Nishant Jindal

Case of double drum

Cylinder-1

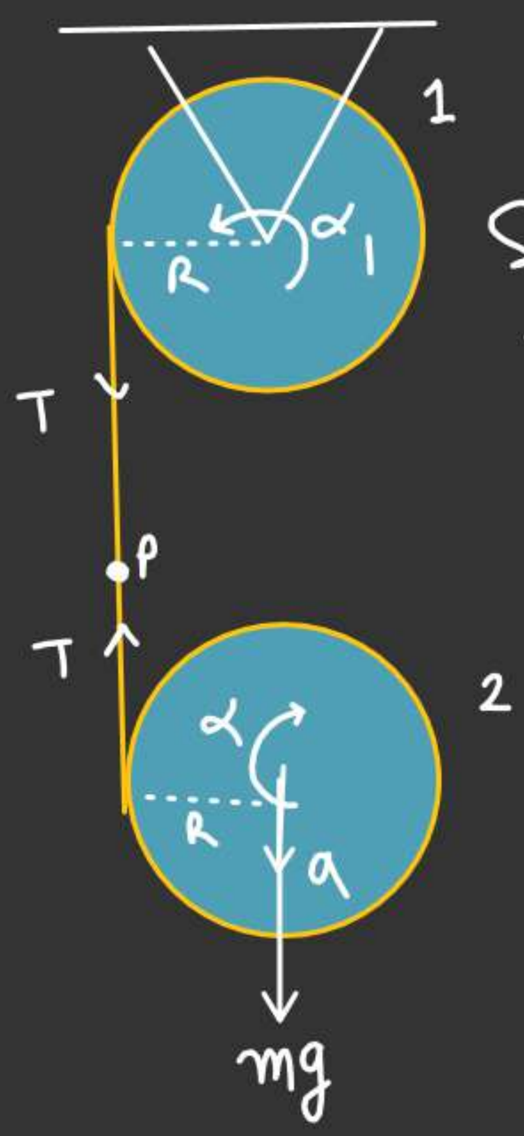
$$T.R = \frac{2mR^2}{2}\alpha_1 \quad - (1)$$

$$\hookrightarrow \alpha_1 = \frac{T}{mR}$$

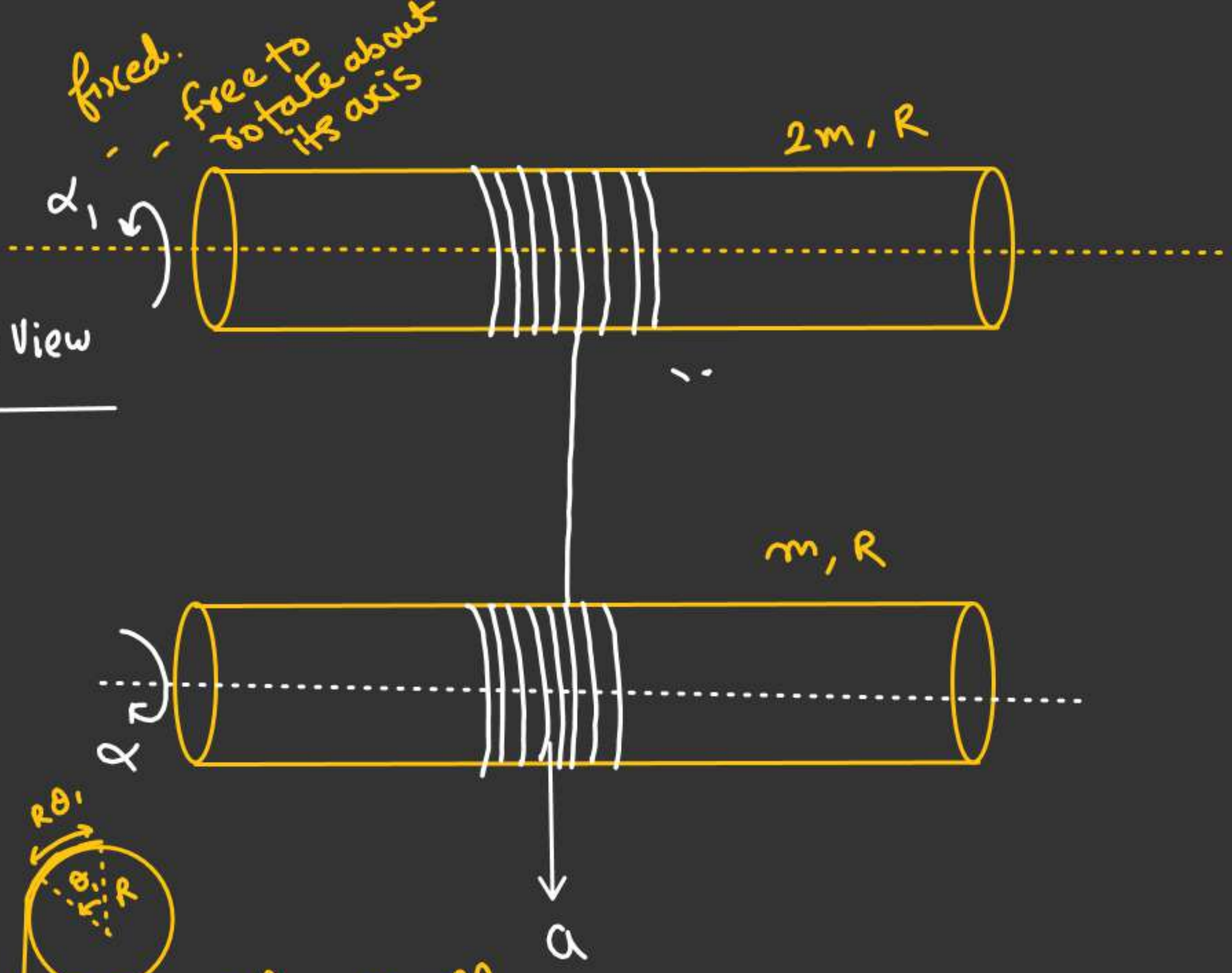
Cylinder- 2

$$mg - T = ma \quad - (2)$$

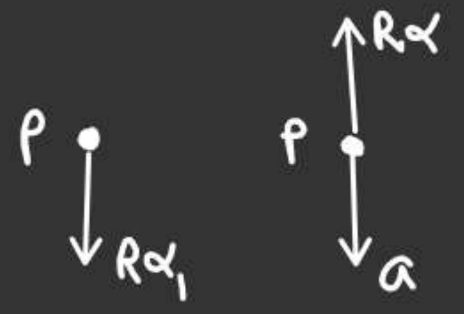
$$TR = \frac{mR^2}{2}\alpha \quad - (3)$$



Side View



Condition of No Slipping



$$R\alpha_1 = a - R\alpha \quad - (4)$$

$$R\left(\frac{T}{mR}\right) = \frac{(mg-T)}{m} - R\left(\frac{2T}{mR}\right)$$

$$\frac{T}{m} + \frac{T}{m} + \frac{2T}{m} = g$$

$$T = \left(\frac{mg}{4}\right)$$

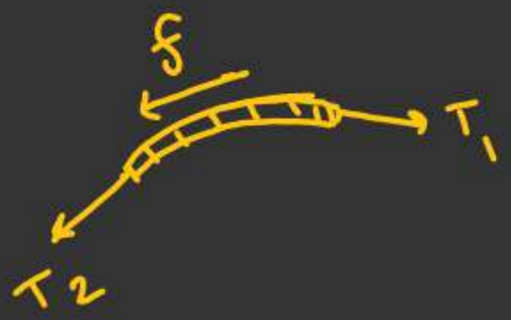
$$R\theta_1 = x - R\theta$$

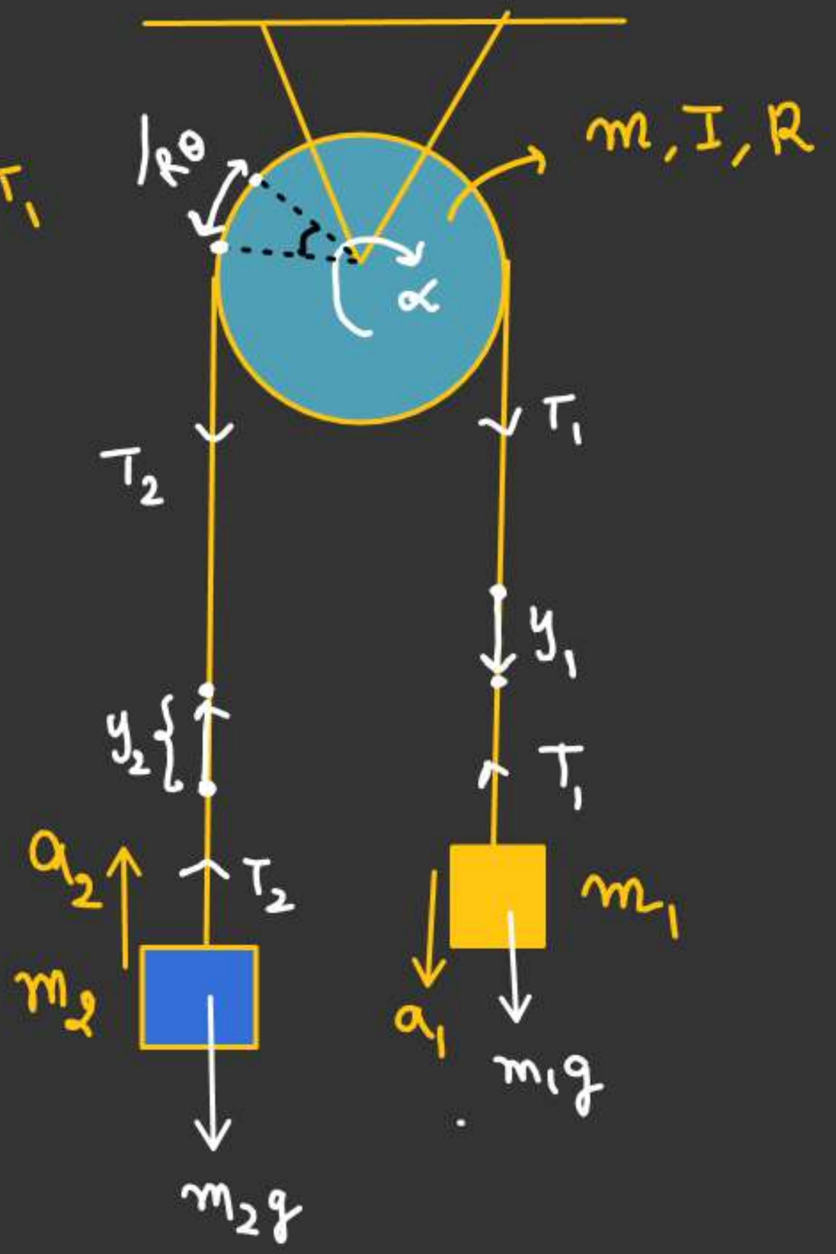
From 2

$$ma = mg - \frac{mg}{4}$$

$$a = \left(\frac{3g}{4}\right)$$

No Slipping of thread on the pully





For No Slipping

$$y_2 = y_1 = R\theta.$$

(Torque) $\boxed{a = a_2 = a_1 = R\alpha}$ — (1) $\quad \alpha = \frac{a}{R}$

$$T_1R - T_2R = I\alpha$$

$$T_1 - T_2 = \left(\frac{I\alpha}{R}\right) \quad \text{— (2)}$$

$$m_1 g - T_1 = m_1 a \quad \text{— (3)}$$

$$T_2 - m_2 g = m_2 a \quad \text{— (4)}$$

$$(T_2 - T_1) + (m_1 - m_2)g = (m_1 + m_2)a$$

$$\Downarrow$$

$$-\frac{I\alpha}{R} + (m_1 - m_2)g = (m_1 + m_2)a$$

$$-\frac{Ia}{R^2} + (m_1 - m_2)g = (m_1 + m_2)a$$

$$(m_1 - m_2)g = \left[(m_1 + m_2) + \frac{I}{R^2}\right]a$$

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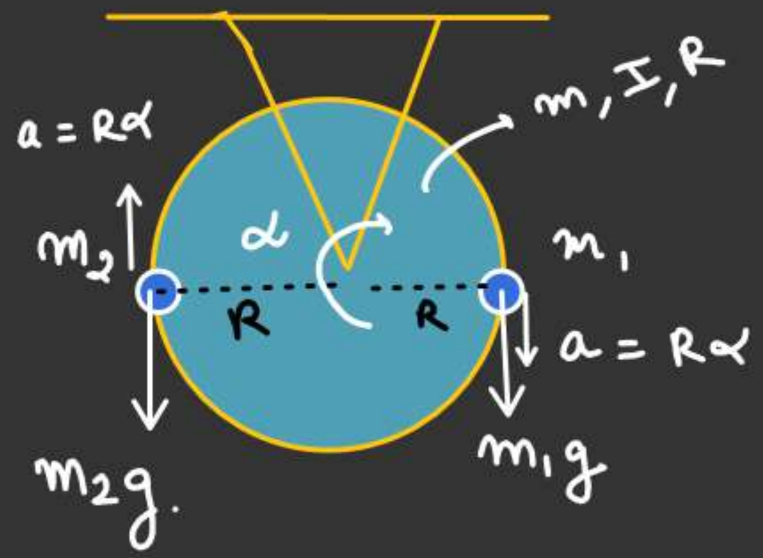
$$a = \left[\frac{(m_1 - m_2)g}{(m_1+m_2) + \frac{I}{R^2}}\right] \checkmark$$

M-2

$$a_1 = a_2 = a$$



$$\tau = I\alpha$$

$$m_1 g R - m_2 g \cdot R = \left[I + (m_1+m_2)R^2\right]\alpha$$

$$\alpha = \frac{(m_1 - m_2) g R}{I + (m_1+m_2)R^2}$$

$$\alpha = \frac{(m_1 - m_2) g}{R\left[\frac{I}{R^2} + m_1 + m_2\right]}$$

$$a = \alpha R = \left[\frac{(m_1 - m_2) g}{\frac{I}{R^2} + (m_1+m_2)}\right]$$

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Energy in Case of pure Rolling → $K.E = \left[\frac{1}{2} I_{com}\omega^2 + \frac{1}{2} M V_{com}^2\right]$

velocity of Smallar Sphere when it looses contact with bigger Sphere.

$$U_i + K.E_i = U_f + K.E_f$$

$$mg(R+r) + 0 = mg(R+r)\cos\theta + \frac{1}{2}Mv^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\omega^2 \quad -(1)$$

w.r.t C, G performing Circular Motion

$$mg\cos\theta - N = m\omega_1^2 (R+r)$$

At the time of loosing contact $N = 0$

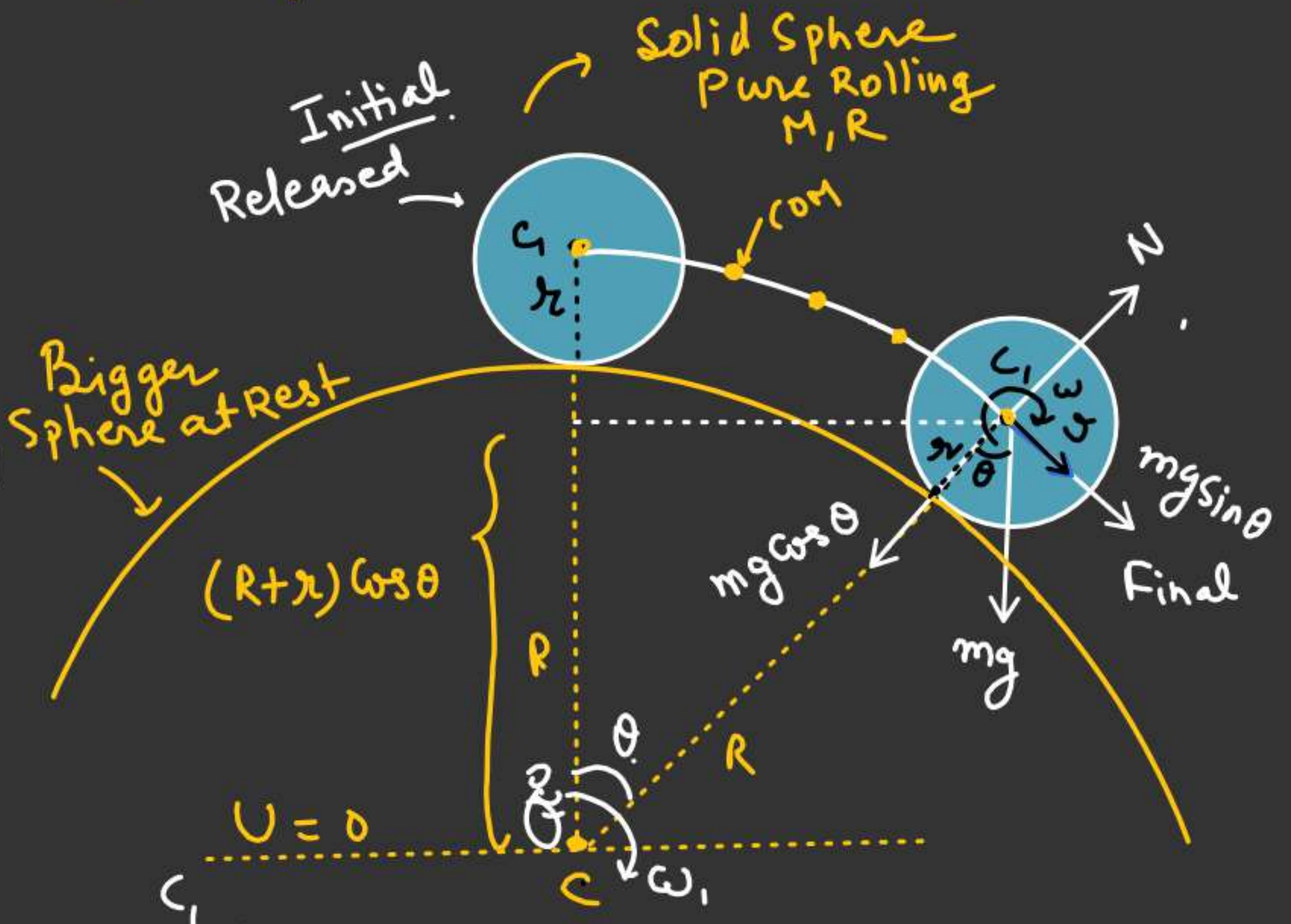
$$mg\cos\theta = m\omega_1^2 (R+r) \quad -(2)$$

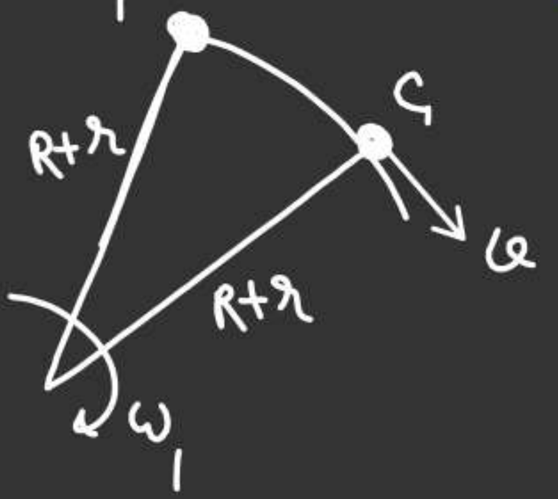
$$v = (R+r)\omega_1 \rightarrow (R+r)\omega_1 = r\omega$$

For pure Rolling

$$v = r\omega$$

$$\boxed{\omega_1 = \left(\frac{r\omega}{R+r}\right)}$$





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$$mg(R+r)+0 = mg(R+r)\cos\theta + \frac{1}{2}Mv^2 + \frac{1}{2}\left(\frac{2}{5}Mr^2\right)\omega^2 \quad -(1)$$

$$mg\cos\theta = m\omega_1^2(R+r) \quad -(2)$$

For pure Rolling

$$v=(R+r)\omega_1 \qquad v=r\omega$$

$$(R+r)\omega_1 = r\omega$$

$$\boxed{\omega_1=\left(\frac{r\omega}{R+r}\right)}$$

$$\omega=\frac{v}{R},\quad \omega_1=\left(\frac{v}{R+r}\right)$$

Put $mg\cos\theta = m\omega_1^2(R+r)$ in (1)

$$mg(R+r) = (R+r)m(R+r)\omega_1^2 + \frac{1}{2}mv^2 + \frac{mr^2}{5}\omega^2$$

$$mg(R+r) = m\cancel{(R+r)^2}\times\frac{v^2}{\cancel{(R+r)^2}} + \frac{mv^2}{2} + \frac{m\cancel{r^2}}{5}\times\frac{v^2}{\cancel{r^2}}$$

$$mg(R+r) = \left(mv^2+\frac{mv^2}{2}+\frac{mv^2}{5}\right)$$

$$mg(R+r) = \frac{10mv^2+5mv^2+2mv^2}{10} = \left(\frac{17mv^2}{10}\right)$$

$$\sqrt{\frac{10g(R+r)}{17}} = v$$

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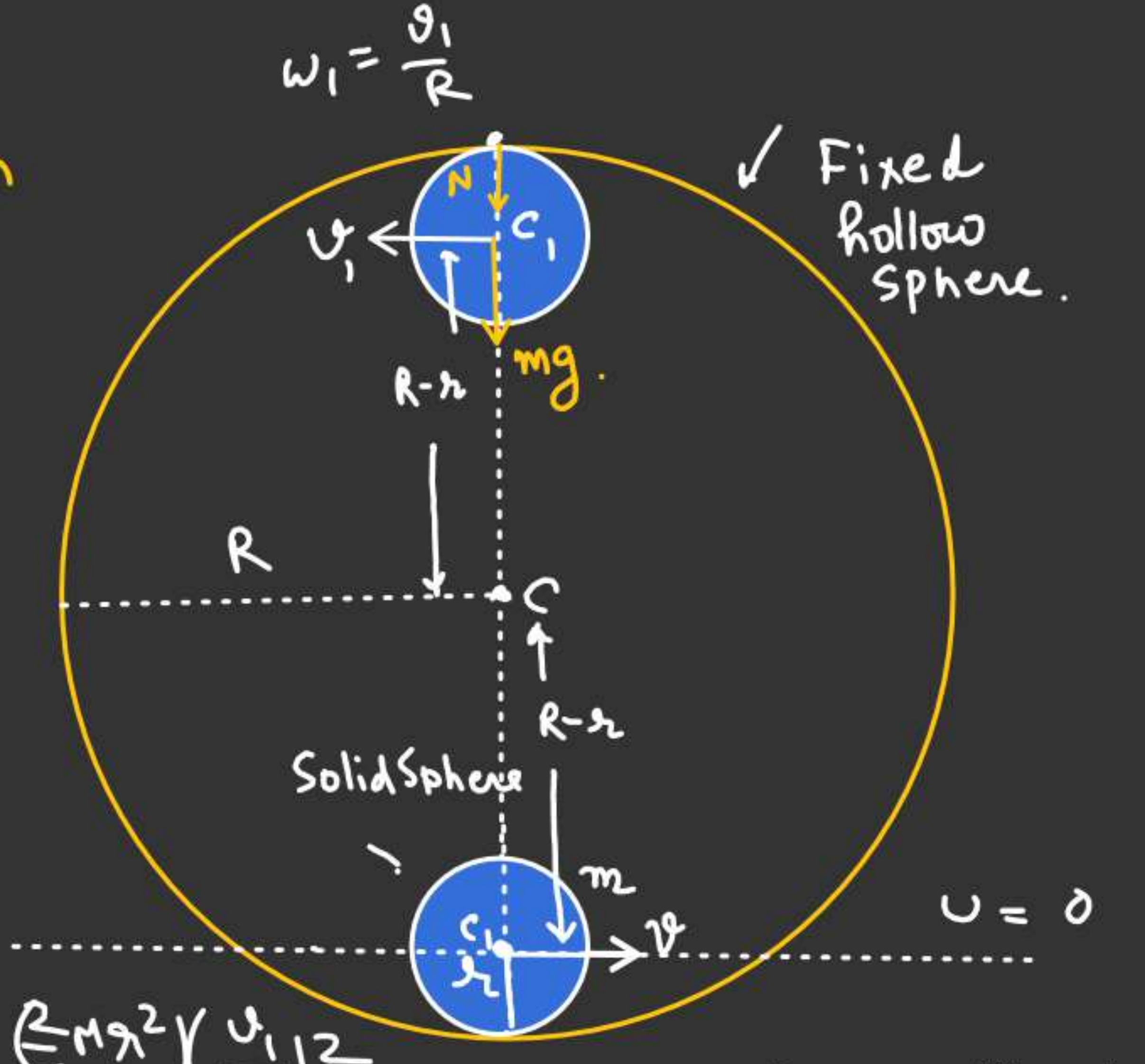
Find v_{min} so that Smaller Sphere Complete the Vertical Circular Motion With pure rolling



$$mg + N = \frac{mv_1^2}{(R-r)}$$

Energy Conservation

$$U_i + K.E_i = U_f + K.E_f$$

$$0 + \frac{1}{2}mv^2 + \frac{1}{2}\times\left(\frac{2}{5}mr^2\right)\left(\frac{v}{r}\right)^2 = mg\,2(R-r) + \frac{1}{2}mv_1^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\left(\frac{v_1}{r}\right)^2 \longrightarrow (1)$$

$\omega r = v$ (Pure Rolling)

$\omega = \frac{v}{r}$

N=0 For v_{min}, v_1 should be min & for v_1 min, $N = 0$

$$mg = \frac{mv_1^2}{R-r}$$

$$g(R-r) = v_1^2 \rightarrow \text{Put in (1)}$$

$$v = \sqrt{\frac{27g(R-r)}{7}}$$