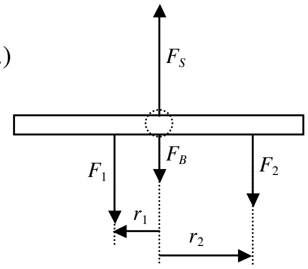
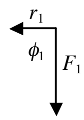
1.)

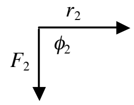


$F_B = 40\text{ N}$, $F_1 = 500\text{ N}$, and $F_2 = 350\text{ N}$

using the center of the board as a reference for torque $r_1 = 1.5\text{ m}$ and $r_B = r_S = 0$



$\phi_1 = 90°$

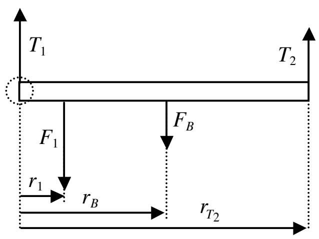


$\phi_2 = -90°$

conditions for static equilibrium are $\sum F_x = 0$, $\sum F_y = 0$, and $\sum \tau = 0$

if $\sum \tau = 0$ then $\tau_1 + \tau_2 = 0$ and $r_1 F_1 \sin\phi_1 + r_1 F_2 \sin\phi_2 = 0$ so $r_2 = \dfrac{-r_1 F_1 \sin\phi_1}{F_2 \sin\phi_2} = \dfrac{-(1.5\text{ m})(500\text{ N})\sin 90°}{(350\text{ N})\sin(-90°)} = \boxed{2.14\text{ m}}$

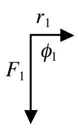
2.)



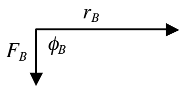
$F_B = 100\text{ N}$ and $F_1 = 400\text{ N}$

using the left end of the board as a reference for torque

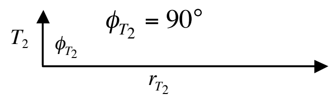
$r_1 = 2.0\text{ m}$, $r_B = 5.0\text{ m}$, $r_{T_2} = 10\text{ m}$, and $r_{T_1} = 0$



$\phi_1 = -90°$



$\phi_B = -90°$



$\phi_{T_2} = 90°$

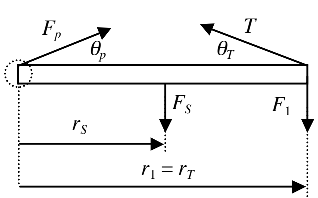
conditions for static equilibrium are $\sum F_x = 0$, $\sum F_y = 0$, and $\sum \tau = 0$

if $\sum \tau = 0$ then $\tau_1 + \tau_B + \tau_{T_2} = 0$ and $r_1 F_1 \sin\phi_1 + r_B F_B \sin\phi_B + r_{T_2} T_2 \sin\phi_{T_2} = 0$ so $T_2 = \dfrac{-r_1 F_1 \sin\phi_1 - r_B F_B \sin\phi_B}{r_{T_2} \sin\phi_{T_2}}$

$$T_2 = \frac{-(2.0\text{ m})(400\text{ N})\sin(-90°) - (5.0\text{ m})(100\text{ N})\sin(-90°)}{(10\text{ m})\sin 90°} = \boxed{130\text{ N}}$$

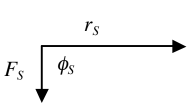
if $\sum F_y = 0$ then $T_1 + T_2 - F_1 - F_B = 0$ and $T_1 = F_1 + F_B - T_2 = 400\text{ N} + 100\text{ N} - 130\text{ N} = \boxed{370\text{ N}}$

3.)

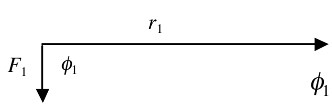


$F_S = 100\text{ N}$, $F_1 = 100\text{ N}$, $\theta_T = 30°$, and strut has length L

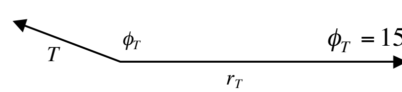
Using the left end of the board as a reference for torque $r_1 = r_T = L$ and $r_S = \dfrac{L}{2}$



$\phi_S = -90°$



$\phi_1 = -90°$



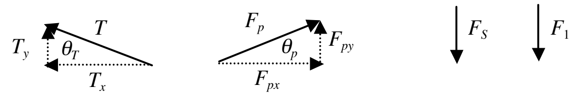
$\phi_T = 150°$

conditions for static equilibrium are $\sum F_x = 0$, $\sum F_y = 0$, and $\sum \tau = 0$

if $\sum \tau = 0$ then $\tau_1 + \tau_S + \tau_T = 0$ and $r_1 F_1 \sin\phi_1 + r_S F_S \sin\phi_S + r_T T \sin\phi_T = 0$ so $T = \dfrac{-r_1 F_1 \sin\phi_1 - r_S F_S \sin\phi_S}{r_T \sin\phi_T}$

$$T = \frac{-L(100\text{ N})\sin(-90°) - \left(\frac{L}{2}\right)(100\text{ N})\sin(-90°)}{L\sin 150°} = \frac{-(100\text{ N})\sin(-90°) - \left(\frac{1}{2}\right)(100\text{ N})\sin(-90°)}{\sin 150°} = \boxed{300\text{ N}}$$

3.) (continued) looking at all the forces (and their components) acting on the strut

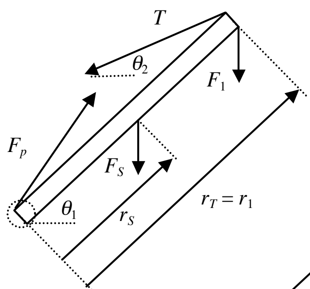


if $\sum F_x = 0$ then $F_{px} - T_x = 0$ and $F_{px} = T_x = T\cos\theta_T = (300\text{ N})\cos 30° = 260\text{ N}$

if $\sum F_y = 0$ then $F_{py} + T_y - F_S - F_1 = 0$ and $F_{py} = F_S + F_1 - T_y = 100\text{ N} + 100\text{ N} - (300\text{ N})\sin 30° = 50\text{ N}$

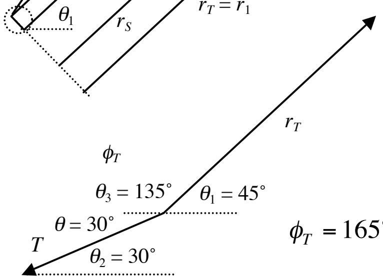
so $F_p = \sqrt{F_{px}^2 + F_{py}^2} = \sqrt{(260\text{ N})^2 + (50\text{ N})^2} = \boxed{265\text{ N}}$ and $\theta_p = \tan^{-1}\dfrac{F_{py}}{F_{py}} = \tan^{-1}\left(\dfrac{50\text{ N}}{260\text{ N}}\right) = \boxed{10.9°}$

4.)

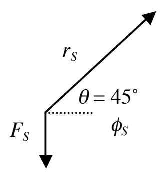


$F_S = 100\text{ N}$, $F_1 = 100\text{ N}$, $\theta_1 = 45°$, $\theta_2 = 30°$, and strut has length L

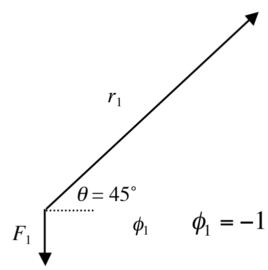
using the pivot point as a reference for torque $r_T = r_1 = L$ and $r_S = \dfrac{L}{2}$



$\phi_T = 165°$



$\phi_S = -135°$



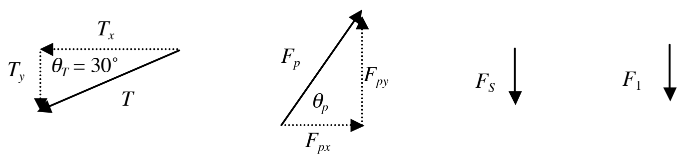
$\phi_1 = -135°$

conditions for static equilibrium are $\sum F_x = 0$, $\sum F_y = 0$, and $\sum \tau = 0$

if $\sum \tau = 0$ then $\tau_1 + \tau_S + \tau_T = 0$ and $r_1 F_1 \sin\phi_1 + r_S F_S \sin\phi_S + r_T T \sin\phi_T = 0$ so $T = \dfrac{-r_1 F_1 \sin\phi_1 - r_S F_S \sin\phi_S}{r_T \sin\phi_T}$

$$T = \frac{-L(100\text{ N})\sin(-135°) - \left(\frac{L}{2}\right)(100\text{ N})\sin(-135°)}{L\sin 165°} = \frac{-(100\text{ N})\sin(-135°) - \left(\frac{1}{2}\right)(100\text{ N})\sin(-135°)}{\sin 165°} = \boxed{410\text{ N}}$$

looking at all the forces (and their components) acting on the strut

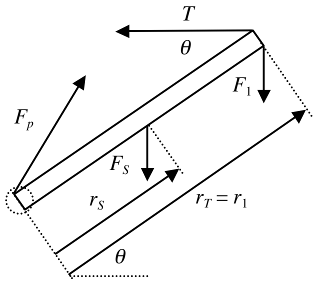


if $\sum F_x = 0$ then $F_{px} - T_x = 0$ and $F_{px} = T_x = T\cos\theta_T = (410\text{ N})\cos 30° = 355\text{ N}$

if $\sum F_y = 0$ then $F_{py} - T_y - F_S - F_1 = 0$ and $F_{py} = F_S + F_1 - T_y = 100\text{ N} + 100\text{ N} + (410\text{ N})\sin 30° = 405\text{ N}$

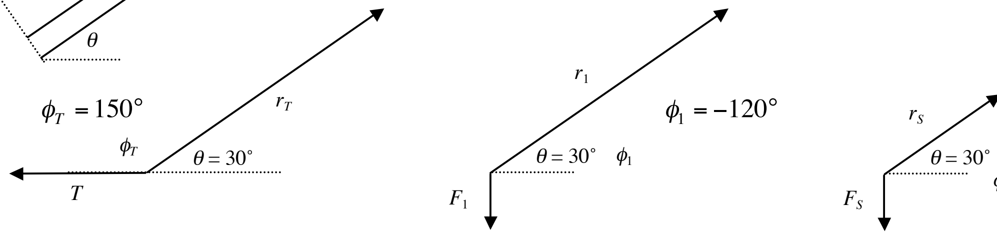
so $F_p = \sqrt{F_{px}^2 + F_{py}^2} = \sqrt{(355\text{ N})^2 + (405\text{ N})^2} = \boxed{539\text{ N}}$ and $\theta_p = \tan^{-1}\dfrac{F_{py}}{F_{py}} = \tan^{-1}\left(\dfrac{405\text{ N}}{355\text{ N}}\right) = \boxed{48.8°}$

5.)



$F_S = 100\text{ N}$, $F_1 = 100\text{ N}$, $\theta = 30°$, and strut has length L

using the pivot point as a reference for torque $r_T = r_1 = L$ and $r_S = \dfrac{L}{2}$



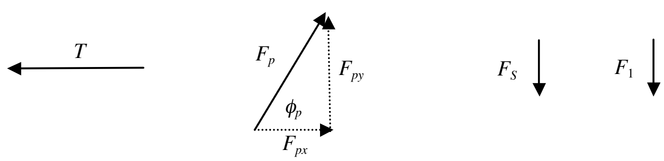
$\phi_T = 150°$ $\qquad$ $\phi_1 = -120°$ $\qquad$ $\phi_S = -120°$

conditions for static equilibrium are $\sum F_x = 0$, $\sum F_y = 0$, and $\sum \tau = 0$

if $\sum \tau = 0$ then $\tau_1 + \tau_S + \tau_T = 0$ and $r_1 F_1 \sin\phi_1 + r_S F_S \sin\phi_S + r_T T \sin\phi_T = 0$ so $T = \dfrac{-r_1 F_1 \sin\phi_1 - r_S F_S \sin\phi_S}{r_T \sin\phi_T}$

$$T = \frac{-L(100\text{ N})\sin(-120°) - \left(\frac{L}{2}\right)(100\text{ N})\sin(-120°)}{L\sin 150°} = \frac{-(100\text{ N})\sin(-120°) - \left(\frac{1}{2}\right)(100\text{ N})\sin(-120°)}{\sin 150°} = \boxed{260\text{ N}}$$

looking at all the forces (and their components) acting on the strut

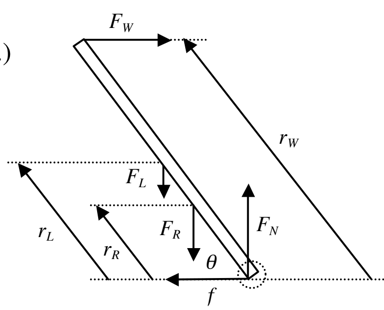


if $\sum F_x = 0$ then $F_{p_x} - T = 0$ and $F_{p_x} = T = 260\text{ N}$

if $\sum F_y = 0$ then $F_{p_y} - F_S - F_1 = 0$ and $F_{p_y} = F_S + F_1 = 100\text{ N} + 100\text{ N} = 200\text{ N}$

so $F_p = \sqrt{F_{p_x}^2 + F_{p_y}^2} = \sqrt{(260\text{ N})^2 + (200\text{ N})^2} = \boxed{328\text{ N}}$ and $\theta_p = \tan^{-1}\dfrac{F_{p_y}}{F_{p_y}} = \tan^{-1}\left(\dfrac{200\text{ N}}{260\text{ N}}\right) = \boxed{37.6°}$

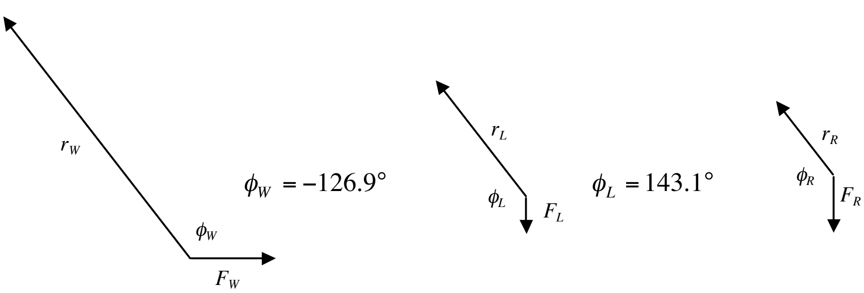
6.)



$F_L = 180\text{ N}$, $F_R = 800\text{ N}$, $\theta = 53.1°$, ladder is 5.0 m long

using the base of the ladder as a reference for torque

$r_W = 5.0\text{ m}$, $r_L = 2.5\text{ m}$, and $r_R = \dfrac{5}{3}\text{ m}$



$\phi_W = -126.9°$ $\qquad$ $\phi_L = 143.1°$ $\qquad$ $\phi_R = 143.1°$

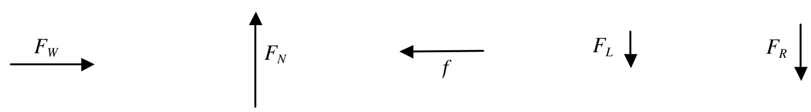
6.) (continued)

conditions for static equilibrium are $\sum F_x = 0$, $\sum F_y = 0$, and $\sum \tau = 0$

if $\sum \tau = 0$ then $\tau_W + \tau_L + \tau_R = 0$ and $r_W F_W \sin\phi_W + r_L F_L \sin\phi_L + r_R F_R \sin\phi_R = 0$ so $F_W = \dfrac{-r_L F_L \sin\phi_L - r_R F_R \sin\phi_R}{r_T \sin\phi_T}$

$$F_W = \frac{-(2.5\text{ m})(180\text{ N})\sin 143.1° - \left(\frac{5}{3}\text{ m}\right)(800\text{ N})\sin 143.1°}{(5.0\text{ m})\sin(-126.9°)} = 268\text{ N}$$

a.) looking at all forces acting on the ladder



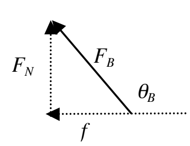
if $\sum F_x = 0$ then $F_W - f = 0$ and $f = F_W = \boxed{268\text{ N}}$

if $\sum F_y = 0$ then $F_N - F_L - F_R = 0$ and $F_N = F_L + F_R = 180\text{ N} + 800\text{ N} = \boxed{980\text{ N}}$

b.)

$$f = \mu F_N \text{ so } \mu = \frac{f}{F_N} = \frac{268\text{ N}}{980\text{ N}} = \boxed{0.27}$$

c.) the forces at the base are the frictional force f and the normal force F_N and they are orthogonal



$$F_B = \sqrt{f^2 + F_N^2} = \sqrt{(-268\text{ N})^2 + (980\text{ N})^2} = \boxed{1016\text{ N}}$$

$$\theta_B = \tan^{-1}\frac{F_N}{f} = \tan^{-1}\left(\frac{980\text{ N}}{-268\text{ N}}\right) = -74.7° + 180° = \boxed{105.3°}$$