12.6. A circular pizza of radius R has a circular piece of radius R/2 removed from one side. Clearly, the center of gravity has moved from C to C' along the x axis. Show that the distance from C to C' is R/6.

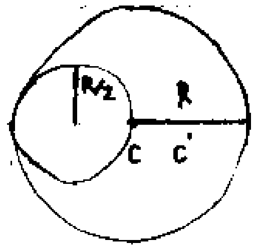
The hole we can count as negative mass

$$X_{CG} = \frac{m_1 X_1 - m_2 X_2}{m_1 - m_2}$$

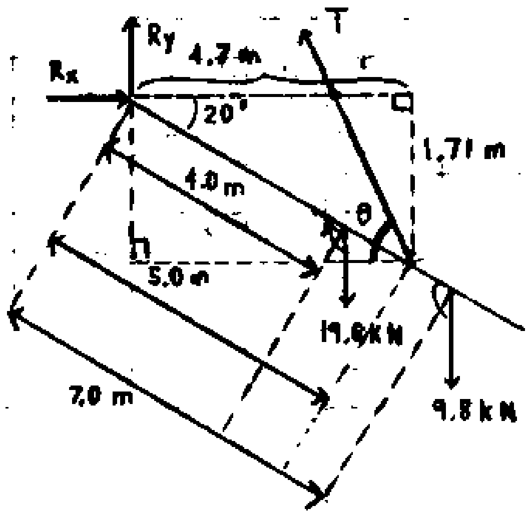
Call σ the mass of each unit of pizza area.

$$X_{CG} = \frac{\sigma \pi R^2\, 0 - \sigma \pi (R/2)^2 (-R/2)}{\sigma \pi R^2 - \sigma \pi (-R/2)^2}$$

$$X_{CG} = \frac{R/8}{1 - 1/4} = \frac{R/8}{3/4} = \frac{R}{6}$$

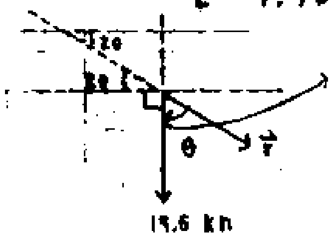


12.21.



Relative to the hinge end of the bridge, the cable is attached horizontally out a distance $x = (5.00\text{ m})\cos 20° = 4.70\text{ m}$ and vertically down a distance $y = (5.00\text{ m})\sin 20° = 1.71\text{ m}$. The cable then makes the following angle with the horizontal:

$$\theta = \tan^{-1}\left[\frac{(12.0 + 1.71)\text{ m}}{4.70\text{ m}}\right] = 71.1°$$



$20 + 90 + \theta = 180$
$\theta = 70$

(a) Determine the tension in the cable.

Take torques about the hinge end of the bridge

$R_x(0) + R_y(0) + 19.6\text{ kN}(4.0\text{ m})\sin(70) + (T\cos 71.7)(1.71\text{ m})\sin 90$
$+ T\sin(-71.7)(4.70\text{m}) + 9.8\text{ kN}(7.0\text{ m})\sin(70) = 0$

$19.6(4)\sin(70) + T(1.71)\cos 71.7 + T(4.7)\sin(-71.7) + 9.8(7)\sin(70) = 0$

$T = 35.5\text{ kN}$

(b) Determine the horizontal component acting on the bridge at the hinge.

$\Sigma F_x = 0$

$R_x - T\cos(71.7) = 0$

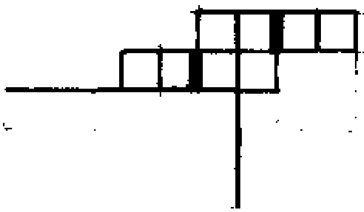
$R_x = (35.5\text{ kN})\cos 71.7 = 11.5\text{ kN}$ right

(c) vertical component

$\Sigma F_y = 0$

$R_y - 19.6\text{ kN} - 9.8\text{ kN} + T\sin 71.7 = -4.19\text{ kN}$

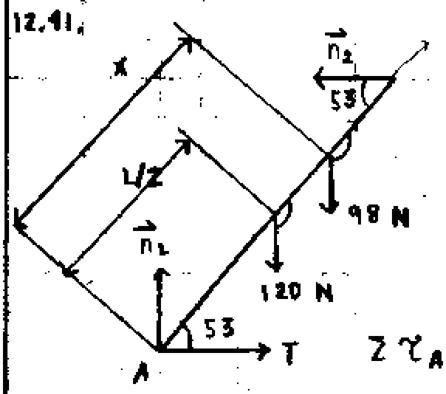
12.22. Two identical, uniform bricks of length L are placed in a stack over the edge of a horizontal surface such that the max possible overhang without falling is achieved. Find the distance x.



If the CM of the 2 bricks does not lie over the edge, then the bricks balance.

If the lower brick is placed L/4 over the edge, then the second brick may be placed so that its end protrudes 3L/4 over the edge. $x = \frac{3}{4}L$

12.41.



(a) Draw a free-body diagram for the ladder.

(b) Find the tension in the rope when the monkey is 1/3 the way up the ladder.

$\Sigma F_x = \Sigma F_y = \Sigma \tau = 0$ no linear and angular acceleration!

$\Sigma F_x = T - n_2 = 0$

$\Sigma F_y = n_1 - 218\ N = 0$

$\Sigma \tau_A = (98\ N)(x)\sin(90+53) + (120\ N)(L/2)\sin(90+53) + (n_2)(L)\sin[-(180-53)] = 0$

When $x = L/3$, the equation gives

$98(\cancel{L}/3)\cos 53 + 120(\cancel{L}/2)\cos 53 + T\cancel{L}\sin(-127) = 0$

$T = 69.8\ N$

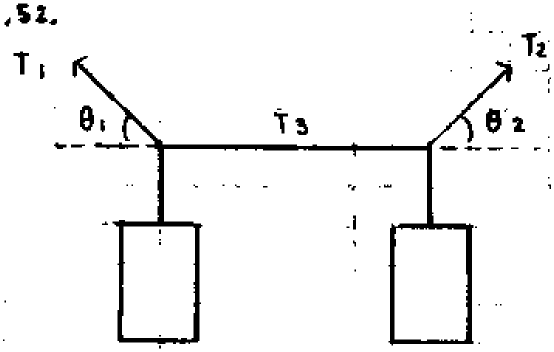
(c) Find the maximum distance d that the monkey can climb up the ladder before the rope breaks.

The rope breaks when $T = 110\ N = n_2$

$\Sigma \tau_A = (98)x\sin(90+53) + (120)(L/2)\sin(90+53) + (110)(L)\sin(-127) = 0$

$x = \dfrac{-(110)L\sin(-127) - (120)(L/2)\cos 53}{98\cos 53} = 0.877\ L$

12.52.



(a) Prove that if $\theta_1 = \theta_2$, then $T_1 = T_2$.

$\Sigma F_x = 0$ gives

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

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

If $\theta_1 = \theta_2$, then $T_2 = T_1$

(b) Determine the three tensions T_1, T_2, and T_3 if $\theta_1 = \theta_2 = 8.00°$

Since $\theta_1 = \theta_2$, $T_2 = T_1$

ΣF_y gives

$T_1 \sin 8.00 - mg = 0$

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

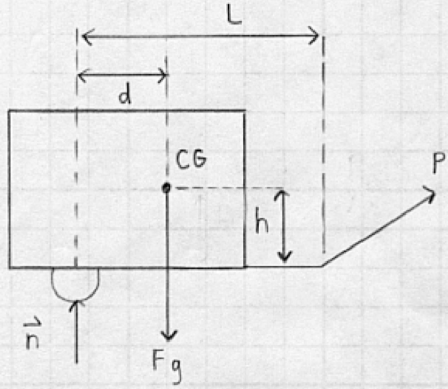
$T_2 = T_1 = 1.44\ kN$

$\Sigma F_x = 0$ gives

$-T_1 \cos 8.00 + T_3 = 0$

$T_3 = (1.44\ kN) \cos 8.00 = 1.42\ kN$

12.59. (a) Find the vertical component of $\vec{P}$ in terms of the given parameters.



$P_x = ma$

$P_y + n - F_g = 0$

Taking the origin at the center of gravity, the torque equation gives

$P_y (L-d) \sin 90 + P_x h \sin 90 + n d \sin(-90) = 0$

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

$P_y (L-d) + (ma) h + d (P_y - F_g) = 0$

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

(b) If $a = 2.00\ m/s^2$ and $h = 1.50\ m$, what must be the value of d so that $P_y = 0$ (that is, no vertical load on the vehicle)?

$$0 = \frac{F_g}{L}\left(d - \frac{ah}{g}\right)$$

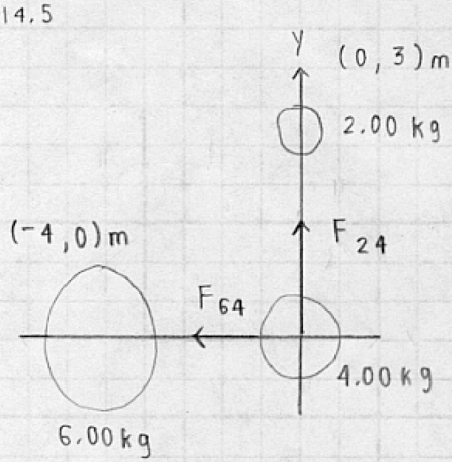
$$d = \frac{ah}{g} = \frac{(2.00\ m/s^2)(1.50\ m)}{9.8\ m/s^2} = 0.306\ m$$

(c) Find the values of P_x and P_y given that $F_g = 1,500\ N$, $d = 0.800\ m$, $L = 3.00\ m$, $h = 1.50\ m$, and $a = -2.00\ m/s^2$.

$$P_y = \frac{1,500\ N}{3.00 m}\left(0.8\ m - \frac{(-2.00 m/s^2)(1.5\ m)}{9.8\ m/s^2}\right) = 553\ N$$

$$P_x = ma = \frac{F_g a}{g} = \frac{(1500\ N)(-2.00\ m/s^2)}{9.8\ m/s^2} = -306\ N$$

14.5



The force exerted on the 4 kg mass by the 2 kg mass is directed upward and given by

$$F_{42} = G\frac{m_4 m_2}{r_{42}^2}\hat{j}$$

$$= \left(6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2}\right) \frac{(4\ kg)(2\ kg)}{(3\ m)^2}\hat{j}$$

$$= 5.93 \times 10^{-11}\ \hat{j}\ N$$

The force exerted on the 4 kg mass by the 6 kg mass is directed to the left

$$F_{46} = G\frac{m_4 m_6}{r_{46}^2}(-\hat{i})$$

$$= \left(-6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2}\right) \frac{(4\ kg)(6\ kg)}{(4\ m)^2}\hat{i}$$

$$= -10.0 \times 10^{-11}\ \hat{i}\ N$$

$$\vec{F}_4 = \vec{F}_{42} + \vec{F}_{46} = (-10.0\hat{i} + 5.93\hat{j}) \times 10^{-11}\ N$$