Kinematika

Gerak lurus

→ $\vec{x}_t = \vec{x}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}\, t^2$

→ $\vec{v}_t = \vec{v}_0 + \vec{a}\, t$

→ $\vec{v}_t^{\,2} = \vec{v}_0^{\,2} + 2\vec{a}\,\Delta\vec{x}$

Kinematika

Rotasi

Gerak lurus

→ $\vec{x}_t = \vec{x}_0 + \vec{v}_0 \cdot t + \frac{1}{2}\vec{a}t^2$

→ $\vec{v}_t = \vec{v}_0 + \vec{a} \cdot t$

→ $\vec{v}_t^{\,2} = \vec{v}_0^{\,2} + 2\vec{a}\,\Delta\vec{x}$

→ $\Delta\vec{\theta} = \vec{\omega}_0 t + \frac{1}{2}\vec{\alpha}t^2$

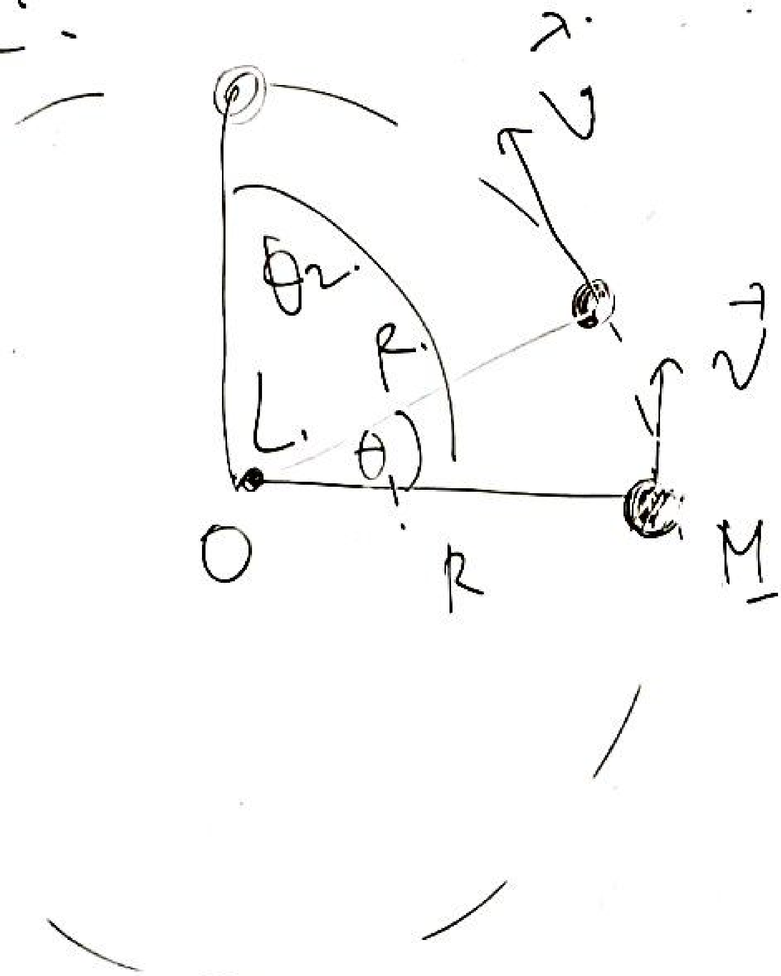
→ $\vec{\omega}_t = \vec{\omega}_0 + \vec{\alpha} \cdot t$

→ $\vec{\omega}_t^{\,2} = \vec{\omega}_0^{\,2} + 2\vec{\alpha}\,\Delta\vec{\theta}$

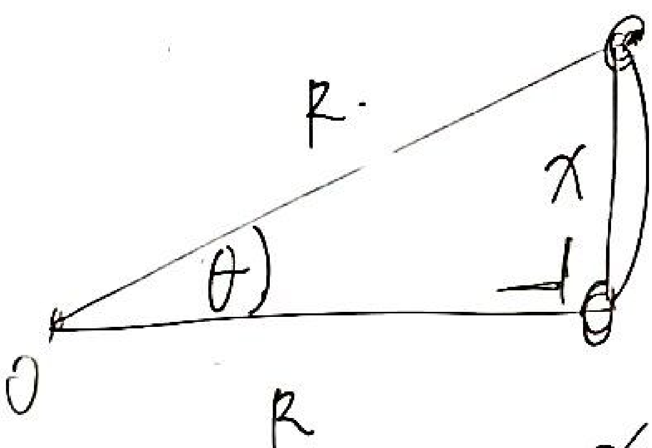
→ $\vec{v} = \frac{\Delta\vec{x}}{\Delta t}$ → $\vec{\omega} = \frac{\Delta\vec{\theta}}{\Delta t}$

→ $\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$ → $\vec{\alpha} = \frac{\Delta\vec{\omega}}{\Delta t}$

asi



$\vec{v} \rightarrow$ Kelajuan Tangensial, Kelajuan linear



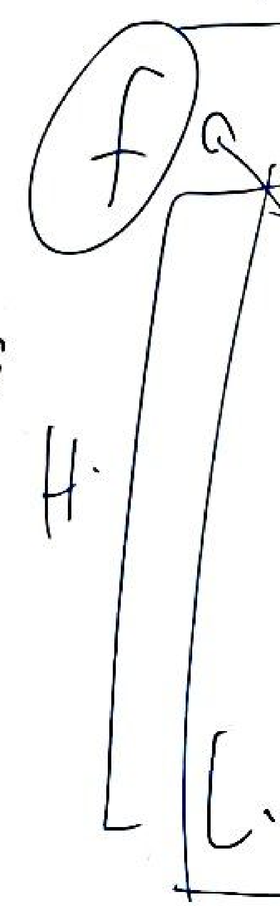
untuk $\theta <<<$

$\sin\theta \approx \tan\theta$
$\approx \theta$

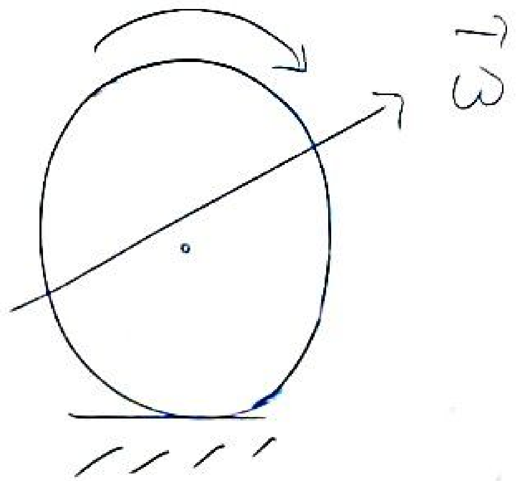
$$\sin\theta = \frac{x}{R}$$

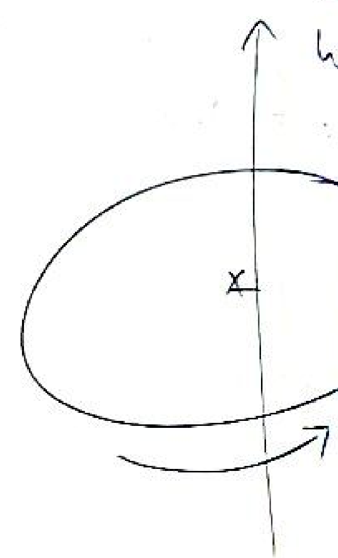
$$\theta = \frac{x}{R} \longleftrightarrow \boxed{\vec{x} = R \cdot \vec{\theta}}$$

An



Arah $\vec{\omega}$



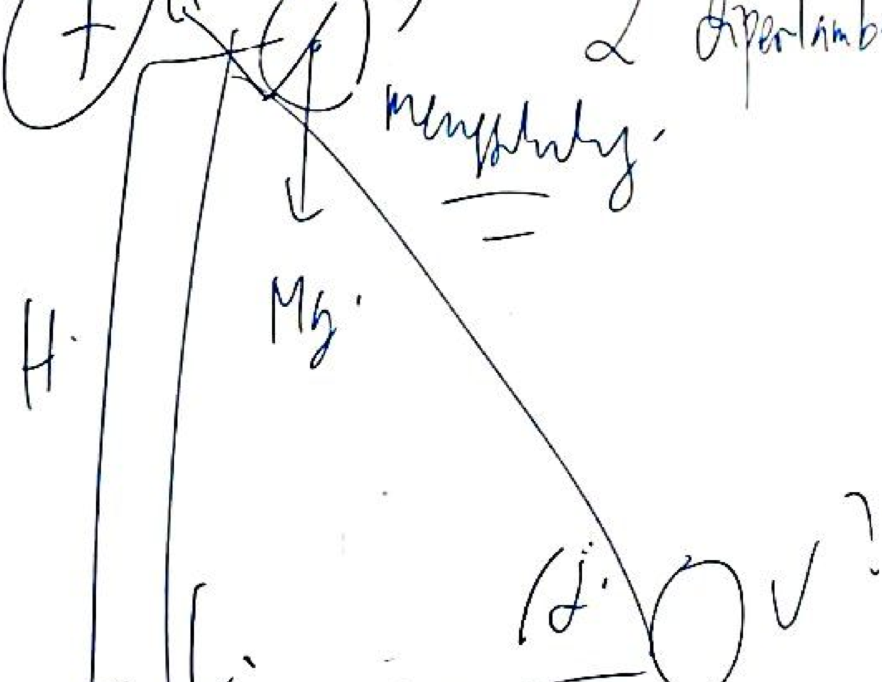


Kelajuan Tangensial,

Kelajuan linear

Arah $\vec{\alpha}$: → $\vec{\alpha}$ dipercepat →

$\vec{\alpha}$ diperlambat →



untuk $\theta <<<$

$\sin\theta \approx \tan\theta$

$\approx \theta$

$\boxed{\vec{x} = R \cdot \vec{\theta}}$

[redacted]

$$\boxed{\vec{x} = R \cdot \vec{\theta}}$$

$x \rightarrow$ meter
$R \rightarrow$ meter
$\vec{\theta} \rightarrow$ rad

$$x = R \times \vec{\theta} \quad (1)$$

- $$\frac{d}{dt}(\vec{x}) = \frac{d}{dt}(R\,\vec{\theta}) = R\,\frac{d}{dt}\vec{\theta}$$

$$\boxed{\vec{v} = R \cdot \vec{\omega}}$$

- $$\frac{d}{dt}(\vec{v}) = \frac{d}{dt}(R\,\vec{\omega})$$

$$\vec{a} = R \cdot \vec{\alpha}$$

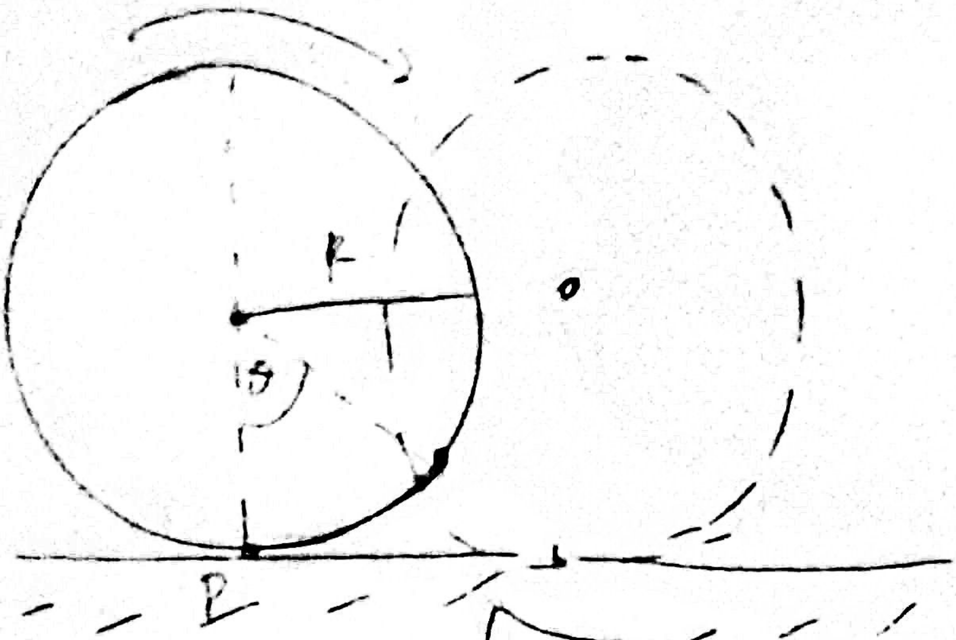
Syarat:

Kondisi

$\boxed{\text{Non-Slip}}$

I

Apa Arti Non Selip → gerak Rotasi Murni



Non Selip → $\boxed{\vec{x} = R \cdot \vec{\theta}}$

→ titik P → bersentuhan dg Aspal

⇓

" Diam Sesaat " / Tidak ada gerak Relatif titik P dengan aspal.

Karena dtk P diam sesaat → "gesekan statis"

↳ Usaha oleh gaya gesek statis → Non selip.

$$\boxed{W_{fges} = 0 \text{ J}}$$

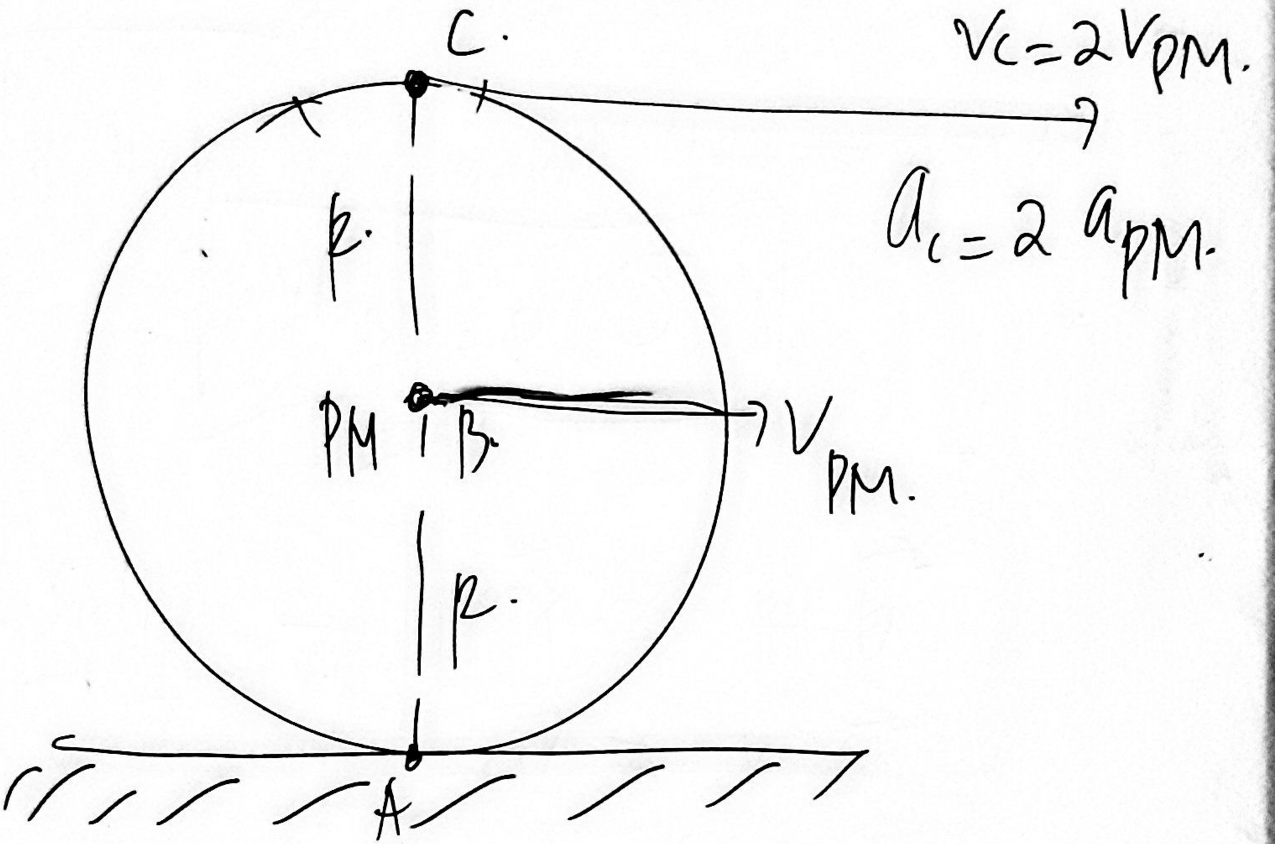
Selip →

$$\vec{x} \neq R \cdot \vec{\theta}$$

$$\vec{v} \neq R \cdot \vec{\omega}$$

$$\vec{a} \neq R \cdot \vec{\alpha}$$

Non selip → $\boxed{\text{Rotasi poros di titik A}}$



$$\vec{v}_A = 0$$

$$\vec{v}_B = \vec{v}_{PM} = \vec{\omega} R$$

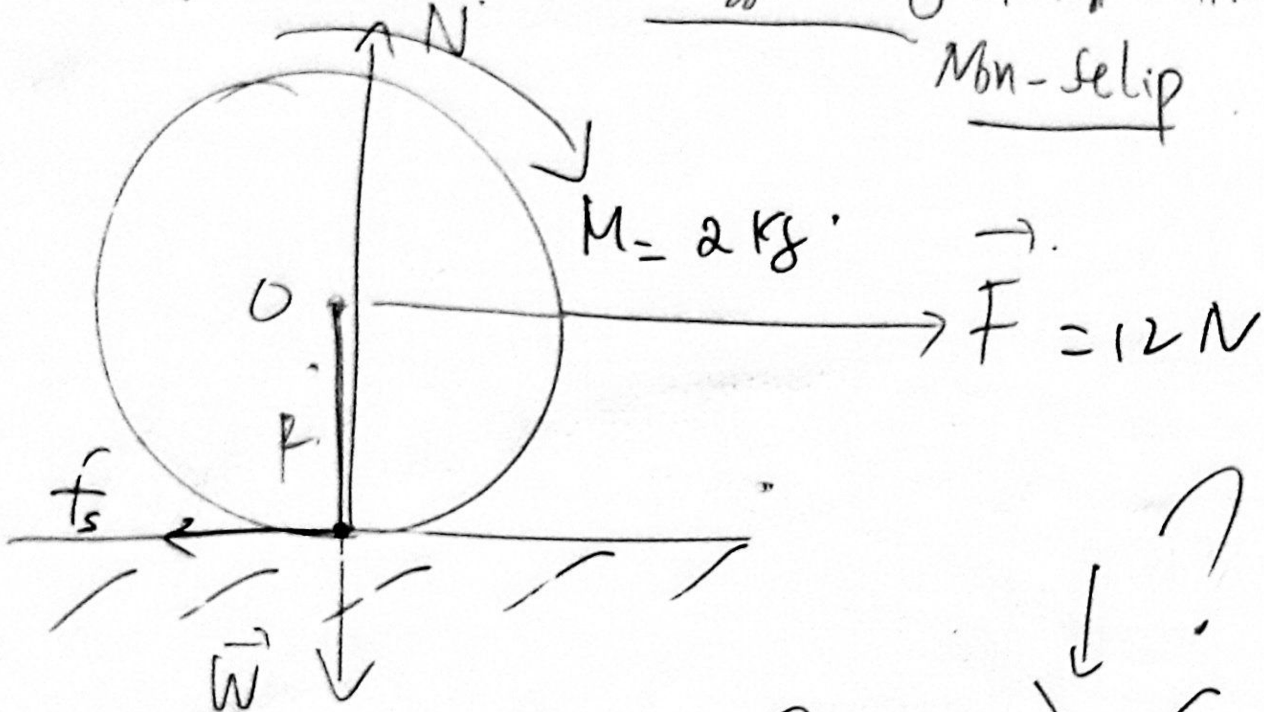
$$\vec{v}_C = \omega \cdot R = \omega(2R) = 2\omega R$$

$$\boxed{v_C = 2v_{PM}}$$

Menerapkan contoh gaya gesek

(1) Akibat Dian ⟶ Menggelinding (Rotasi + Translasi)

Non-Selip



Ditanyakan : a) $\vec{a}$ benda ?

(b) gaya gesek ?

$\cancel{\boxed{f_{ges} = \mu . N}}$?

Jwb : (a) Translasi

$$\sum \vec{F} = m . \vec{a}$$

$$F - f_s = m . a \quad (1)$$

Rotasi

$$\sum \vec{\tau}_0 = I \cdot \vec{\alpha}$$

$$f_s . R = I \vec{\alpha} \qquad \vec{\alpha} = \frac{a}{R}$$

$$f_s \cdot \cancel{R} = \frac{1}{2} M R^{\cancel{2}} \cdot \frac{\vec{a}}{\cancel{R}}$$

$$f_s = \frac{1}{2} M \cdot \vec{a} \quad \ldots (2)$$

(2) ke (1)

$$\Sigma\tau = I\alpha$$

$$F - \frac{1}{2} M a = M a \qquad F \cdot R - f \cdot R =$$

$$(F - f) R$$

$$F = \frac{3}{2} M a$$

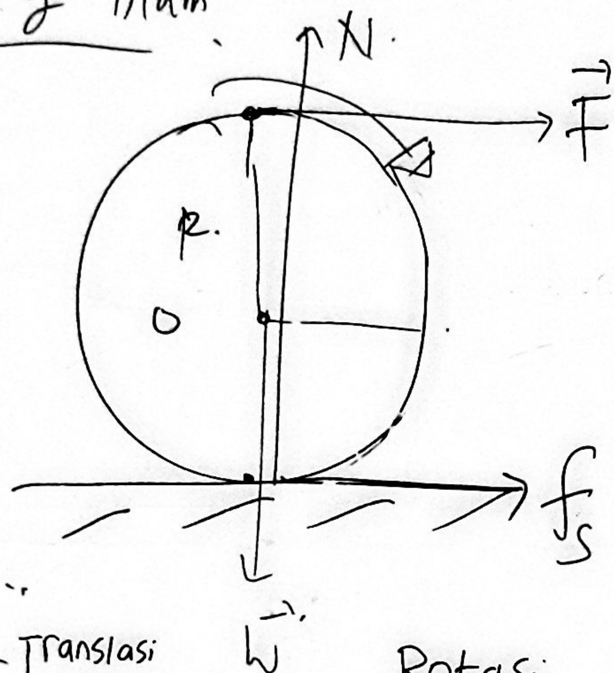
(a) $$\boxed{\vec{a} = \frac{2F}{3M}} = \frac{2 \cdot 12}{3 \cdot 2} = 4 \text{ m/s}^2$$

(b) $$f_s = \frac{1}{2} M \cdot a = \frac{1}{2} \cancel{M} \cdot \frac{2F}{3\cancel{M}}$$

$$\boxed{f_s = \frac{1}{3} F} \checkmark = \frac{1}{3} \cdot 12 = 4 \text{ N}$$

Awaly Diam

②



a) $\vec{a}$?

b) $f_{s(?)}$?

Jb: — Translasi

Rotasi

$F \cdot R - f R = I \alpha$

a.) $\Sigma \vec{F} = m \cdot \vec{a}$ $\quad$ $\Sigma \vec{\tau} = I \cdot \vec{\alpha}$

$\vec{F} + F_s = m \cdot \vec{a}_{(1)}$ $\quad$ $(F - F_s)R = I \cdot \vec{\alpha}$

$F + \left(-\frac{1}{2} m \cdot a + F\right) = m \cdot a$ $\quad$ $(F - F_s)R = I \cdot \frac{a}{R}$

$2F - \frac{1}{2} m \cdot a = m \cdot a$ $\quad$ $(F - F_s)\cancel{R} = \frac{1}{2} m R^{\cancel{2}} \cdot \frac{a}{\cancel{R}}$

$2F = \frac{3}{2} m \cdot a$ $\quad$ $F - F_s = \frac{1}{2} m \cdot a$ $\quad$ (2) ke (1)

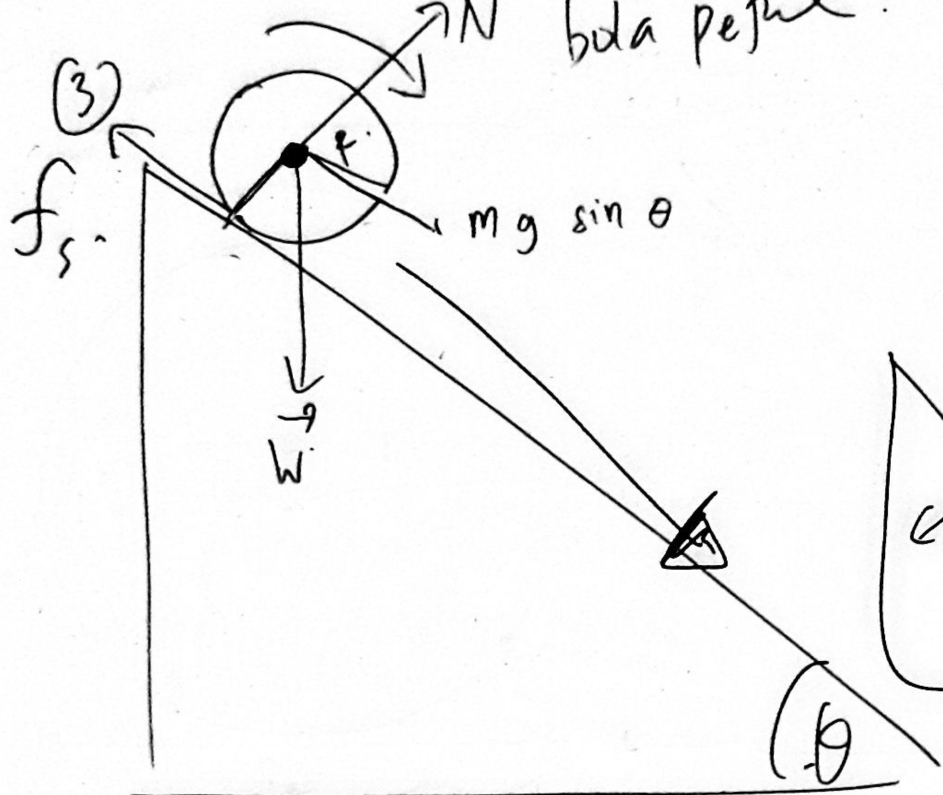
$4F = 3 m a$ $\quad$ $-F_s = \frac{1}{2} m \cdot a - F$

a.) $\frac{4F}{3m} = a$ $\quad$ $F_s = -\frac{1}{2} m \cdot a + F$ (2)

b.) $F_s = -\frac{1}{2} \cancel{m} \cdot \frac{4F}{3\cancel{m}} + F \rightarrow F_s = \frac{2}{6} F$

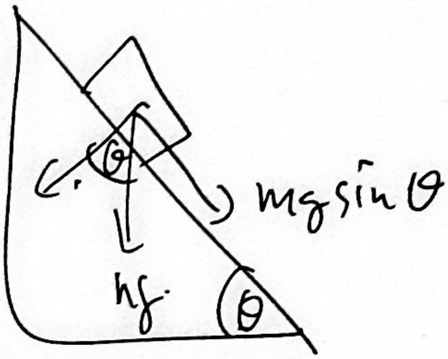
$F_s = -\frac{4}{6} F + F$

I



bola pejal. Non selip

$\vec{a}$?



Translasi

a) $\Sigma F = m . a$

$m g \sin\theta - f_s = m . a$ ... (1)

Rotasi :

$\Sigma \tau = I . \bar{\alpha}$

$f_s . \cancel{R} = \frac{2}{5} m \cancel{R^2} \frac{a}{\cancel{R}}$

$f_s = \frac{2}{5} m a$ ... (2)

$m g \sin\theta - \left(\frac{2}{5} m a\right) = m . a$

$\cancel{m} g \sin\theta = \frac{7}{5} \cancel{m} a$

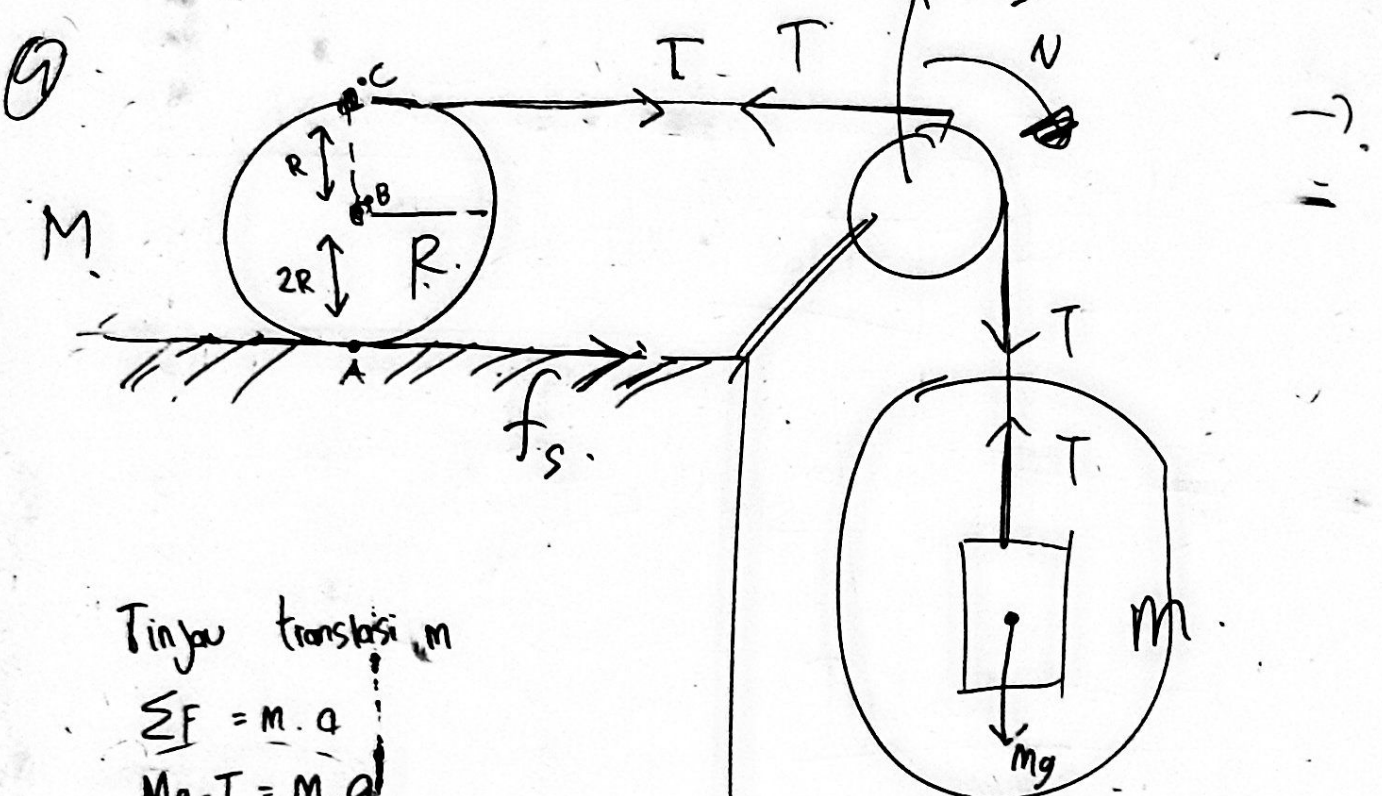
A. $\bar{a} = \frac{5}{7} g \sin\theta$

$f_s = \frac{2}{5} m . \frac{5}{7} g \sin\theta$

b) $f_s = \frac{10}{35} m g \sin\theta$

[redacted]

Non selip



Tinjau translasi m

$\Sigma F = m \cdot a$

$Mg - T = m \cdot a$

$-T = -mg + m \cdot a$

$\boxed{T = mg - m a_c}$ ... (1)

$a_c = a_m$

$a_c = a$

Tinjau Rotasi M

$\Sigma \tau = I \cdot \alpha$

$\alpha = \frac{\vec{a}_{pM}}{R}$

$T \cdot \cancel{R} - Fs \cdot \cancel{R} = \frac{1}{2} M \cancel{R}^2 \cdot \frac{a_{pM}}{\cancel{R}}$

$T - Fs = \frac{1}{2} M \cdot \vec{a}_{pM}$ → $\boxed{a_{pM} = \frac{1}{2} a_c}$

$\boxed{T - F_s = \frac{1}{2} M \cdot \frac{1}{2} a_c}$

Tinjau Translasi M

$\Sigma F = m.a$

$T + Fs = m.\frac{1}{2}ac$

$$\boxed{T = m.\frac{1}{2}ac - Fs}$$

→ f_s ?

$T - Fs = \frac{1}{2} m . \frac{1}{2}ac$

$m.\frac{1}{2}ac - Fs - Fs = \frac{1}{2} m . \frac{1}{2} ac$

$m.\frac{1}{2}ac - Fs - Fs = \frac{1}{2} m . \frac{1}{2} ac$

$\frac{1}{2}.mac - 2Fs = \frac{1}{4} mac$

$-2Fs = \frac{1}{4} mac - \frac{1}{2} mac$

$-2f_s = -\frac{1}{2} mac$

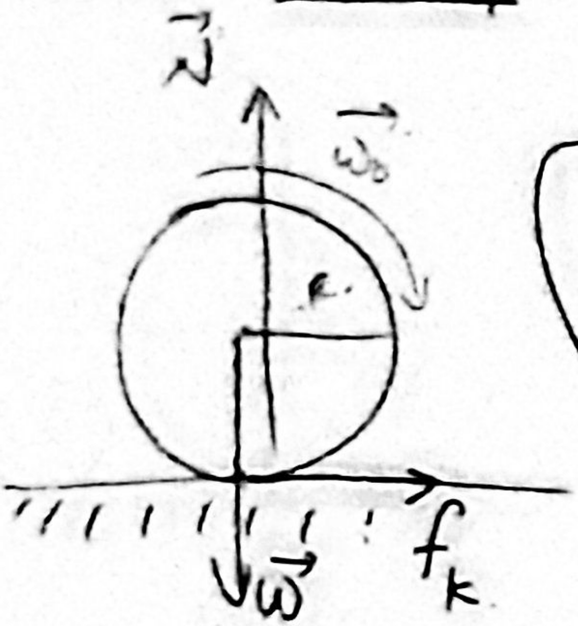
a ?

$$\boxed{f_s = \frac{1}{4} mac}$$

[redacted]

(5)

- Kondisi "Non selip"



$$\alpha = -\frac{2 f_k}{MR}$$

$$= -\frac{2 \cdot \mu_k \cdot M \cdot g}{M \cdot R}$$

$$\alpha = -\frac{2 \mu_k g}{R} \;///$$

Tinjau Translasi

$$\Sigma \vec{F} = m \, \vec{a}$$

$$f_k = m \cdot \vec{a} \quad (1)$$

$$\vec{a} \neq \frac{v}{t}$$

$$\mu_k N = m \cdot \vec{a}$$

$$\boxed{\mu_k \cdot g = \vec{a}}$$

$$\boxed{a = \frac{\Delta v}{\Delta t}}$$

Tinjau Rotasi

$$\Sigma \vec{\tau} = I \cdot \alpha$$

$$-f_k \cdot R = \frac{1}{2} M R^2 \cdot \alpha \quad (2)$$

$$\boxed{\alpha \neq \frac{a}{R}}$$

$\Downarrow$ selip

Lama silinder pepal selip.

↳ Syarat untuk mulai non selip !

⇓

$V_t = \omega_t R$

$\vec{V}_t = \vec{\omega}_t \cdot R$

$$\boxed{V_0 + a t = (\omega_0 + \alpha \cdot t) R}$$

$$0 + \mu_k \cdot g \cdot t = \left[\omega_0 - \frac{2 \mu_k \cdot g}{R} \cdot t\right] R$$

$$\mu_k \cdot g \cdot t = \omega_0 \cdot R - 2 \mu_k g t$$

$$3 \mu_k g t = \omega_0 \cdot R$$

$$\boxed{t = \frac{\omega_0 R}{3 \mu_k g}} \Rightarrow \text{waktu untuk selip}$$

(b) Jarak yg ditempuh selama slip!

$$x = \frac{1}{2} a t^2$$

$$x = \frac{1}{2} \mu_k . g . \frac{\omega_0^2 R^2}{9 \mu_k^2 g^2}$$

$$x = \frac{1}{18} \frac{\omega_0^2 R^2}{\mu_k g}$$

(c) Usaha gaya gesek!

(1) $W_{fges} = Ek' - Ek_0$

$$= \left[\frac{1}{2} m v_t^2 + \frac{1}{2} I \omega_t^2\right] - \left(\frac{1}{2} I \omega_0^2\right)$$

(2) $W_{f_{945}} = f_{945} \cdot x$

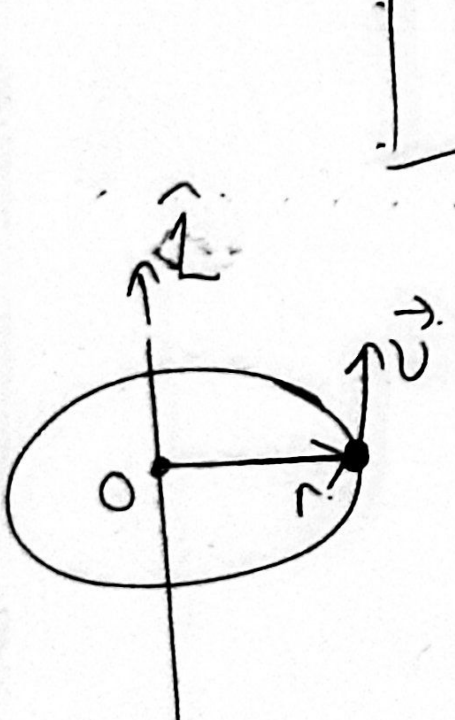
$$= \cancel{\mu_k} \cdot mg \cdot \frac{1}{18} \frac{\omega_0^2 r^2}{\cancel{\mu_k} g}$$

$$\boxed{W_{f_{945}} = -\frac{1 m \omega_0^2 r^2}{18}}$$ ✓

Momentum Sudut $\vec{L}$

Definisi : $\boxed{\hat{L} = \hat{r} \times \hat{p}}$ $\tau = \hat{r} \times \hat{F}$

$\boxed{\hat{L} = \hat{r}\,\hat{p}\,\sin\theta}$ → Translasi
→ punya lengan !



$\boxed{L = \bar{r}\,\bar{p} = mvr}$

$L = m\omega r\, r = m\omega r^2$
$= mr^2\,\omega$

$\boxed{L = I\omega}$

L

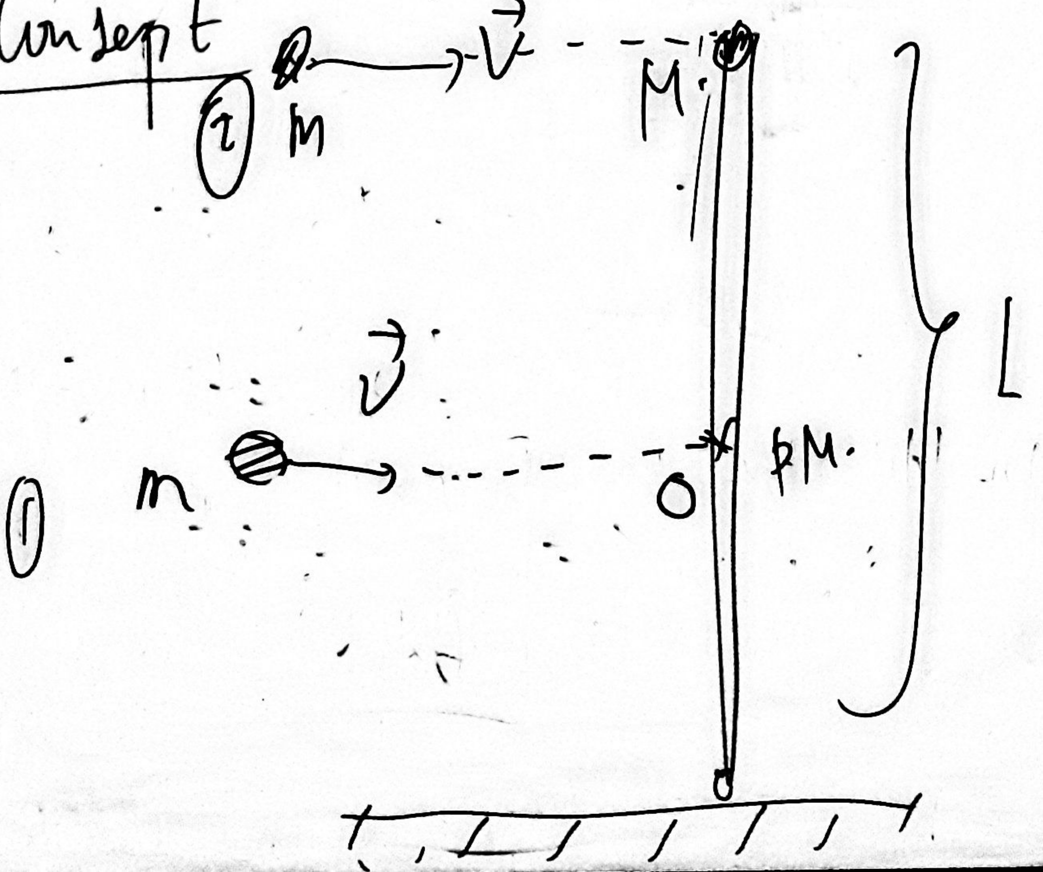
Momentum Linear $\hat{p} \rightarrow$ searah $\vec{v}$

Momentum Sudut $\hat{L} \rightarrow$ searah $\vec{\omega}$

(1) $\hat{L} = mvr \rightarrow$ gerak translasi memiliki lengan

(2) $\hat{L} = I\vec{\omega} \rightarrow$ Rotasi

Consept



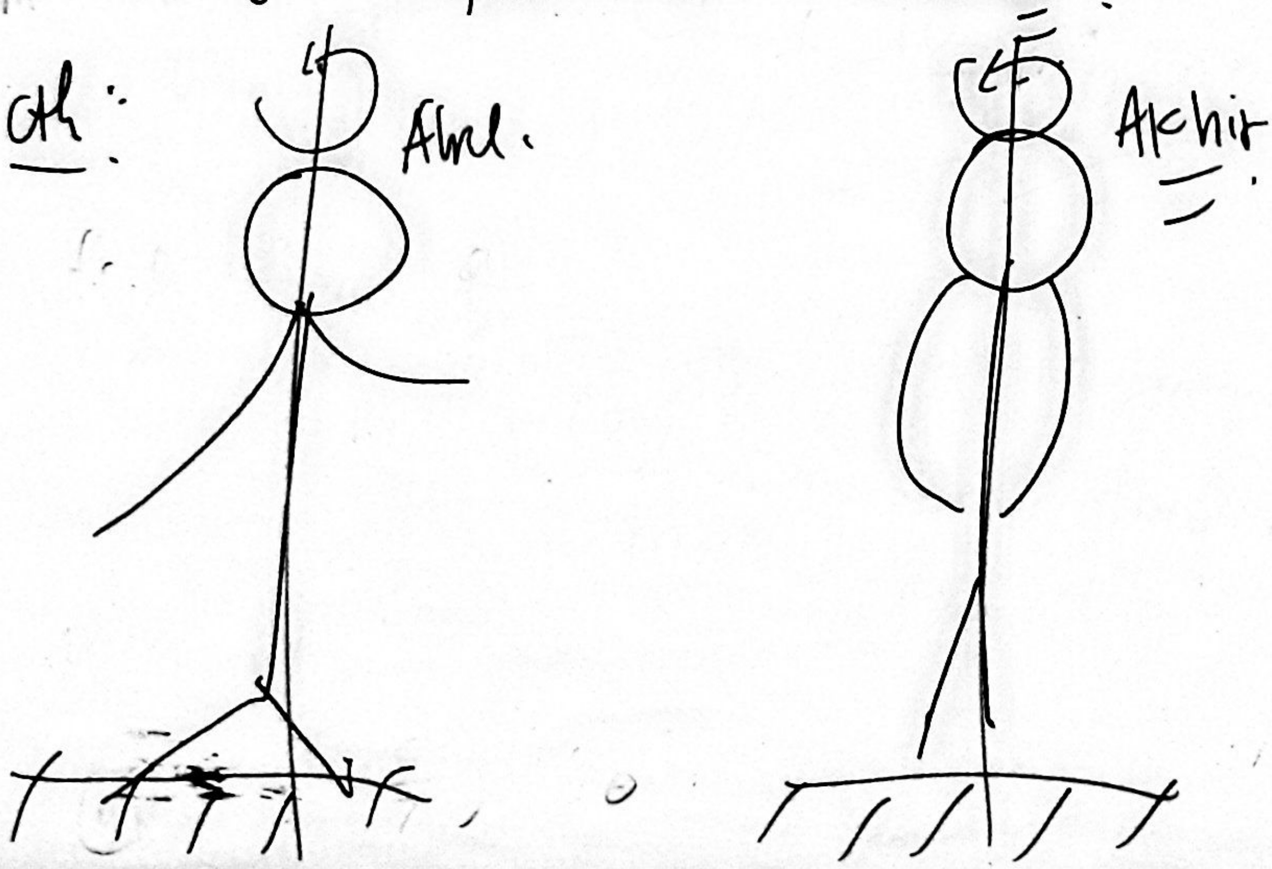
Hkm Kekekalan Momentum Sudut

$$\boxed{\vec{L}_{awal} = \vec{L}_{akhir}}$$

↳ Syarat: $\boxed{\vec{\tau}_{ekst} = \vec{0}}$

$$[I\omega]_{Awal} = [I\omega]_{akhir}.$$

Ctt:



$I = Mr^2 \rightarrow I_{Awal} > I_{akhir}$

$L_{Awal} = L_{akhir}$

$I_0 \omega_0 = I' \omega'$

$$\frac{I_0}{I'} = \frac{\omega'}{\omega_0}$$

Karena $I_0 > I'$ maka $\boxed{\omega' > \omega_0}$

$\vec{v}$

$\vec{\omega}$

Kasus (1)

Jika Tanah liat menumbuk Tongkat di titik O (PM)

(Momentum Sudut Tanah liat) $_{Awal}$ = L_{awal}.

$$L_{awal} = mV \cdot R = 0$$

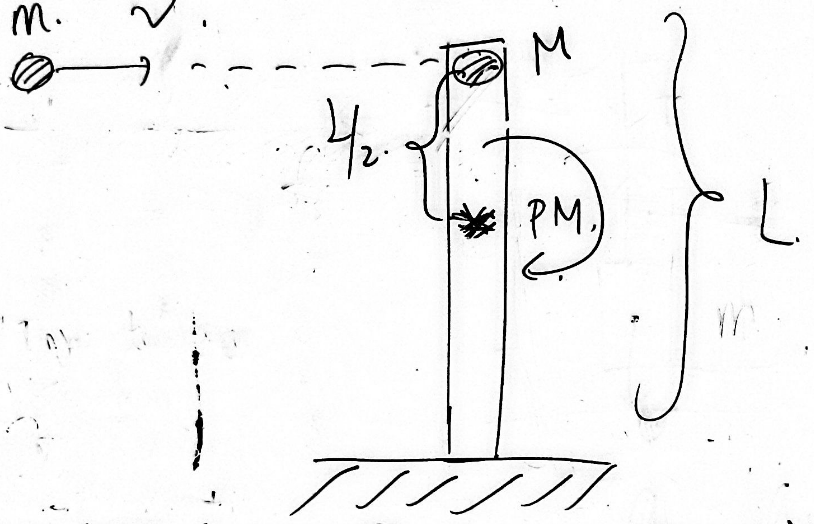
Kasus (2)

Jika Tanah liat menumbuk Tongkat di yang atas.

$$L_{Awal} = mV \cdot \frac{d}{2}$$

L

9



Setelah tumbukan, m nempel di M; sistem berotasi thd pusat massa.

Ide I

Hkm kekekalan momentum sudut

$L_0 = L'$

$mv\frac{L}{2} = I'\omega'$

Ingat I

$I' = I_{tongkat} + I_m$, $I_m = mr^2$

$I' = \frac{1}{12}ML^2 + \frac{mL^2}{4}$