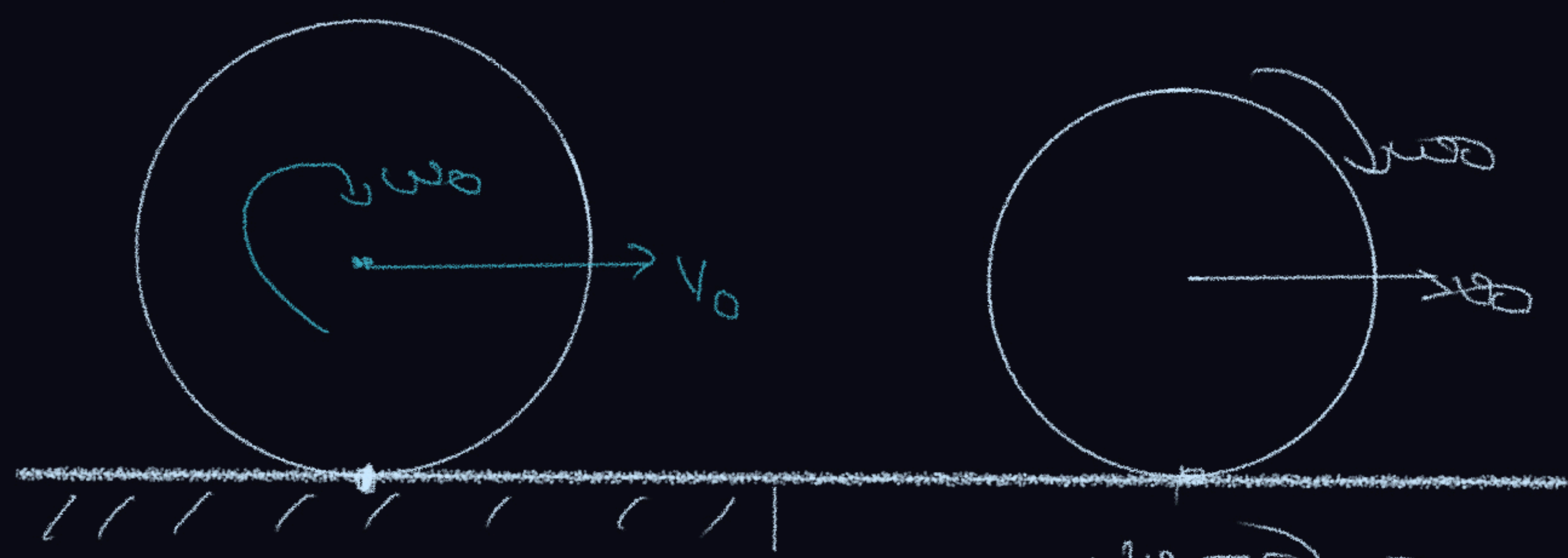
Initially its rolling without sliding. what happens next?



rough → here $v_p = 0$

$v_p = v_{pc} + u$ $v = R\omega$

$v_p = 0$

Smooth → $v_p = (u - R\omega)$

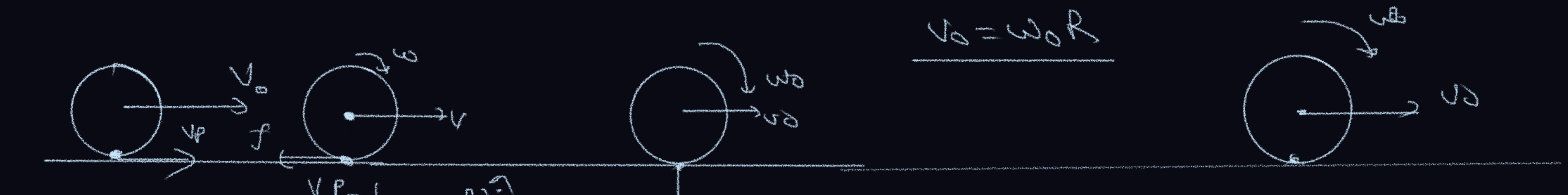
$v_p = 0$

∴ no sliding ~~...~~

what happens next?

If a ball is thrown with $\omega_i = 0$ $V_i = V$

$V_0 = \omega_0 R$



rough

$V_P = (v - \omega R)\hat{i}$

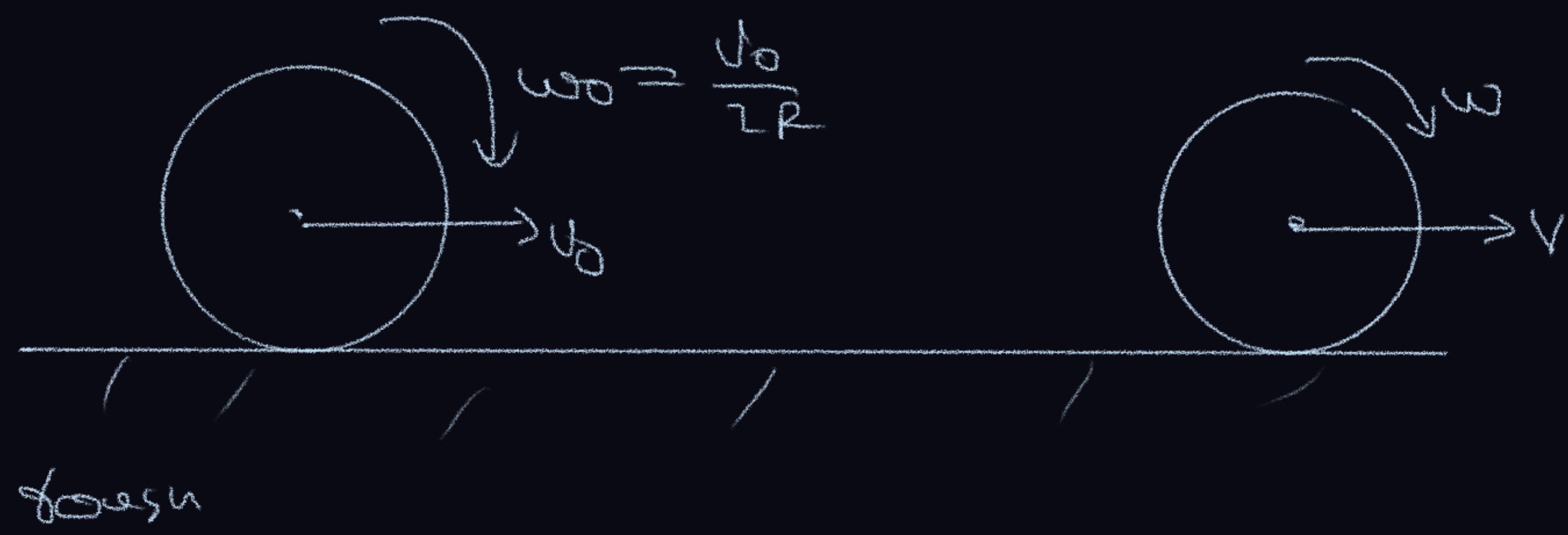
$v_p = 0$

$v_p = 0$

$v_p = \left(v - \omega R \right)$

rolling without sliding

$v_p = \left(v_0 - \omega_0 R \right) = 0$



Kinem EQ on point P

Kinem EQ on COM

$$a_c = \frac{F_{net}}{M} = \frac{f}{m} = \frac{\mu mg}{m} = \mu g$$

$$V = v_0 - \cancel{\mu g}\,\frac{v_0}{7\cancel{\mu g}} = v_0 - \frac{v_0}{7} = \frac{6v_0}{7}$$

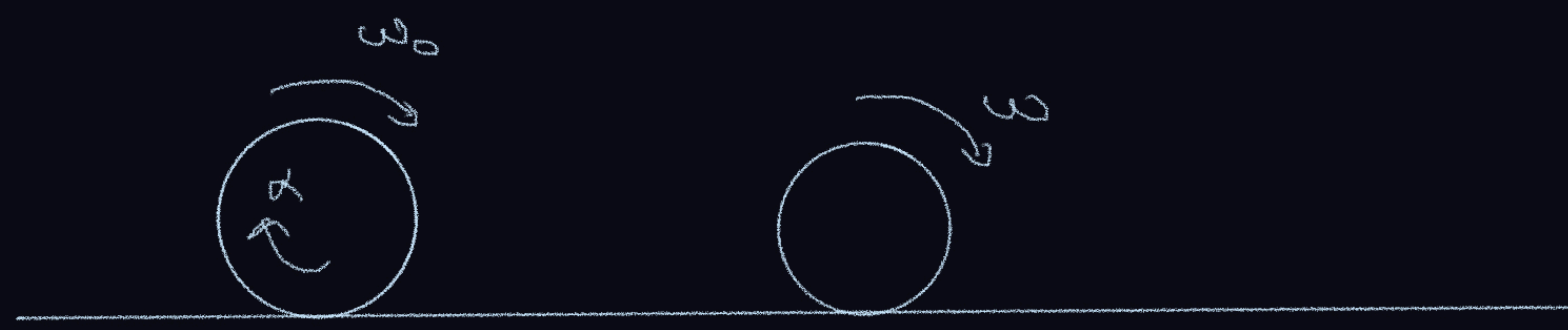
$$\alpha = \frac{5\mu g}{2R}$$

$$u_p = \frac{v_0}{2}\hat{i} \qquad v_p = 0 \qquad a_p = \underset{a_R + a_c}{\longleftarrow} = \frac{5\mu g}{2} + \mu g$$

$$= \frac{7\mu g}{2}$$

$$t = \frac{v_p - u_p}{a_p} = \frac{\frac{v_0}{\cancel{2}}}{\frac{7\mu g}{\cancel{2}}} = \frac{v_0}{7\mu g}$$

$$s = \frac{v^2 - u^2}{2a} = \frac{\frac{v_0^2}{4}}{\cancel{2} \times \frac{7\mu g}{\cancel{2}}} = \frac{v_0^2}{28\mu g}$$



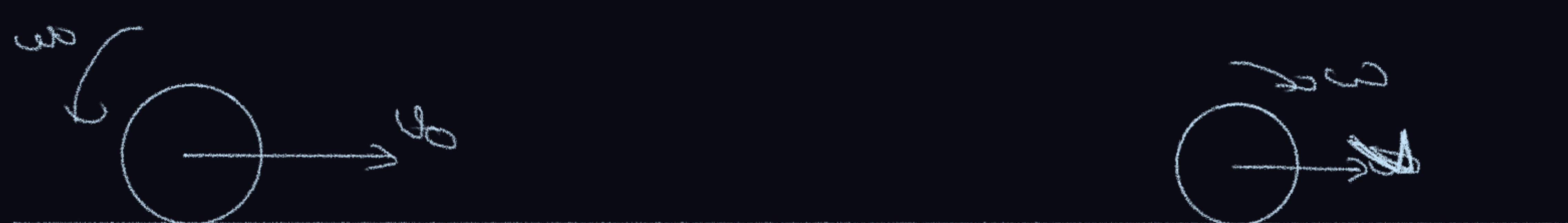
$t = ?$

substitute time

$$\omega = \omega_0 + (\alpha)\, t$$

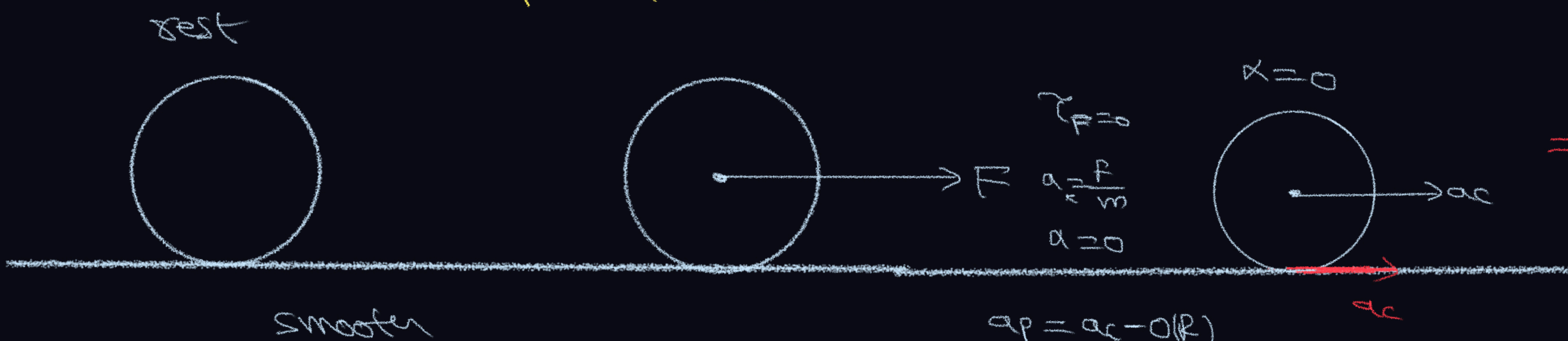

v_0
ω
v


ω_0
ω
v


ω_0
v_0
ω

Point of Percussion $\Rightarrow a_P = 0$

$a_P = a_{PC} + a_C$



$\tau_P = 0$

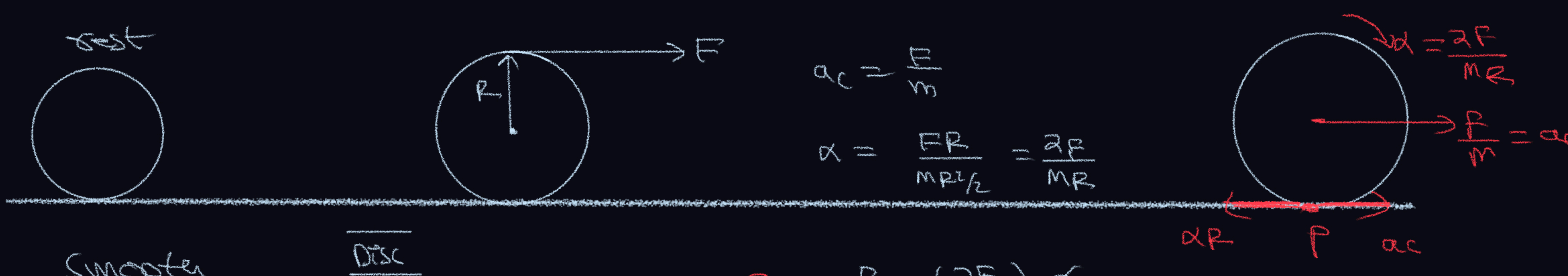
$a_c = \frac{F}{m}$

$\alpha = 0$

$\Rightarrow$ sliding

$a_P = a_c - 0(R)$

$= a_c \hat{i}$



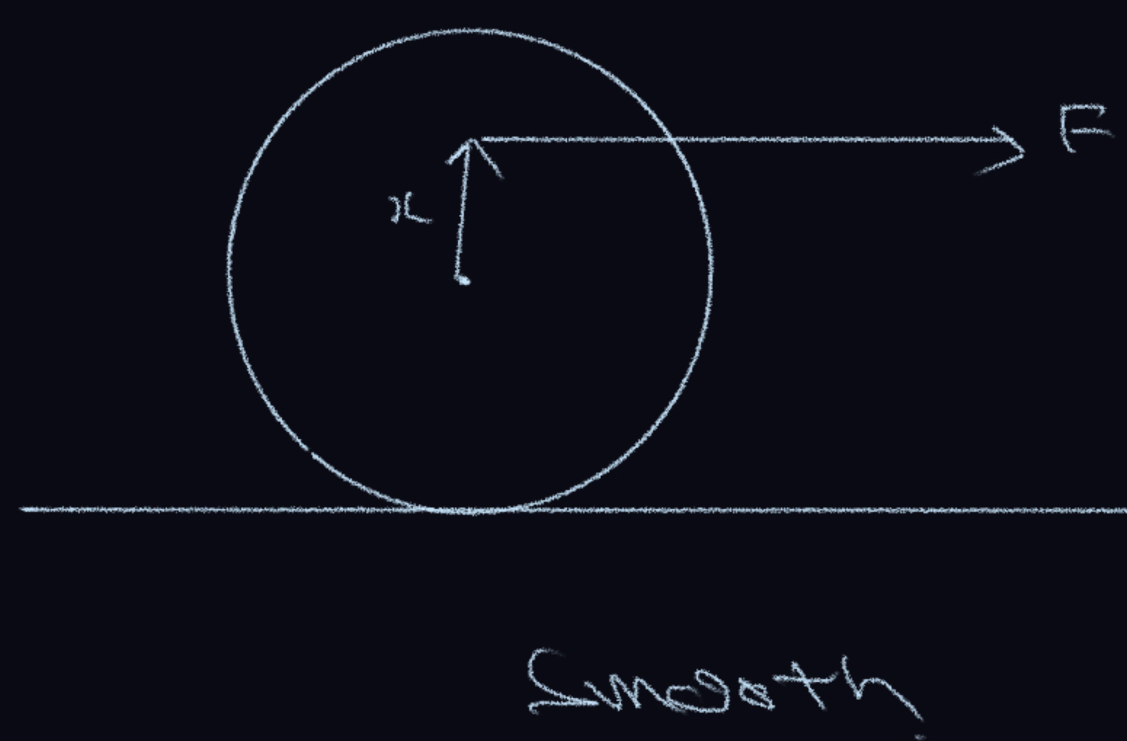
$a_c = \frac{F}{m}$

$\alpha = \frac{FR}{mR^2/2} = \frac{2F}{mR}$

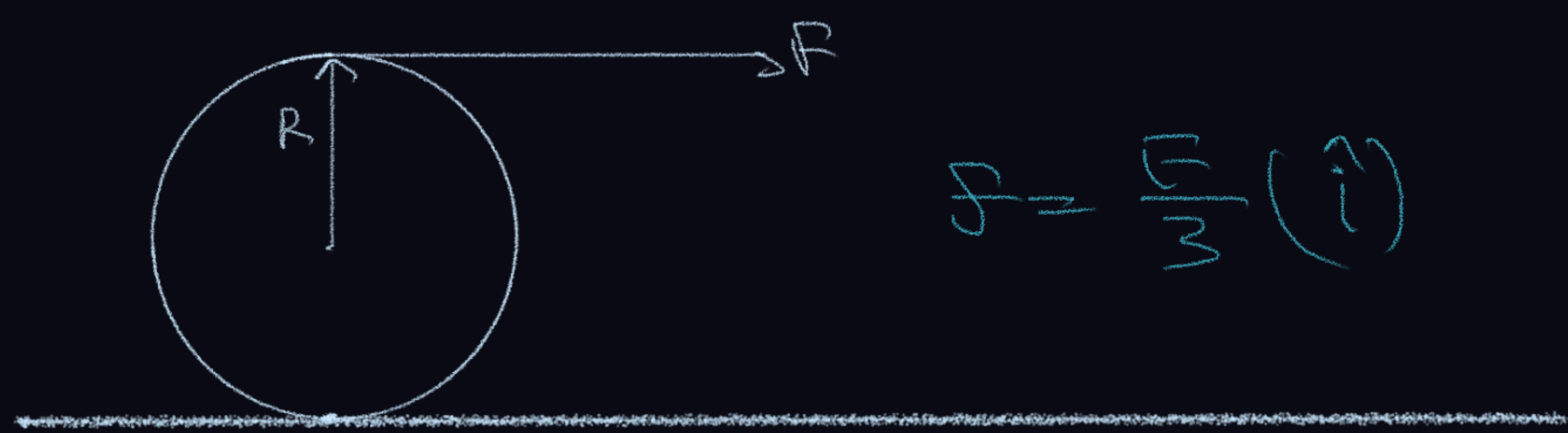
$a_P = \frac{F}{m} - \left(\frac{2F}{m\cancel{R}}\right)\cancel{R}$

$= -\frac{F}{m} = \overleftarrow{\ \frac{F}{m}\ } P$

Find x such body rolls without sliding



disc (M, R)



μ

i) given F : find $\vec{f}$, $\vec{a_c}$ (given its not sliding)

ii) what is F_{max} for it to not slide.

$f = \frac{F}{3}(\hat{i})$

$F_{max} = 3\mu mg$

F is acting above point of percussion $\left(R > \frac{I}{MR}\right)$

∴ $\alpha R > a_c$ ∴ a_p = left side ∴ f = right side

$\tau = FR - fR$

$\alpha = \frac{(F-f)R}{\frac{MR^2}{2}} = \frac{2(F-f)}{MR}$

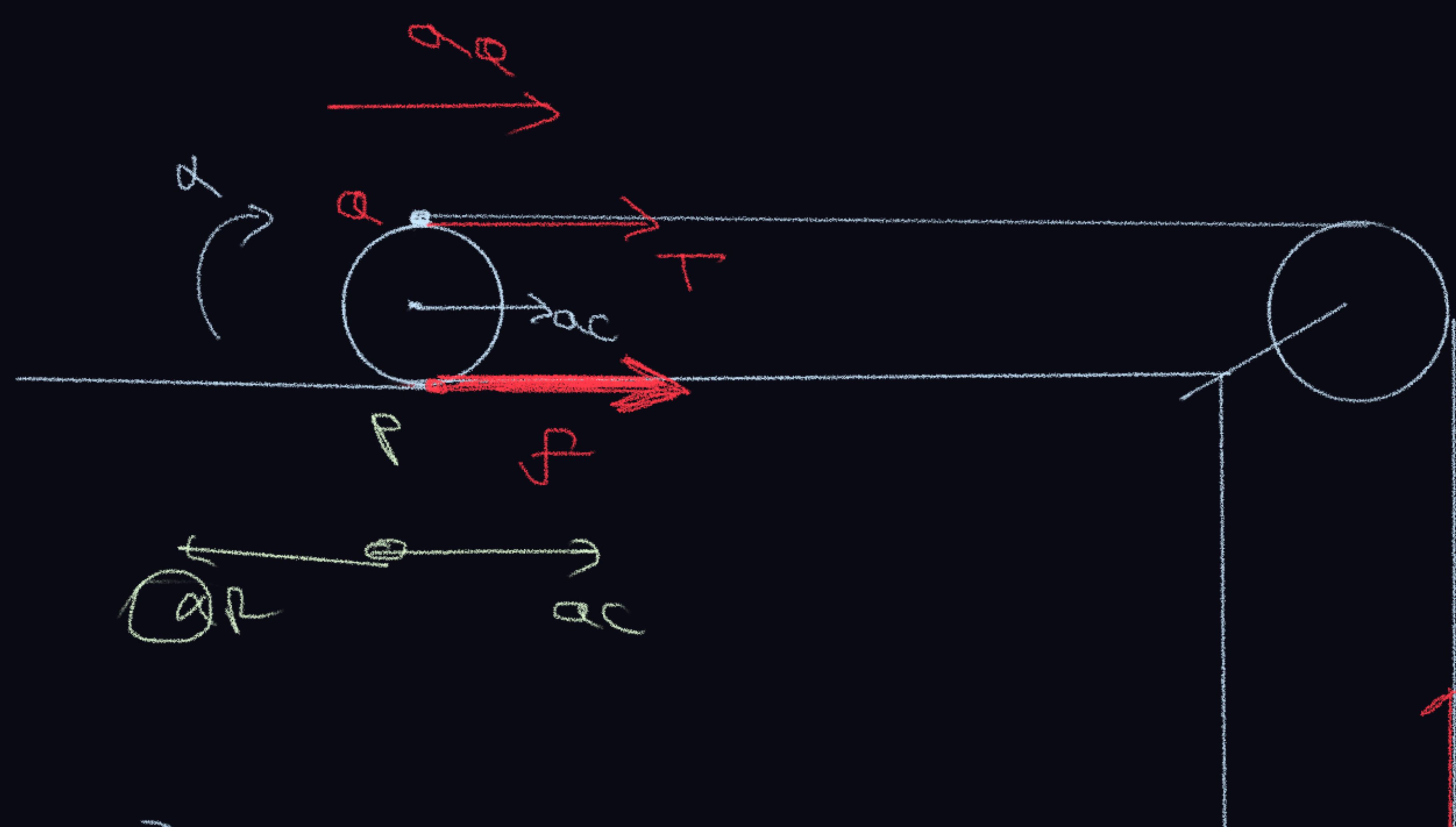
$a_c = \frac{F+f}{M}$

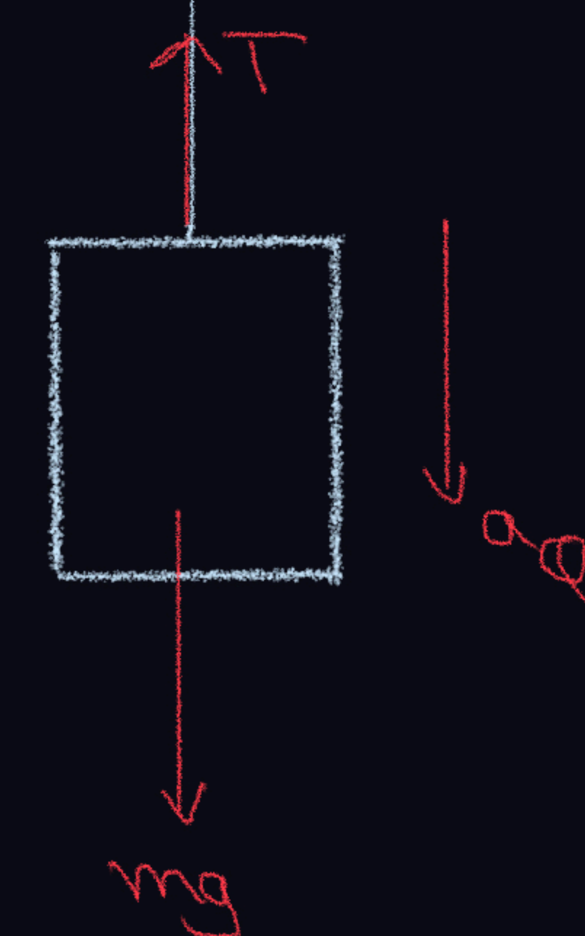
$\boxed{\alpha R = a_c} \rightarrow \frac{F+f}{M} = 2\left(\frac{F-f}{M}\right)$

then $a_p = 0$

$f = \frac{F}{3}$

I





$$\vec{a}_Q = \vec{a}_{QO} + \vec{a}_O = (\alpha R + a_c)$$

$$T + f = M a_c$$

$$mg - T = m a_Q = m(\alpha R + a_c)$$

$$(T - f)R = I\alpha$$

3EQ   vars: T, f, α, a_c

$$a_c = \frac{F_{net}}{M} = \frac{T+f}{M}$$

$$\alpha = \frac{(T-f)R}{I}$$

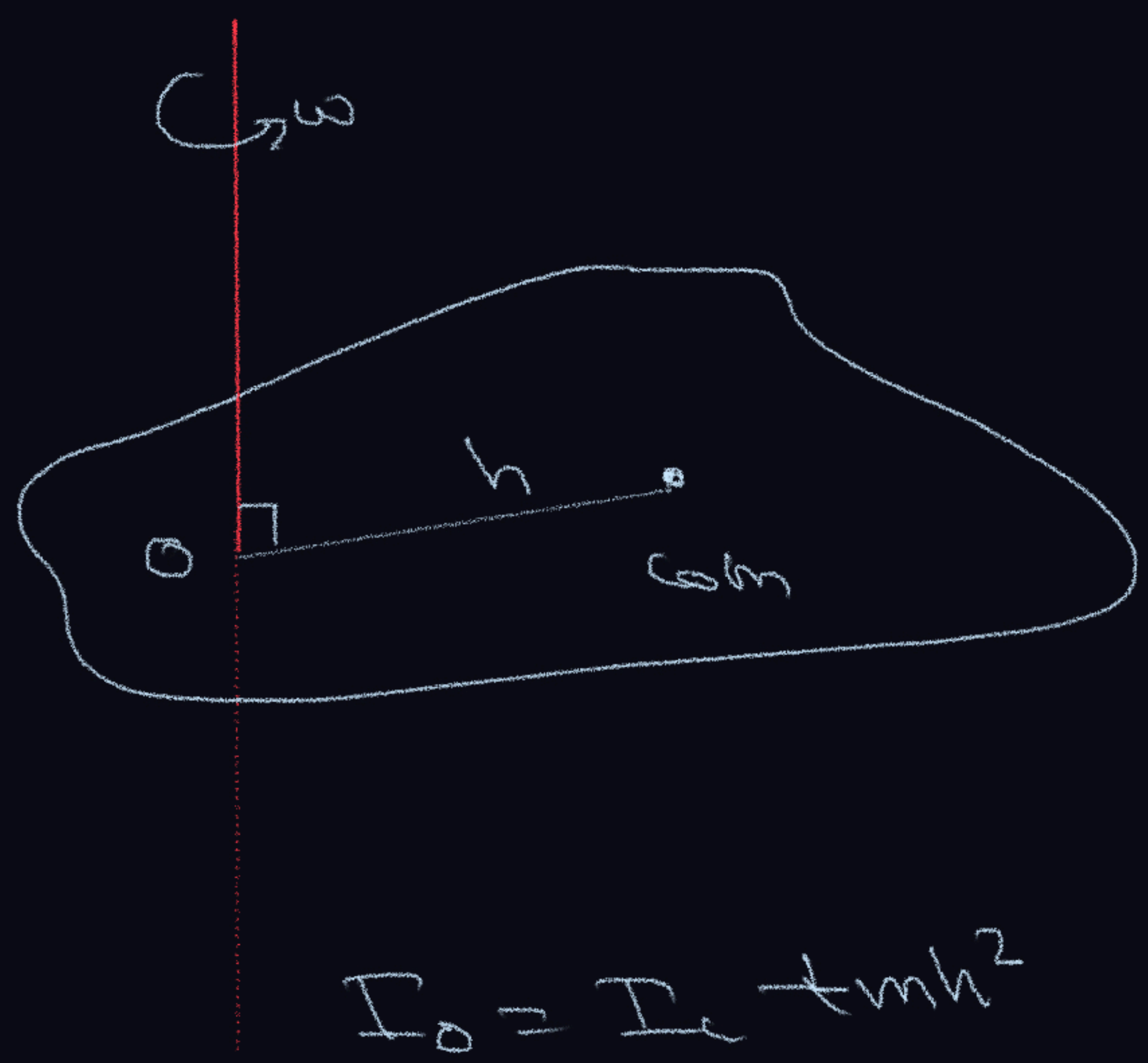
$a_P = 0$ $a_{PC} = -a_c$

$\Downarrow$

$$\frac{(T-F)R}{I} = \frac{(T+F)}{M}$$

4 Equations
variable

Kinetic energy of Rotation (K)



$$K = \frac{1}{2} \sum dm(v^2)$$

$$K = \frac{1}{2} \int \omega^2 x^2 \, dm$$

$$K = \frac{1}{2} \omega^2 \int x^2 \, dm$$

$$\boxed{K = \frac{1}{2} \omega^2 I_o}$$

$I_o = I_c + mh^2$

$v_c = \omega h$

$$K = \frac{1}{2} \omega^2 (I_c + mh^2) = \frac{1}{2} \omega^2 I_c + \frac{1}{2} (\omega^2 h^2) m$$

$$\boxed{K = \frac{1}{2} I_c \omega^2 + \frac{1}{2} m v_c^2}$$

$$\boxed{a = \frac{g\sin\theta}{1 + \frac{I}{mR^2}}}$$