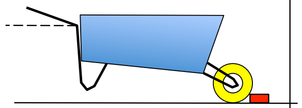
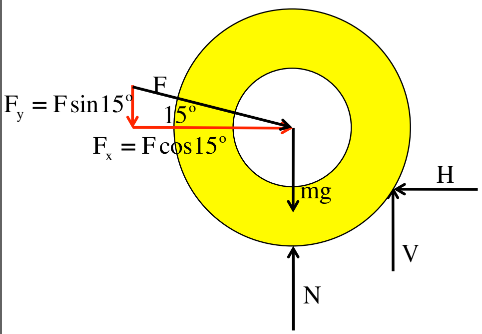
Problem 12.21

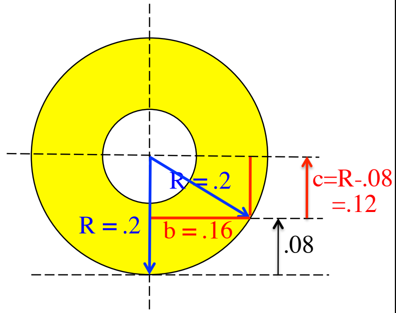
A wheel barrel is stopped by a brick.

a.) To push the barrel over the brick, what force must be applied at the handle?

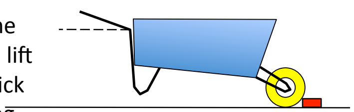


We need the forces acting on the wheel and some distances. With the force applied at the handle acting through the center of the wheel, an f.b.d. for the system (plus some components) is shown below with a “distances diagram” on the right.





The trick it to notice that the *normal force* at the ground goes to zero just as the barrel begins to lift of, and that summing the torques about the brick will eliminate the torques due to *H* and *V*. Using that information and N.S.L., we can write:



$\sum \Gamma_{brick}$:

$$\Gamma_H + \Gamma_V - F_x a + F_y b + mgb = I_{brick}\alpha \quad (\Gamma_H = 0,\ \Gamma_V = 0,\ \alpha = 0)$$

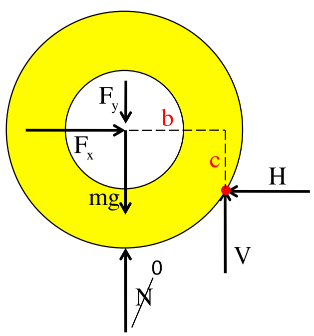
$$-\left(F\cos 15^\circ\right)c + \left(F\sin 15^\circ\right)b + mgb = 0$$

$$\Rightarrow \quad F\left(b\sin 15^\circ - a\cos 15^\circ\right) = -mgb$$

$$\Rightarrow \quad F = \frac{+mgb}{\left(c\cos 15^\circ - b\sin 15^\circ\right)}$$

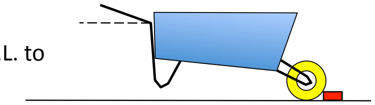
$$= \frac{\left(4.00\text{x}10^2\ \text{N}\right)(.16\ \text{m})}{\left((.12\ \text{m})\cos 15^\circ - (.16\ \text{m})\sin 15^\circ\right)}$$

$$= 859\ \text{N}$$



b.) Determine the forces at the brick.

These are just *H* and *V*, so we can use N.S.L. to determine them:



$\sum F_x$:

$$F\cos 15^\circ - H = ma_x \quad (a_x = 0)$$

$$\Rightarrow \quad H = (859\ \text{N})\cos 15^\circ$$

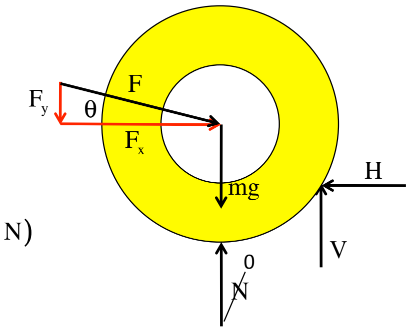
$$= 830\ \text{N}$$

$\sum F_y$:

$$-F\sin 15^\circ - mg + V = ma_y \quad (a_y = 0)$$

$$\Rightarrow \quad V = (859\ \text{N})\sin 15^\circ + (400\ \text{N})$$

$$= 622\ \text{N}$$



In polar notation (so we have the magnitude of the force), we get:

$$\vec{F}_{brick} = -(H)\hat{i} + (V)\hat{j}$$

$$= -(830\ \text{N})\hat{i} + (622\ \text{N})\hat{j}$$

$$= \left((-830\ \text{N})^2 + (622\ \text{N})^2\right)^{1/2} \measuredangle \left(\tan^{-1}\left(\frac{622}{-830}\right) + 180^\circ\right)$$

$$= \left(1.04\text{x}10^3\ \text{N}\right) \measuredangle 143^\circ$$