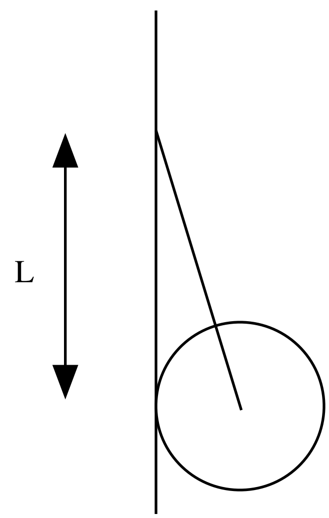
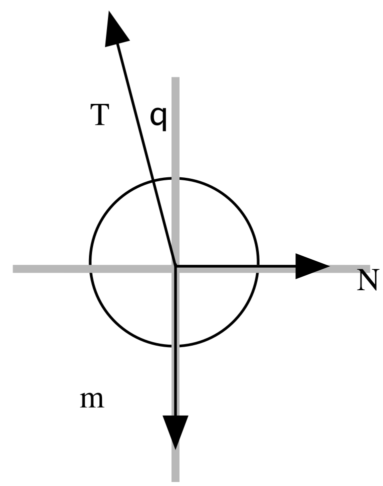
Chapter 12

12.5 In the figure, a uniform sphere of mass $m = 0.85kg$ and radius $r = 4.2cm$ is held in place by a massless rope attached to a frictionless wall of distance $L = 8.0cm$ above the center of the sphere. Find (a) the Tension in the cord and (b) the force of the sphere from the wall





$$\tan\theta = \frac{r}{L} \Rightarrow \theta = \tan^{-1}(\frac{r}{L}) = 27.70°$$

$y\,direction$

$$0 = T\cos\theta - mg$$

$$T = \frac{mg}{\cos\theta} = 9.41N$$

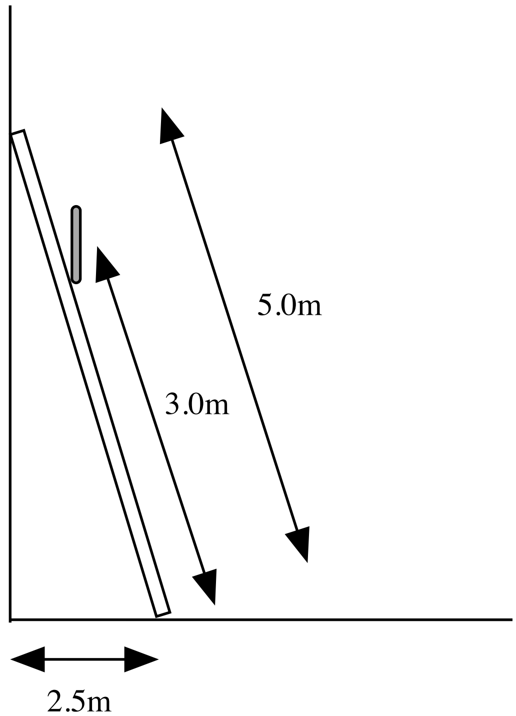
$x\ direction$

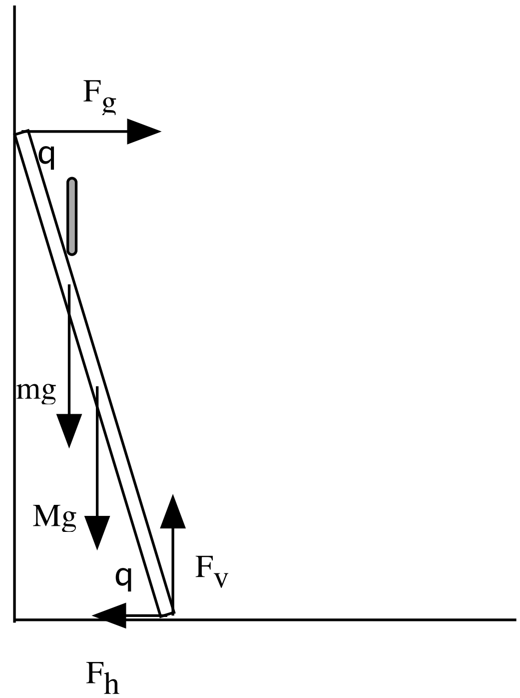
$$0 = N - T\sin\theta$$

$$N = T\sin\theta = 4.373N$$

12.9 A 75 kg window cleaner uses a 10 kg ladder that is 5.0 m long. He places one end on the ground 2.5 m from a a wall, rests the upper end against a cracked window and climbs the ladder. He is 3m up along the ladder when the window breaks. Neglect friction between the ladder and window and assume that the base of the ladder does not slip. When the window is on the verge of breaking, what are (a) the magnitude of the force on the window from the ladder, (b) the magnitude of the force on the ladder from the ground and (c)the angle (relative to the horizontal of that force on the ladder.

We definitely need a picture for this problem.





Since we don't know either of the forces at the base of the ladder we will choose that as our axis and compute the net torque. This will allow us to find the force on the glass. The net torque about the base of the ladder is

$$
\begin{aligned}
m &= 75kg \\
M &= 10kg \\
\cos\theta &= \frac{2.5}{5} \Rightarrow \theta = \cos^{-1}\frac{2.5}{5} = 60^\circ \\
\tau &= 0 = 5\cdot F_g \sin(180-\theta) - 3\cdot mg\cdot\sin(180-(90-\theta)) - 2.5\cdot Mg\cdot\sin(180-(90-\theta)) \\
0 &= 5\cdot F_g \sin(120) - 3\cdot mg\cdot\sin(150) - 2.5\cdot Mg\cdot\sin(150) \\
F_g &= \frac{3\cdot mg\cdot\sin(150) + 2.5\cdot Mg\cdot\sin(150)}{5\sin(120)} \\
&= 282.9N
\end{aligned}
$$

Now we consider the net force in the horizontal direction and the vertical direction.

$$
\begin{aligned}
&x\ direction \\
&0 = F_g - F_h \\
&F_h = F_g = 282.9N
\end{aligned}
$$

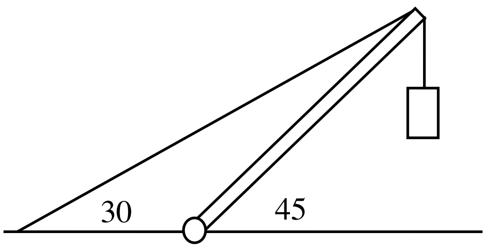
$$
\begin{aligned}
&y\ direction \\
&0 = F_v - mg - Mg \\
&F_v = mg + Mg \\
&\quad = 833N
\end{aligned}
$$

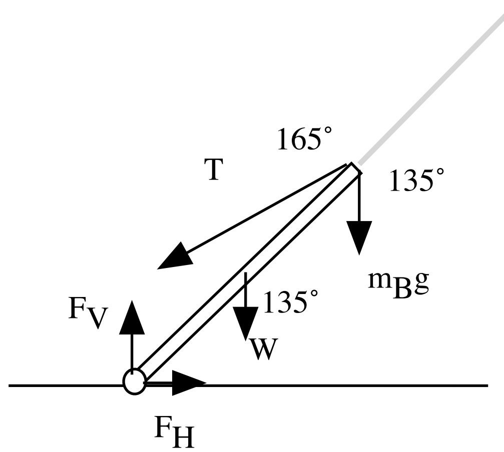
Now that we know the components, we can find magnitude and angle

$$F = \sqrt{282.9^2 + 833^2} = 879N$$

$$\varphi = \tan^{-1}\left(\frac{833}{282.9}\right) = 71°$$

12.27 The system in the figure is in equilibrium. A concrete block of mass 225 kg hangs from the end of the uniform strut whose mass is 45 kg. Find (a) the tension T in the cable and the (b) horizontal and (c) vertical force components on the strut from the hinge.





This problem is made more complicated by the geometry involved. We set the torque about the hinge to 0 Here W is the weight of the strut that acts at the center of mass.

$$0 = \frac{L}{2} \cdot W \cdot \sin 135 + L \cdot mg \cdot \sin 135 - L \cdot T \cdot \sin 165$$

$$T = \frac{\frac{L}{2} \cdot W \cdot \sin 135 + L \cdot mg \cdot \sin 135}{L \cdot \sin 165} = \frac{\frac{1}{2} \cdot W \cdot \sin 135 + mg \cdot \sin 135}{\sin 165}$$

$$= \frac{\frac{1}{2} \cdot 45kg \cdot 9.8m/s^2 \cdot \sin 135 + 225kg \cdot 9.8m/s^2 \cdot \sin 135}{\sin 165}$$

$$= 6626.6N$$

Now we can balance forces in each direction. Note: The angle between T and the horizontal direction is 30 degrees.

x direction

$$0 = F_H - T\cos 30$$

$$F_H = T\cos 30$$

$$= 6626.6\cos 30° = 5738.7N$$

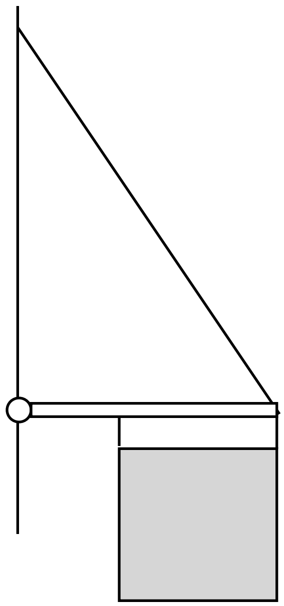
$$0 = F_V - W - m_B g - T\sin 30$$

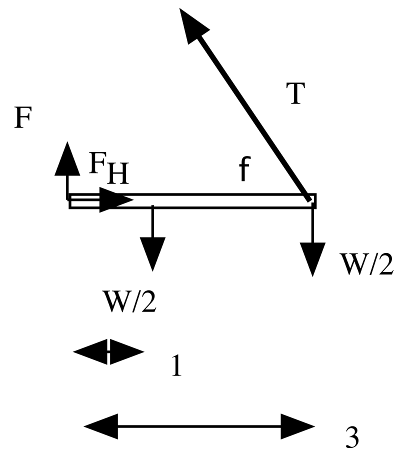
$$F_V = W + m_B g + T\sin 30$$

$$= 45kg \cdot 9.8m/s^2 + 225kg \cdot 9.8m/s^2 + 6626.6\sin 30$$

$$= 5959N$$

12.28 In the figure, a 50 kg uniform square sign, 2.00 m on a side, is hung from a 3.00 m horizontal rod of negligible mass. A cable is attached to the end of the rod and to a point on the wall 4.00 m above the point where the rod is hinged to the wall. (a) What is the tension in the cable? What are the magnitudes and directions of the (b) horizontal and (c) vertical components of the force on the rod from the wall?





a. To begin, we will compute the net torque about the hinge and set it equal to 0.

$$W = 50kg \cdot 9.8 = 490N$$

$$\tan\phi = \frac{4}{3} \Rightarrow \phi = 53.13°$$

$$\tau = rF\sin\theta$$

$$\tau = 0 = 1 \cdot \frac{W}{2}\sin 90° + 3 \cdot \frac{W}{2}\sin 90° - 3 \cdot T\sin(180 - \phi)$$

$$T = \frac{2W}{3\sin(180-\phi)} = \frac{2 \cdot 490N}{3\sin(180-53.13)} = 408.3N$$

b, c. We now use the total force in the x and y directions to compute forces due to the hinge.

x direction

$$0 = F_H - T\cos\phi$$

$$F_H = 408.3N\cos 53.3°$$

$$= 244.01N$$

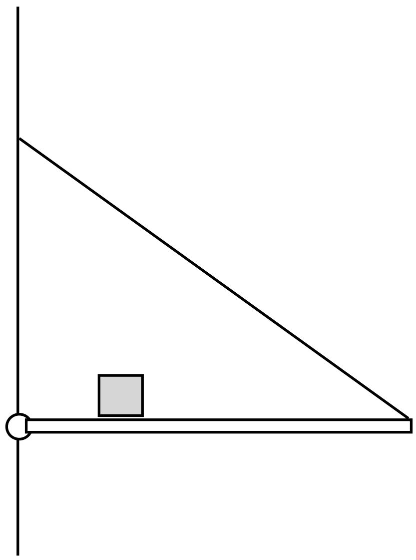
y direction

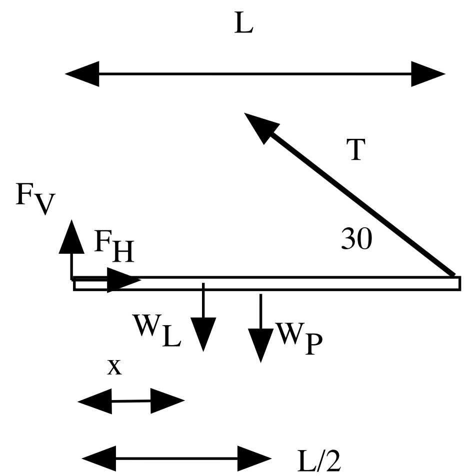
$$0 = F_V + T\sin\phi - W$$

$$F_F = W - T\sin\phi = 490N - 408.3\sin 53.13$$

$$= 162.63N$$

12.30 In Fig 13-39, suppose the length L of the uniform bar is 3m and its weight is 200N. Also, let the load's weight W=300N and the angle be 30 degrees. The wire can withstand a maximum tension of 500N. (a) What is the maximum possible distance x before the wire breaks? With the load placed at this maximum x, what are the (b) horizontal and (c) vertical components of the force on the bar from the hinge at A





a) We compute the torque about the hinge and set it equal to zero.

$$W_L = 300N$$
$$W_P = 200N$$
$$T = 500N$$

$$\tau = 0 = x \cdot W_L \cdot \sin 90 + \frac{L}{2} \cdot W_P \cdot \sin 90 - L \cdot T \sin(180-30)$$
$$= x \cdot W_L + \frac{L}{2} \cdot W_P - L \cdot T \sin(150)$$
$$x = \frac{L \cdot T \sin(150) - \frac{L}{2} \cdot W_P}{W_L} = \frac{3 \cdot 500 \sin(150) - \frac{3}{2} \cdot 200}{300}$$
$$= 1.5m$$

Now balance forces

x direction

$$0 = F_H - T\cos 30$$
$$F_H = T\cos 30 = 500N\cos 30$$
$$= 433N$$

y direction

$$0 = F_V + T\sin 30 - W_L - W_P$$
$$F_V = W_L + W_P - T\sin 30$$
$$= 300N + 200N - 500\sin 30$$
$$= 250N$$