·m. The square threaded screw has a mean radius of $r$ =10 mm and a lead of $l$ = 3 mm, and the coefficient of static friction is $\mu_s = 0.35$.




Check if screw is self-locking $\phi_s > \theta$

$$\phi_s = \tan^{-1}(\mu_s) = \tan^{-1}(0.35) = 19.29°$$

$$\theta = \tan^{-1}\left(\frac{l}{2r\pi}\right) = \tan^{-1}\left(\frac{3}{2(10)\pi}\right) = 2.734°$$

Since $\phi_s > \theta$, then we have a self-locking screw

Eq. of tightening

$$M = Wr\tan(\theta + \phi_s)$$

$$F = W = \frac{M}{r\tan(\theta + \phi_s)} = \frac{8}{0.01\tan(2.734 + 19.29)}$$

$$F = 1,978 \text{ N}$$