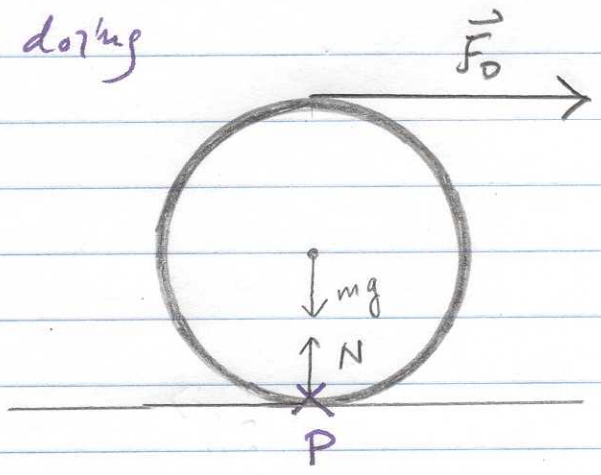
Sample Problem for S&B, Ch 11 P63_ (PS)

Exactly the same set up as P63, except that instead of a cylinder, we use a hoop. Note that we do not right now (at least without doing a bit more work) as to which direction the frictional force is going to act. So we have two choices.



#1/ calculate the torque about the instantaneous point of contact P.

Q. Why does that help? Ans. That helps because no matter which way f_s points, it is acting exactly at point P so applies a zero torque on the hoop, about point P. Now, let's use $\tau_{net,ext\,P} = I_P \alpha$

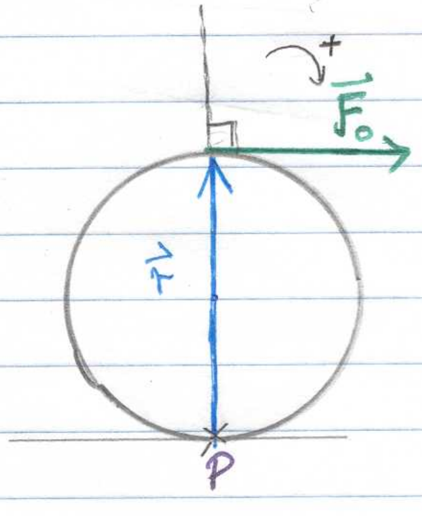
mg & N & f_s do not apply any torque about P.

Also, using the parallel axis theorem

$$I_P = I_{cm} + Mh^2 \quad , \quad h = R \text{ here so}$$

$$= MR^2 + MR^2$$

$$\Rightarrow \boxed{I_P = 2MR^2}$$



Now $\tau_{net,ext\,P} = I_P \alpha$

$$F_0 (2R) = (2MR^2)\alpha$$

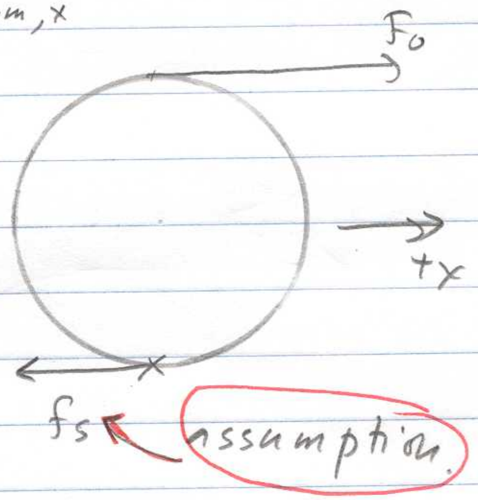
$$F_0 (\not{2}\not{R}) = (\not{2}M R^{\not{2}}) \frac{a_{cm}}{\not{R}}$$

$$\Rightarrow \boxed{F_0 = Ma_{cm}} \quad \text{eq 1.}$$

This result actually implies that f_s is in fact zero!

Because suppose we didn't know it was zero and we assumed that it acts in some direction, then we would've written: $F_{net,ext,x} = M a_{cm,x}$

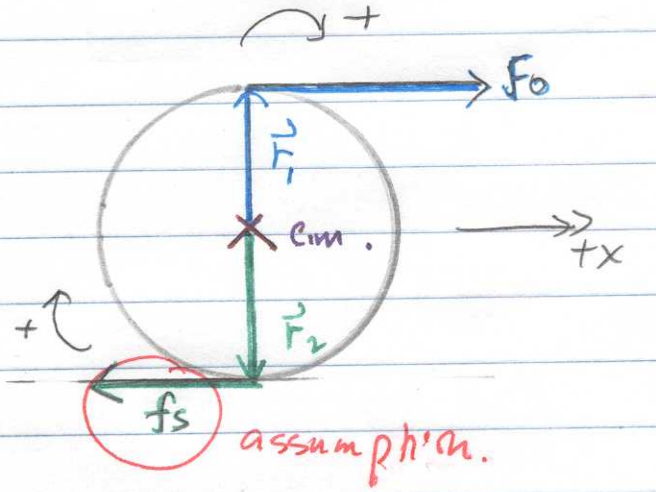
$$\Rightarrow \boxed{F_0 - f_s = M a_{cm}} \quad \text{eq 2.}$$



using eq1 & eq2. together

$$\left.\begin{aligned} F_0 &= M a_{cm} \\ F_0 - f_s &= M a_{cm} \end{aligned}\right\} \Rightarrow f_s = 0!$$

Now let's calculate torques about the center of mass.



$$\tau_{net,ext,cm} = I_{cm}\,\alpha$$

$$F_0 R + f_s R = M R^2 \alpha$$

$$F_0 R + f_s R = M R^2 \frac{a_{cm}}{R}$$

$$\Rightarrow \boxed{F_0 + f_s = M a_{cm}} \quad \text{eq 1.}$$

using $F_{net,ext,x} = M a_{cm,x}$

$$\boxed{F_0 - f_s = M a_{cm}} \quad \text{eq 2.}$$

Solving eq1 & eq2 simultaneously, we again find

$$\boxed{f_s = 0}$$

P.S: In problem 63, you can use either of these two choices. Just assume a direction for f_s — Do everything consistent with that assumption. If you find that f_s turns out to be negative, that means f_s is just acting in the opposite direction to what you assumed.