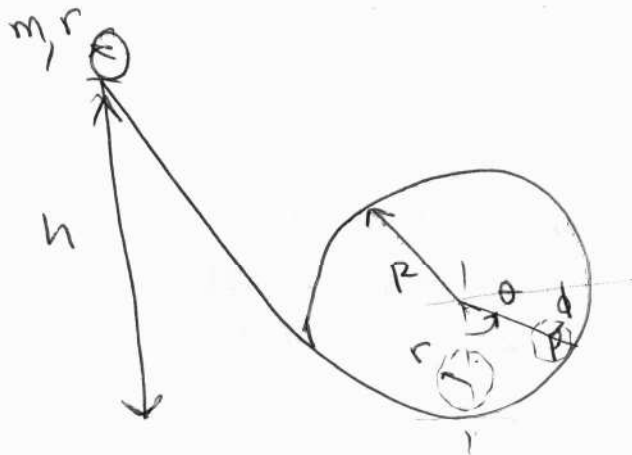


P4



$$\phi r = \theta R$$

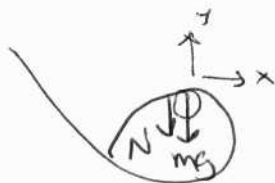
$$\Rightarrow \omega r = \dot{\theta} R$$

$$\text{r.s.i} \Rightarrow v = \omega r = \dot{\theta} R$$

(a) $I_{cm} = \frac{2}{5} m r^2$

$$\Rightarrow mgh = \frac{1}{2} m v^2 + \frac{1}{2} I_{cm} \omega^2 \Rightarrow v = \sqrt{\frac{2mgh}{m + \frac{I}{r^2}}} = \sqrt{\frac{10}{7} gh}$$

(b)



$$\Rightarrow N - mg = m a_y = -m r \dot{\theta}^2 = -\frac{v^2}{R} m$$

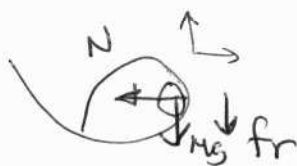
además, $mgh = \frac{1}{2} m v^2 + \frac{1}{2} \frac{2}{5} m r^2 \cdot \frac{v^2}{R^2} + mg(R-r) \cdot 2$

$$\Rightarrow v^2 = \frac{10}{7} [h - 2R + 2r] g$$

$$\Rightarrow \text{para } N=0 \Rightarrow mg = m \frac{10}{7} g [h - 2R + 2r] \frac{1}{R} \Rightarrow \frac{7}{10} R + 2R - 2r = h$$

$$\boxed{h = \frac{27}{10} R - 2r}$$

(c)



$$h = 3R$$

$$-N = m a_x = -\frac{m v^2}{R} = -\frac{m g \frac{10}{7}}{R} [h - R + r] = -\frac{m g \frac{10}{7}}{R} [2R + r]$$

$$\text{Energía } v^2 = \frac{10}{7} [h - R + r] g$$

$$\Rightarrow \boxed{N = \frac{m g \frac{10}{7}}{R} [2R + r]}$$

$$-f_r - mg = m a_y = m \frac{dv}{dt}$$

$$mgh = \frac{7}{10} m v^2 + mg(R-r)(1 - \cos \theta)$$

$$\frac{d(\cdot)}{dt} \Rightarrow 0 = \frac{7}{5} m v \frac{dv}{dt} + mg(R-r)(\sin \theta \dot{\theta}) = \frac{7}{5} m v \frac{dv}{dt} + mg(R-r)(1) \cdot \frac{v}{R} = 0$$

$$\Rightarrow \frac{dv}{dt} = -\frac{5}{7} g \frac{(R-r)}{R}$$

$$\Rightarrow f_r = -mg - m \frac{dv}{dt} = -mg \left[1 + \frac{5}{7} \left(\frac{R-r}{R} \right) \right] = \boxed{-mg \left[\frac{2R - 5r}{7R} \right] = f_r}$$