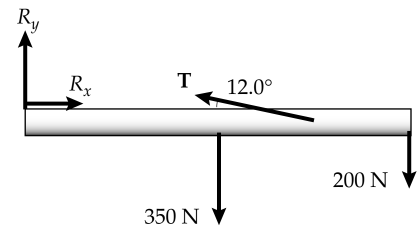
12.51 Choosing torques about **R**, with $\sum \tau = 0$,



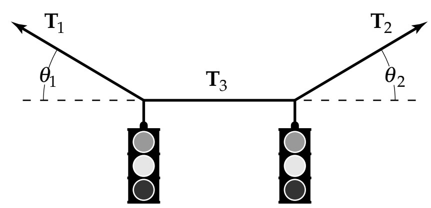
$$-\frac{L}{2}(350\text{ N}) + (T\sin 12.0°)\left(\frac{2L}{3}\right) - (200\text{ N})L = 0$$

From which, $T = \boxed{2.71\text{ kN}}$

Let R_x = compression force along spine, and from $\sum F_x = 0$,

$$R_x = T_x = T\cos 12.0° = \boxed{2.65\text{ kN}}$$

12.52 (a) Using the first diagram, $\sum F_x = 0$ gives



$$-T_1\cos\theta_1 + T_2\cos\theta_2 = 0$$

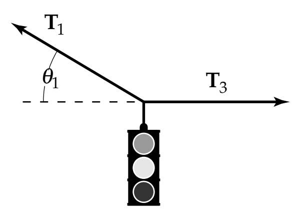
or $$T_2 = \left(\frac{\cos\theta_1}{\cos\theta_2}\right)T_1$$

If $\theta_1 = \theta_2$,

then $\boxed{T_2 = T_1}$

(b) Since $\theta_1 = \theta_2$, $T_2 = T_1$

Using the second diagram and $\sum F_y$ gives:



$$T_1\sin 8.00° - mg = 0 \quad \text{so}$$

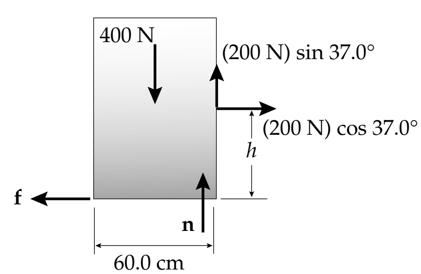
$$T_1 = \frac{200\text{ N}}{\sin 8.00°} = 1.44\text{ kN}$$

Then, $\boxed{T_2 = T_1 = 1.44\text{ kN}}$

Also, $\sum F_x = 0$ gives $-T_1\cos 8.00° + T_3 = 0$, or

$$T_3 = (1.44\text{ kN})\cos 8.00° = \boxed{1.42\text{ kN}}$$

12.53 (a) Locate the origin at the bottom left corner of the cabinet and let x = distance between the *resultant normal force* and the *front of the cabinet.* Then we have



(1) $\sum F_x = 200\cos(37.0°) - \mu n = 0$

(2) $\sum F_y = 200\sin(37.0°) + n - 400 = 0$, and

(3) $\sum \tau = n(0.600 - x) - 400(0.300) + 200\sin 37.0°(0.600) - 200\cos 37.0°(0.400) = 0$

From (2), $n = 400 - 200 \sin 37.0° = 280$ N

From (3), $x = \dfrac{[72.2 - 120 + 260(0.600) - 64.0]}{280} = \boxed{20.1 \text{ cm}}$ to the left of the front edge.

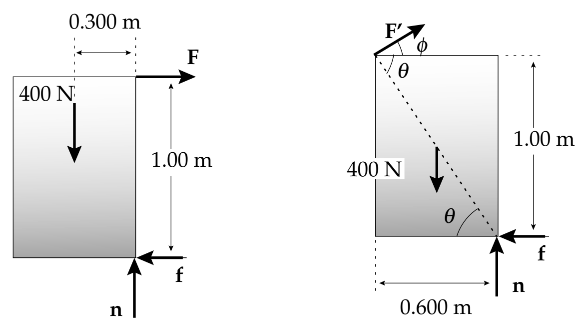
Then from (1), $\mu_k = \dfrac{200 \cos 37.0°}{280} = \boxed{0.571}$

(b) In this case, locate the origin $x = 0$ at the bottom right corner of the cabinet. Since the cabinet is about to tip, we can use $\sum\tau = 0$ to find h:

$$\sum\tau = 400(0.300) - 300 \cos 37.0°(h) = 0$$

$$h = \frac{120}{300 \cos 37.0°} = \boxed{0.501 \text{ m}}$$

12.54 (a) & (b) Use the first diagram and sum the torques about the lower front corner of the cabinet.



$$\sum\tau = 0 \Rightarrow -F(1.00 \text{ m}) + (400 \text{ N})(0.300 \text{ m}) = 0$$

yielding $F = \dfrac{(400 \text{ N})(0.300 \text{ m})}{1.00 \text{ m}} = \boxed{120 \text{ N}}$

$\sum F_x = 0 \Rightarrow -f + 120 \text{ N} = 0$, or $f = 120$ N

$\sum F_y = 0 \Rightarrow -400 \text{ N} + n = 0$, so $n = 400$ N

Thus, $\mu_s = \dfrac{f}{n} = \dfrac{120 \text{ N}}{400 \text{ N}} = \boxed{0.300}$

(c) Apply F' at the upper rear corner and directed so $\theta + \phi = 90.0°$ to obtain the largest possible lever arm.

$$\theta = \tan^{-1}\left(\frac{1.00 \text{ m}}{0.600 \text{ m}}\right) = 59.0°$$

Thus, $\phi = 90.0° - 59.0° = 31.0°$

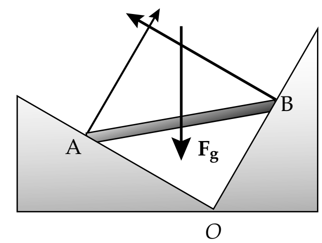
Sum the torques about the lower front corner of the cabinet:

$$-F'\sqrt{(1.00\text{ m})^2 + (0.600\text{ m})^2} + (400\text{ N})(0.300\text{ m}) = 0$$

so $F' = \dfrac{120\text{ N}\cdot\text{m}}{1.17\text{ m}} = 103\text{ N}$

Therefore, the minimum force required to tip the cabinet is
$\boxed{\text{103 N applied at 31.0° above the horizontal at the upper left corner}}$.

12.55 (a) Just three forces act on the rod: forces perpendicular to the sides of the trough at A and B, and its weight. The lines of action of A and B will intersect at a point above the rod. They will have no torque about this point. The rod's weight will cause a torque about the point of intersection as in Figure 1, and the rod will not be in equilibrium unless the center of the rod lies vertically below the intersection point, as in Figure 2. All three forces must be concurrent. Then the line of action of the weight is a diagonal of the rectangle formed by the trough and the normal forces, and the rod's center of gravity is vertically above the bottom of the trough.

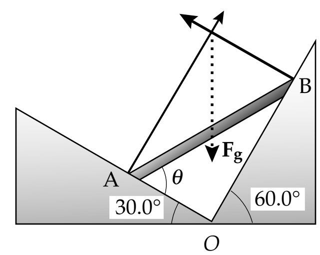


(b) In Figure 2, $\overline{AO}\cos 30.0° = \overline{BO}\cos 60.0°$ and

$$L^2 = \overline{AO}^{\,2} + \overline{BO}^{\,2} = \overline{AO}^{\,2} + \overline{AO}^{\,2}\left(\frac{\cos^2 30.0°}{\cos^2 60.0°}\right)$$

$$\overline{AO} = L/\sqrt{1 + \cos^2 30.0°/\cos^2 60.0°} = L/2$$

So $\cos\theta = \overline{AO}/L = 1/2$ and $\theta = \boxed{60.0°}$

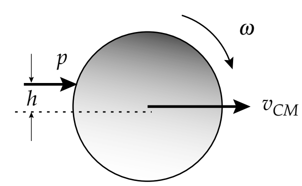


12.56 (1) $ph = I\omega$

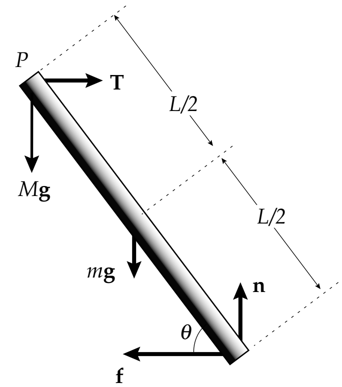
(2) $p = Mv_{CM}$

If the ball rolls without slipping, $R\omega = v_{CM}$

So, $h = \dfrac{I\omega}{p} = \dfrac{I\omega}{Mv_{CM}} = \dfrac{I}{MR} = \boxed{\dfrac{2}{5}R}$



12.57 (a) We can use $\Sigma F_x = \Sigma F_y = 0$ and $\Sigma\tau = 0$ with pivot point at the contact on the floor.



Then $\Sigma F_x = T - \mu_s n = 0$,

$$\Sigma F_y = n - Mg - mg = 0, \quad \text{and}$$

$$\Sigma\tau = Mg(L\cos\theta) + mg\left(\frac{L}{2}\cos\theta\right) - T(L\sin\theta) = 0$$

Solving the above equations gives

$$M = \boxed{\frac{m}{2}\left(\frac{2\mu_s\sin\theta - \cos\theta}{\cos\theta - \mu_s\sin\theta}\right)}$$

(b) At the floor, we have the normal force in the y-direction and frictional force in the x-direction. The reaction force then is

$$R = \sqrt{n + (\mu_s n)^2} = \boxed{(M+m)g\sqrt{1+\mu_s^2}}$$

At point P, the force of the beam on the rope is

$$F = \sqrt{T^2 + (Mg)^2} = \boxed{g\sqrt{M^2 + \mu_s^2(M+m)^2}}$$

Goal Solution

G: The solution to this problem is not as obvious as some other problems because there are three independent variables that affect the maximum mass M. We could at least expect that more mass can be supported for higher coefficients of friction (μ_s), larger angles (θ), and a more massive beam (m).

O: Draw a free-body diagram, apply Newton's second law, and sum torques to find the unknown forces for this statics problem.

A: (a) Use $\Sigma F_x = \Sigma F_y = \Sigma\tau = 0$ and choose the origin at the point of contact on the floor to simplify the torque analysis.

On the verge of slipping, the friction $f = \mu_s n$, and

$\Sigma F_x = 0$: $T - \mu_s n = 0$

$\Sigma F_y = 0$: $n - Mg - mg = 0$

Solving these two equations, $T = \mu_s g(M+m)$

From $\sum \tau = 0$, $Mg(\cos\theta)L + mg(\cos\theta)\dfrac{L}{2} - T(\sin\theta)L = 0$

where we have used L for the length of the beam.

Substituting for T, we get $M = \dfrac{m}{2}\left[\dfrac{2\mu_s \sin\theta - \cos\theta}{\cos\theta - \mu_s \sin\theta}\right]$

Notice that this result does not depend on L, which is reasonable since the center of mass of the beam is proportional to the length of the beam.

(b) At the floor, we see that the normal force is in the y direction and frictional force is in the x direction. The reaction force of the floor on the beam opposes these two forces and is

$$R = \sqrt{n^2 + (\mu_s n)^2} = g(M + m)\sqrt{1 + \mu_s^2}$$

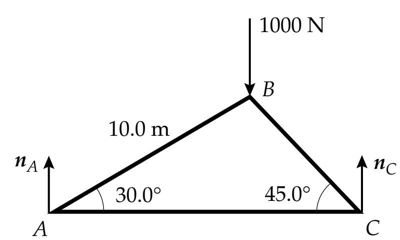
At point P, the force of the beam on the rope is

$$F = \sqrt{T^2 + (Mg)^2} = g\sqrt{M^2 + \mu_s^2 (M + m)^2}$$

L: The answer to this problem is certainly more complex than most problems. We can see that the maximum mass M that can be supported is proportional to m, but it is not clear from the solution that M increases proportional to μ_s and θ as predicted. To further examine the solution to part (a), we could graph or calculate the ratio M/m as a function of for several reasonable values of μ_s ranging from 0.5 to 1.0. Since the mass values must be positive, we find that only angles from about 40 to 60 are possible for this scenario (which explains why we don't encounter this precarious configuration very often!).

***12.58** (a) The height of pin B is

$$(10.0\text{ m})\sin 30.0° = 5.00\text{ m}$$



The length of bar BC is then

$$\overline{\text{BC}} = 5.00\text{ m}/\sin 45.0° = 7.07\text{ m}$$

Consider the entire truss:

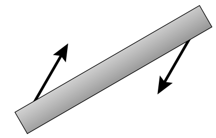
$$\sum F_y = n_A - 1000\text{ N} + n_C = 0$$

$$\sum \tau_A = -(1000\text{ N})10.0\cos 30.0° + n_C[10.0\cos 30.0° + 7.07\cos 45.0°] = 0$$

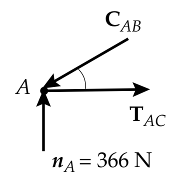
Which gives $\boxed{n_C = 634\text{ N}}$

Then, $\boxed{n_A = 1000\text{ N} - n_C = 366\text{ N}}$

(b) Suppose that a bar exerts on a pin a force not along the length of the bar. Then, the pin exerts on the bar a force with a component perpendicular to the bar. The only other force on the bar is the pin force on the other end. For $\Sigma \mathbf{F} = 0$, this force must also have a component perpendicular to the bar. Then, the total torque on the bar is not zero. The contradiction proves that the bar can only exert forces along its length.



(c) Joint A:



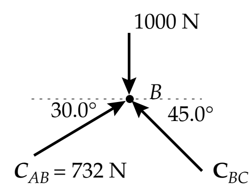
$\Sigma F_y = 0$: $-C_{AB} \sin 30.0° + 366 \text{ N} = 0$,

so $C_{AB} = \boxed{732 \text{ N}}$

$\Sigma F_x = 0$: $-C_{AB} \cos 30.0° + T_{AC} = 0$

$T_{AC} = (732 \text{ N}) \cos 30.0° = \boxed{634 \text{ N}}$

Joint B:

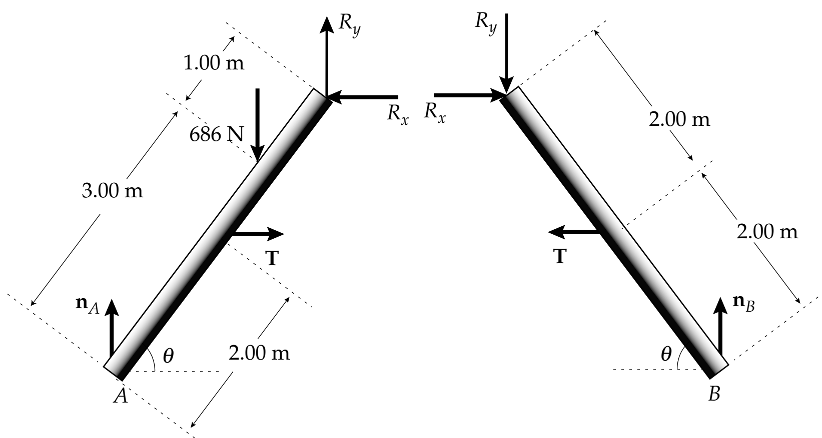


$\Sigma F_x = 0$: $(732 \text{ N}) \cos 30.0° - C_{BC} \cos 45.0° = 0$

$$C_{BC} = \frac{(732 \text{ N}) \cos 30.0°}{\cos 45.0°} = \boxed{897 \text{ N}}$$

12.59 From geometry, observe that

$$\cos \theta = \frac{1}{4} \quad \text{and} \quad \theta = 75.5°$$



For the left half of the ladder, we have

(1) $\Sigma F_x = T - R_x = 0$

(2) $\Sigma F_y = R_y + n_A - 686 \text{ N} = 0$

(3) $\Sigma \tau_{\text{top}} = (686 \text{ N})(1.00 \cos 75.5°) + T(2.00 \sin 75.5°) - n_A(4.00 \cos 75.5°) = 0$

For the right half of the ladder we have

$$\Sigma F_x = R_x - T = 0$$

(4) $\Sigma F_y = n_B - R_y = 0$

(5) $\Sigma \tau_{\text{top}} = n_B\,(4.00 \cos 75.5°) - T(2.00 \sin 75.5°) = 0$

Solving Equations 1 through 5 simultaneously yields:

(a) $\boxed{T = 133\text{ N}}$

(b) $\boxed{n_A = 429\text{ N}}$ and $\boxed{n_B = 257\text{ N}}$

(c) $\boxed{R_x = 133\text{ N}}$ and $\boxed{R_y = 257\text{ N}}$

12.60 (a) $x_{\text{CG}} = \dfrac{\Sigma m_i x_i}{\Sigma m_i}$

$$= \frac{(1000\text{ kg})10.0\text{ m} + (125\text{ kg})0 + (125\text{ kg})0 + (125\text{ kg})20.0\text{ m}}{1375\text{ kg}} = \boxed{9.09\text{ m}}$$

$$y_{\text{CG}} = \frac{(1000\text{ kg})10.0\text{ m} + (125\text{ kg})20.0\text{ m} + (125\text{ kg})20.0\text{ m} + (125\text{ kg})0}{1375\text{ kg}}$$

$$= \boxed{10.9\text{ m}}$$

(b) By symmetry, $x_{\text{CG}} = \boxed{10.0\text{ m}}$

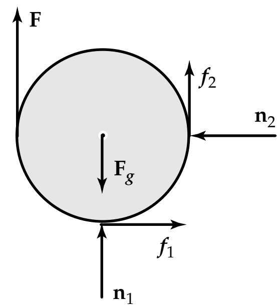
There is no change in $y_{\text{CG}} = \boxed{10.9\text{ m}}$

(c) $v_{\text{CG}} = \left(\dfrac{10.0\text{ m} - 9.09\text{ m}}{8.00\text{ s}}\right) = \boxed{0.114\text{ m/s}}$

12.61 Considering the torques about the point at the bottom of the bracket yields:

$(0.0500\text{ m})(80.0\text{ N}) - F(0.0600\text{ m}) = 0$ so $\boxed{F = 66.7\text{ N}}$

12.62 $f_1 = n_2 = \mu_s n_1$ and $f_2 = \mu_s n_2$



$F + n_1 + f_2 = F_g$ and $F = f_1 + f_2$

As F grows so do f_1 and f_2

Therefore, since $\mu_s = \dfrac{1}{2}$,

$$f_1 = \frac{n_1}{2} \quad \text{and} \quad f_2 = \frac{n_2}{2} = \frac{n_1}{4}$$

$$F + n_1 + \frac{n_1}{4} = F_g \ (1) \quad \text{and} \quad F = \frac{n_1}{2} + \frac{n_1}{4} = \frac{3}{4} n_1 \ (2)$$

$$F + \frac{5}{4} n_1 = F_g \quad \text{becomes} \quad F + \frac{5}{4}\left(\frac{4}{3} F\right) = F_g \quad \text{or} \quad \frac{8}{3} F = F_g$$

Therefore, $F = \boxed{\dfrac{3}{8} F_g}$

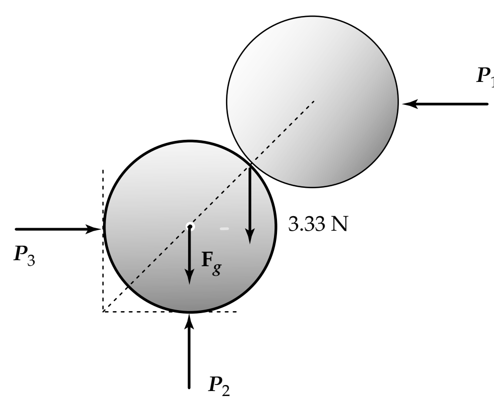
12.63 (a) $|F| = k(\Delta L)$, Young's modulus is $Y = \left(\dfrac{F}{A}\right) \Big/ \left(\dfrac{\Delta L}{L_i}\right) = \dfrac{F L_i}{A(\Delta L)}$

Thus, $Y = \dfrac{kL_i}{A}$ and $k = \boxed{\dfrac{YA}{L_i}}$

(b) $W = -\displaystyle\int_0^{\Delta L} F dx = -\int_0^{\Delta L} (-kx) dx = \frac{YA}{L_i} \int_0^{\Delta L} x \, dx =$

$$\boxed{YA \frac{(\Delta L)^2}{2L_i}}$$

12.64 (a) Take both balls together. Their weight is 3.33 N and their CG is at their contact point.



$\sum F_x = 0$: $+P_3 - P_1 = 0$

$\sum F_y = 0$: $+P_2 - 3.33 \text{ N} = 0 \quad P_2 = \boxed{3.33 \text{ N}}$

$\sum \tau_A = 0$: $-P_3 R + P_2 R - 3.33 \text{ N}(R + R \cos 45.0°)$

$$+ P_1(R + 2R \cos 45.0°) = 0$$

Substituting,

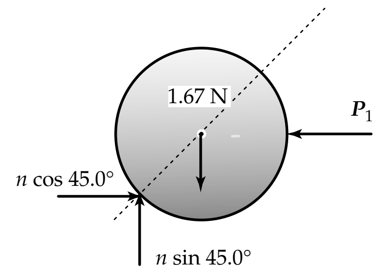
$$-P_1 R + (3.33 \text{ N})R - (3.33 \text{ N})R(1 + \cos 45.0°)$$

$$+ P_1 R(1 + 2 \cos 45.0°) = 0$$

$$(3.33 \text{ N}) \cos 45.0° = 2P_1 \cos 45.0°$$

$P_1 = \boxed{1.67\ \text{N}}$ so $P_3 = \boxed{1.67\ \text{N}}$

(b) Take the upper ball. The lines of action of its weight, of P_1, and of the normal force n exerted by the lower ball all go through its center, so for rotational equilibrium there can be no frictional force.

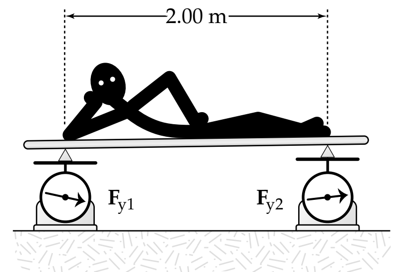


$$\sum F_x = 0: \; n\cos 45.0° - P_1 = 0$$

$$n = 1.67\text{ N}/\cos 45.0° = \boxed{2.36\text{ N}}$$

$$\sum F_y = 0: \; n\sin 45.0° - 1.67\text{ N} = 0 \text{ gives the same result}$$

12.65 $\sum F_y = 0: \quad +380\text{ N} - F_g + 320\text{ N} = 0$



$$F_g = 700\text{ N}$$

Take torques about her feet:

$$\sum \tau = 0: \quad -380\text{ N}(2.00\text{ m}) + 700\text{ N}(x) + 320\text{ N}(0) = 0$$

$$x = \boxed{1.09\text{ m}}$$

12.66 The tension in this cable is not uniform, so this becomes a fairly difficult problem.

$$\frac{dL}{L} = \frac{F}{YA}$$

At any point in the cable, F is the weight of cable below that point. Thus, $F = \mu g y$ where μ is the mass per unit length of the cable.

Then, $\Delta y = \int_0^{L_i} \left(\frac{dL}{L}\right) dy = \frac{\mu g}{YA}\int_0^{L_i} y\,dy \;= \frac{1}{2}\frac{\mu g L_i^2}{YA}$

$$\Delta y = \frac{1}{2}\frac{(2.40)(9.80)(500)^2}{(2.00\times 10^{11})(3.00\times 10^{-4})} = 0.0490\text{ m} = \boxed{4.90\text{ cm}}$$

12.67 (a) $F = m\left(\frac{\Delta v}{\Delta t}\right) = (1.00\text{ kg})\frac{(10.0 - 1.00)\text{ m/s}}{0.002\text{ s}} = \boxed{4500\text{ N}}$

(b) $\text{stress} = \frac{F}{A} = \frac{4500\text{ N}}{(0.010\text{ m})(0.100\text{ m})} = \boxed{4.50\times 10^6\text{ N/m}^2}$

(c) $\boxed{\text{Yes}}$ This is more than sufficient to break the board.

12.68 The CG lies above the center of the bottom. Consider a disk of water at height y above the bottom. Its radius is

$$25.0\text{ cm} + (35.0 - 25.0\text{ cm})\left(\frac{y}{30.0\text{ cm}}\right) = 25.0\text{ cm} + \frac{y}{3}$$

Its area is $\pi(25.0\text{ cm} + y/3)^2$. Its volume is $\pi(25.0\text{ cm} + y/3)^2 dy$ and its mass is $\pi\rho(25.0\text{ cm} + y/3)^2 dy$. The whole mass of the water is

$$M = \int_{y=0}^{30.0\text{ cm}} dm = \int_0^{30.0\text{ cm}} \pi\rho\,(625 + 50.0y/3 + y^2/9)\,dy$$

$$M = \pi\rho\,[625y + 50.0y^2/6 + y^3/27]_0^{30.0}$$

$$M = \pi\rho\,[625(30.0) + 50.0(30.0)^2/6 + (30.0)^3/27]$$

$$M = \pi(10^{-3}\text{ kg/cm}^3)(27250\text{ cm}^3) = 85.6\text{ kg}$$

The height of the center of gravity is

$$y_{CG} = \int_{y=0}^{30.0\text{ cm}} y\,dm/M$$

$$= \pi\rho\int_0^{30.0\text{ cm}} (625y + 50.0y^2/3 + y^3/9)dy/M$$

$$= \frac{\pi\rho}{M}\,[625y^2/2 + 50.0y^3/9 + y^4/36]_0^{30.0\text{ cm}}$$

$$= \frac{\pi\rho}{M}\,[625(30.0)^2/2 + 50.0(30.0)^3/9 + (30.0)^4/36]$$

$$= \frac{\pi(10^{-3}\text{ kg/cm}^3)}{M}\,[453750\text{ cm}^4]$$

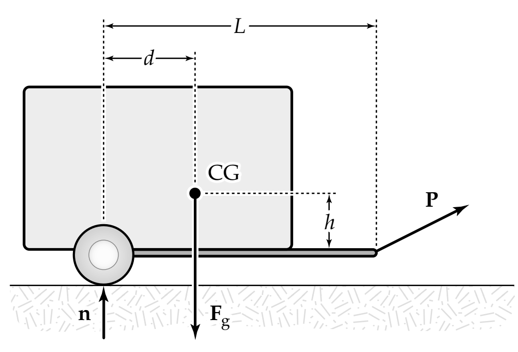
$$y_{CG} = \frac{1.43\times10^3\text{ kg}\cdot\text{cm}}{85.6\text{ kg}} = \boxed{16.7\text{ cm}}$$

12.69 (a) If the acceleration is a, we have $P_x = ma$ and $P_y + n - F_g = 0$. Taking the origin at the center of gravity, the torque equation gives

$$P_y(L-d) + P_x h - nd = 0$$

Solving these equations, we find

$$P_y = \boxed{\frac{F_g}{L}\left(d - \frac{ah}{g}\right)}$$

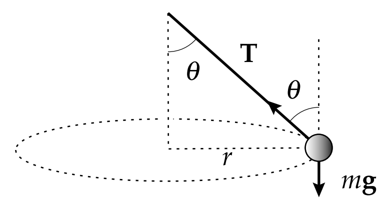


(b) If $P_y = 0$, then $d = \dfrac{ah}{g} = \dfrac{(2.00\text{ m/s}^2)(1.50\text{ m})}{9.80\text{ m/s}^2} = \boxed{0.306\text{ m}}$

(c) Using the given data, $P_x = -306$ N and $P_y = 553$ N

Thus, $\boxed{\mathbf{P} = (-306\mathbf{i} + 553\mathbf{j})\text{ N}}$

***12.70** Let θ represent the angle of the wire with the vertical. The radius of the circle of motion is $r = (0.850\text{ m})\sin\theta$.



For the mass:

$$\Sigma F_r = ma_r = m\frac{v^2}{r} = mr\omega^2$$

$$T\sin\theta = m\,[(0.850\text{ m})\sin\theta]\omega^2$$

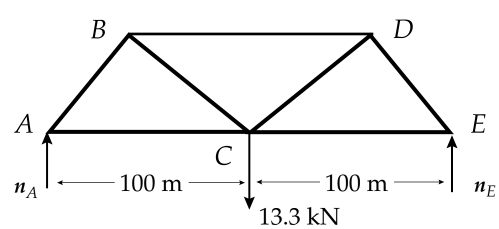
Further, $\dfrac{T}{A} = Y \cdot (\text{strain})$ or $T = AY \cdot (\text{strain})$

Thus, $AY \cdot (\text{strain}) = m(0.850\text{ m})\omega^2$, giving

$$\omega = \sqrt{\frac{AY \cdot (\text{strain})}{m(0.850\text{ m})}} = \sqrt{\frac{\pi(3.90\times10^{-4}\text{ m})^2(7.00\times10^{10}\text{ N/m}^2)(1.00\times10^{-3})}{(1.20\text{ kg})(0.850\text{ m})}}$$

or $\omega = \boxed{5.73\text{ rad/s}}$

***12.71** For the bridge as a whole:



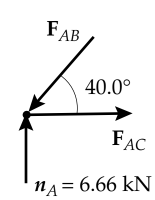
$$\Sigma\tau_A = n_A(0) - (13.3\text{ kN})(100\text{ m}) + n_E(200\text{ m}) = 0$$

so $n_E = \dfrac{(13.3\text{ kN})(100\text{ m})}{200\text{ m}} = \boxed{6.66\text{ kN}}$

$\Sigma F_y = n_A - 13.3\text{ kN} + n_E = 0$ gives

$n_A = 13.3\text{ kN} - n_E = \boxed{6.66\text{ kN}}$

At Pin A:



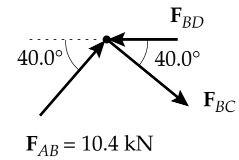
$\Sigma F_y = -F_{AB}\sin 40.0° + 6.66\text{ kN} = 0$ or

$$F_{AB} = \frac{6.66\text{ kN}}{\sin 40.0°} = \boxed{10.4\text{ kN (compression)}}$$

$\Sigma F_x = F_{AC} - (10.4\text{ kN})\cos 40.0° = 0$ so

$$F_{AC} = (10.4\text{ kN})\cos 40.0° = \boxed{7.94\text{ kN (tension)}}$$

At Pin B:



$$\Sigma F_y = (10.4 \text{ kN}) \sin 40.0° - F_{BC} \sin 40.0° = 0$$

Thus, $F_{BC} =$ $\boxed{10.4 \text{ kN (tension)}}$

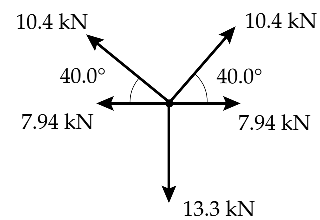
$$\Sigma F_x = F_{AB} \cos 40.0° + F_{BC} \cos 40.0° - F_{BD} = 0$$

$$F_{BD} = 2(10.4 \text{ kN}) \cos 40.0° = \boxed{15.9 \text{ kN (compression)}}$$

By symmetry: $\boxed{F_{DE} = F_{AB} = 10.4 \text{ kN (compression)}}$

$\boxed{F_{DC} = F_{BC} = 10.4 \text{ kN (tension)}}$

and $\boxed{F_{EC} = F_{AC} = 7.94 \text{ kN (tension)}}$



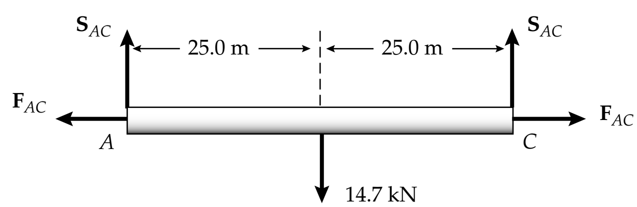
We can check by analyzing Pin C:

$$\Sigma F_x = +7.94 \text{ kN} - 7.94 \text{ kN} = 0 \quad \text{or} \quad 0 = 0$$

$$\Sigma F_y = 2(10.4 \text{ kN}) \sin 40.0° - 13.3 \text{ kN} = 0$$

which yields 0 = 0

***12.72** Member AC is not in pure compression or tension. It also has shear forces present. It exerts a downward force S_{AC} and a tension force F_{AC} on Pin A and on Pin C. Still, this member is in equilibrium.



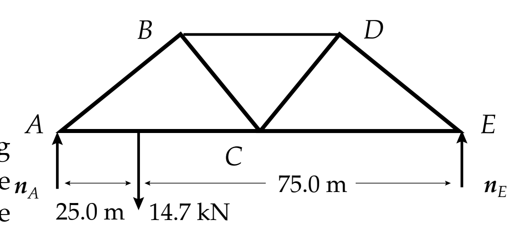
$$\Sigma F_x = F_{AC} - F'_{AC} = 0 \Rightarrow F_{AC} = F'_{AC}$$

$$\Sigma \tau_A = 0:$$

$$-(14.7 \text{ kN})(25.0 \text{ m}) + S'_{AC}(50.0 \text{ m}) = 0$$

or $S'_{AC} = 7.35$ kN

$$\Sigma F_y = S_{AC} - 14.7 \text{ kN} + 7.35 \text{ kN} = 0 \Rightarrow S_{AC} = 7.35$$
kN



Then $S_{AC} = S'_{AC}$ and we have proved that the loading by the car is equivalent to one-half the weight of the car pulling down on each of pins A and C, so far as the rest of the truss is concerned.

For the Bridge as a whole: $\sum \tau_A = 0$:

$$-(14.7\text{ kN})(25.0\text{ m}) + n_E(100\text{ m}) = 0$$

$$\boxed{n_E = 3.67\text{ kN}}$$

$$\sum F_y = n_A - 14.7\text{ kN} + 3.67\text{ kN} = 0$$

$$\boxed{n_A = 11.0\text{ kN}}$$

At Pin A:

$$\sum F_y = -7.35\text{ kN} + 11.0\text{ kN} - F_{AB}\sin 30.0° = 0$$

$$\boxed{F_{AB} = 7.35\text{ kN (compression)}}$$

$$\sum F_x = F_{AC} - (7.35\text{ kN})\cos 30.0° = 0$$

$$\boxed{F_{AC} = 6.37\text{ kN (tension)}}$$

At Pin B:

$$\sum F_y = -(7.35\text{ kN})\sin 30.0° - F_{BC}\sin 60.0° = 0$$

$$\boxed{F_{BC} = 4.24\text{ kN (tension)}}$$

$$\sum F_x = (7.35\text{ kN})\cos 30.0° + (4.24\text{ kN})\cos 60.0° - F_{BD} = 0$$

$$\boxed{F_{BD} = 8.49\text{ kN (compression)}}$$

At Pin C:

$$\sum F_y = (4.24\text{ kN})\sin 60.0° + F_{CD}\sin 60.0° - 7.35\text{ kN} = 0$$

$$\boxed{F_{CD} = 4.24\text{ kN (tension)}}$$

$$\sum F_x = -6.37\text{ kN} - (4.24\text{ kN})\cos 60.0° + (4.24\text{ kN})\cos 60.0° + F_{CE} = 0$$

$$\boxed{F_{CE} = 6.37\text{ kN (tension)}}$$

At Pin E:

$$\sum F_y = -F_{DE}\sin 30.0° + 3.67\text{ kN} = 0$$

$$\boxed{F_{DE} = 7.35\text{ kN (compression)}}$$

or $\sum F_x = -6.37\text{ kN} - F_{DE}\cos 30.0° = 0$

which gives $F_{DE} = 7.35$ kN as before.