T6 Pr 12.25 & 26

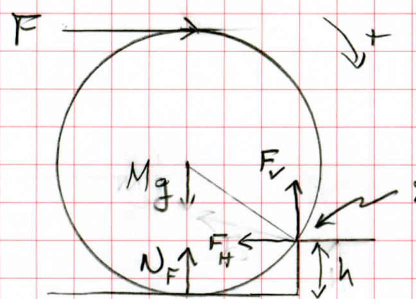
A horizontal force is applied to a cylinder against a step.

a) Show the force of the floor is $N_F = Mg - F\sqrt{\frac{2R-h}{h}}$.

b) Find F_H

c) Find F_V

d) Find F minimum that will roll cylinder up the step.



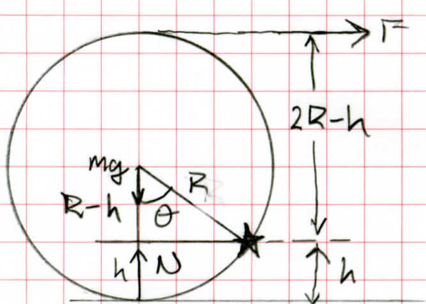
$\curvearrowright +$ Apply NSL to torques about ★

$$\Sigma \tau_\star = I\cancel{\alpha}^{0}$$

$$(2R-h)F + (R\sin\theta)N_F - (R\sin\theta)Mg = 0$$

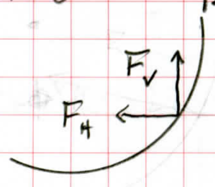
$$(2R-h)F + N_F R\sin\theta = RMg\sin\theta$$

$$(2R-h)F = (Mg - N_F)R\sin\theta$$



$$\cos\theta = \frac{R-h}{R}$$

$$\sin\theta = \frac{\sqrt{R^2-(R-h)^2}}{R}$$



Substituting for $\sin\theta$:

$$(2R-h)F = (Mg - N_F)\cancel{R}\frac{\sqrt{R^2-(R-h)^2}}{\cancel{R}}$$

$$(2R-h)F = (Mg-N_F)\sqrt{\cancel{R^2} - \cancel{R^2} + 2Rh - h^2}$$

$$(2R-h)F = (Mg - N_F)\sqrt{2Rh-h^2}$$

$$\cancel{(2R-h)}^{\sqrt{\ }}F = (Mg - N_F)\sqrt{h}\cancel{\sqrt{2R-h}}$$

$$\sqrt{2R-h}\,F = \sqrt{h}(Mg - N_F)$$

$$\boxed{N_F = Mg - \sqrt{\frac{2R-h}{h}}\,F}$$ QED!

b & c) Apply NSL to forces

$$\Sigma F_{HORIZ} = m\cancel{a}^{0}_{HORIZ}$$

$$F - F_H = 0$$

$$\boxed{F_H = F}$$

$$\Sigma F_{VERT} = m\cancel{a}^{0}_{VERT}$$

$$F_V + N_F - Mg = 0$$

$$F_V = Mg - N_F$$

$$\boxed{F_V = \sqrt{\frac{2R-h}{h}}\,F}$$

d) Find minimum F that will roll cylinder over step

$\Rightarrow N_F \to 0$ when cylinder rolls

$$N_F = Mg - \sqrt{\frac{2R-h}{h}}\, F_{MIN} = 0$$

$$F_{MIN} = \sqrt{\frac{h}{2R-h}}\, Mg$$

e) For $R = 10\text{cm}$, $h = 3\text{cm}$ and $M = 2\text{kg}$

$$F_{MIN} = \sqrt{\frac{3}{20-3}}\,(2)\,g = \boxed{\begin{array}{l} 0.84\,g = F_{MIN} \\ = 8.23\,N = F_{MIN} \end{array}}$$