FONDAMENTI DI MECCANICA E BIOMECCANICA [IN/0165]

Lezione del 10 novembre 2017.

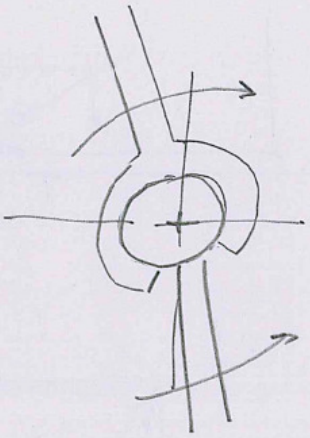
Titolo:
Attrito statico e dinamico, esempi di accoppiamenti di superfici coniugate in presenza di attrito e aderenza.

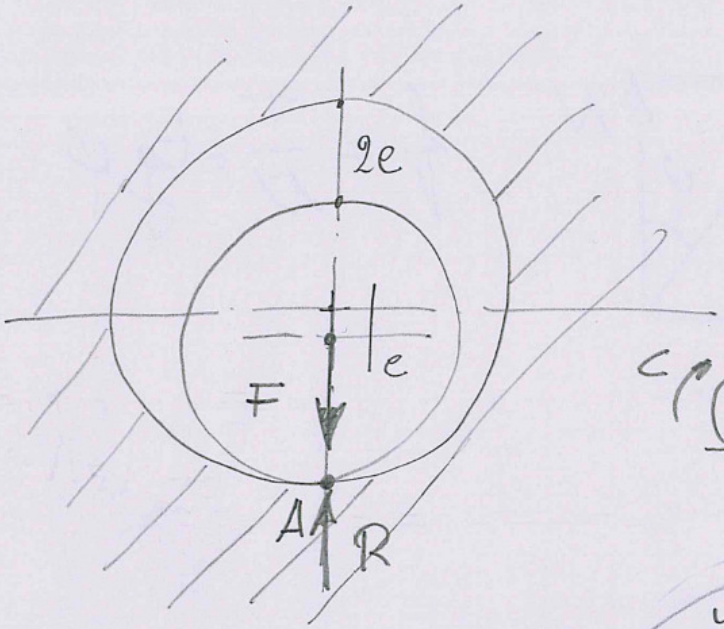
Contenuti:
Attrito statico e dinamico, esempi di accoppiamenti di superfici coniugate in presenza di attrito e aderenza.
Perno ad attrito secco, forze scambiate, forze di attrito, momento resistente al moto dovuto all'attrito.
Attrito volvente; valutazione delle azioni dissipatore in avanzamento di mezzo ferroviario su rotaia e mezzo stradale su ruota pneumatica.
Analisi del moto di mezzo interagente con ista in presenza di attrito.
Analisi del moto di corpo su piano inclinato: corpo strisciante, corpo in rotolamento puro e corpo rotante e strisciante.
Applicazione del teorema dell'energia a corpi in moto in presenza di attrito.

Riferimento:
Ferraresi C., Raparelli T. "Meccanica applicata - Terza edizione", CLUT, 2007.
Cap. 3 – Attrito.
Pagg. 93 - 114
Legnani G., Palmieri G. "Fondamenti di meccanica e biomeccanica del movimento", CittàStudi, 2016.
Cap. 4.4 – Forze di attrito e dissipative.
Pagg. 175 - 184

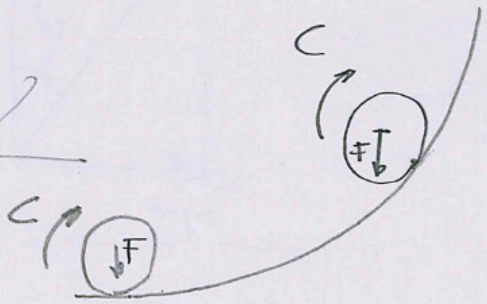
10.XI.17

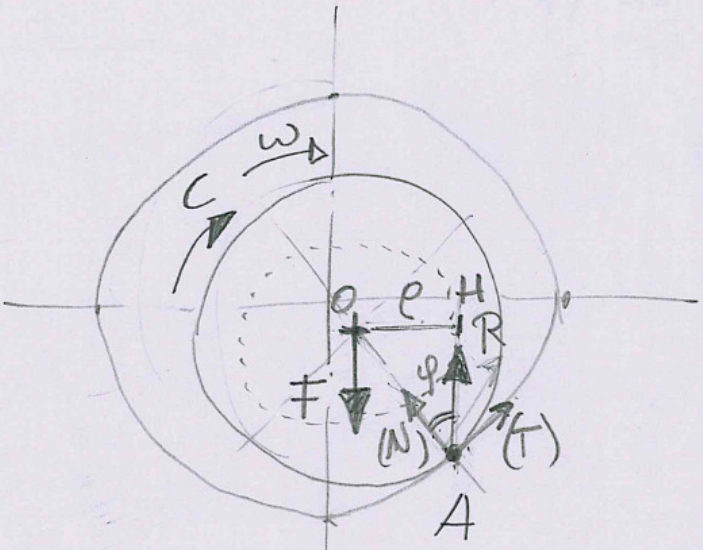
ACCOPPIAMENTO PERNO - BOCCOLA

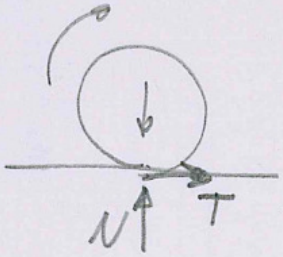




$$\bar{R} - \bar{F} = \bar{0}$$

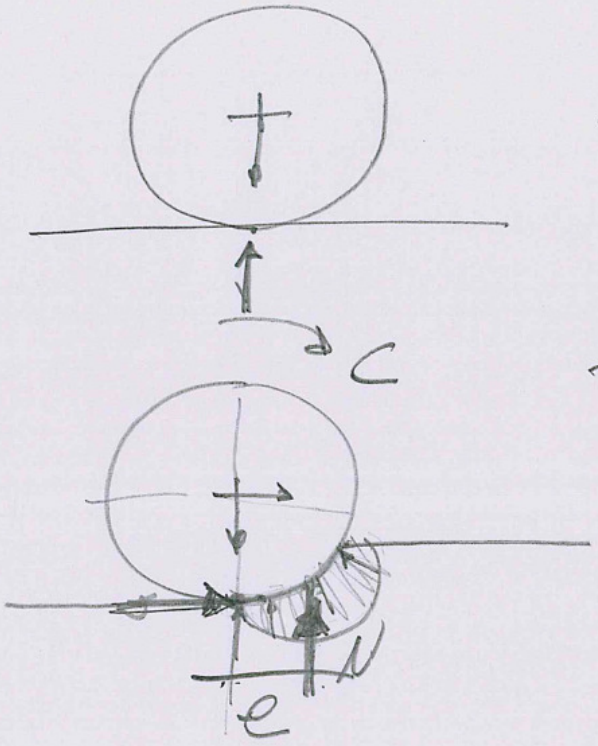






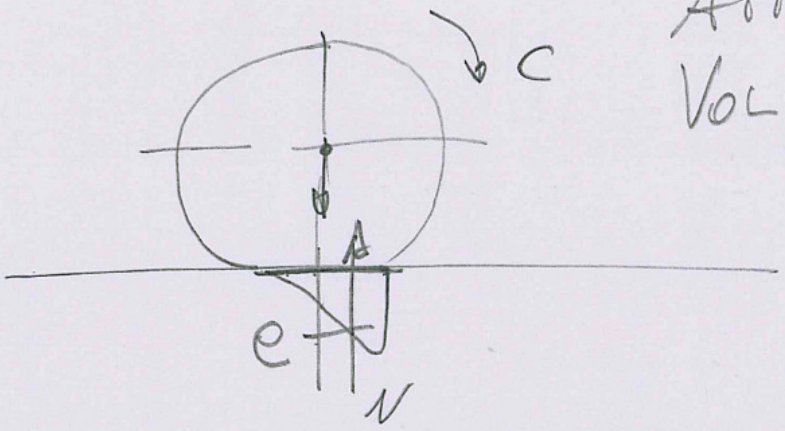
$$\begin{cases} \bar{F} - \bar{R} = 0 \\ R\,e - C = 0 \\ e = OA \cdot \sin\varphi = r_p \sin\varphi \end{cases}$$

$$C = F\, r_p \sin\varphi \qquad \varphi = \operatorname{atan} f$$

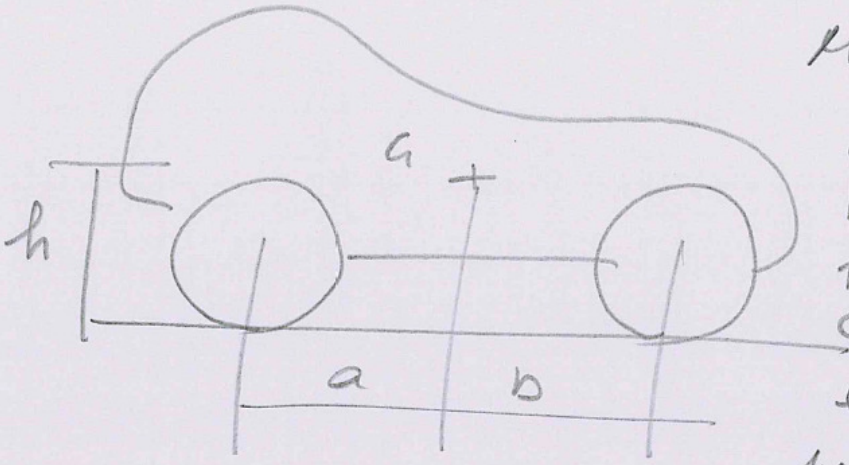


$P \cong 1000$ CV
15 VAGONI

$P \cong 500$ CV
1 RIMORCHIO
N 1 VAGONE



ATTRITO
VOLVENTE



$M = 1000\ kg$

$a = 1\ m$

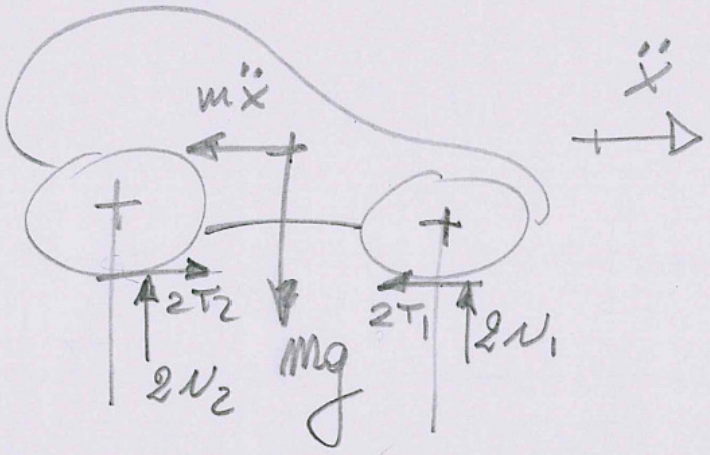
$b = 1{,}5\ m$

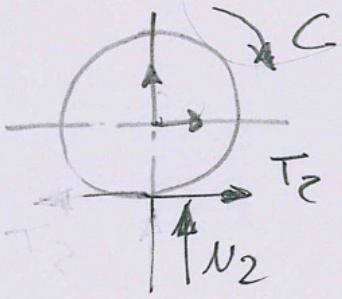
$h = 0{,}5\ m$

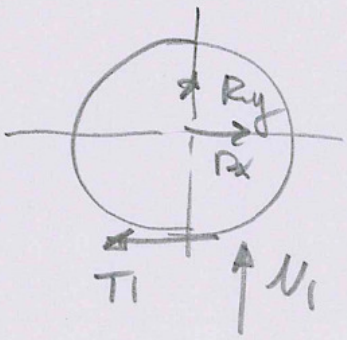
$C_M = 100\ Nm$

$e = 2\ cm$

AUTO TRAZ. POST.







$M = 100\,kg$

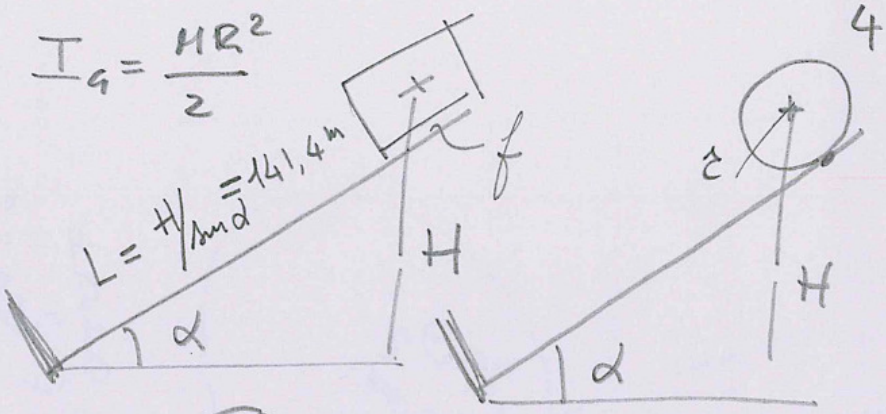
$H = 100\,m$

$f = 0,1$

$\alpha = 45°$

$r = 0,25\,m$

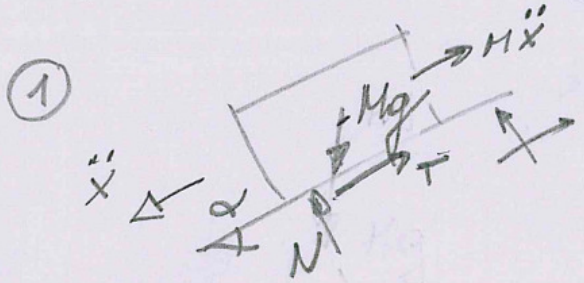
$I_G = \frac{MR^2}{2}$



t, V DERIVO

ADERENZA

(1)



$$\begin{cases} T - Mg\sin\alpha + M\ddot{x} = 0 \\ N - Mg\cos\alpha = 0 \\ T = fN \end{cases}$$

$$fMg\cos\alpha - Mg\sin\alpha + M\ddot{x} = 0$$

$$\ddot{x} = g(\sin\alpha - f\cos\alpha)$$

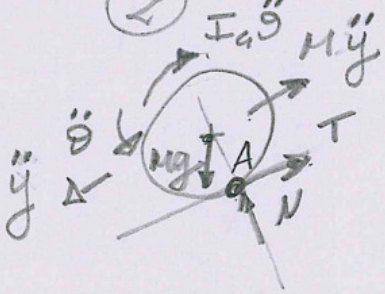
$$\ddot{x} = 9,81(\sin 45° - 0,1\cos 45°)$$

$$\ddot{x} = 6,24\ m/s^2$$

$$L = \frac{1}{2}\ddot{x}t^2 \qquad t = 6,73\,s$$

$$V = \ddot{x}\,t \qquad V = 42,01\ m/s$$

(2)



$$\begin{cases} T - Mg\sin\alpha + M\ddot{y} = 0 \\ N - Mg\cos\alpha = 0 \\ \ddot{y} = \ddot{\vartheta}r \end{cases}$$

$$A)\quad Mg\sin\alpha\, r - M\ddot{y}\,r - I_G\ddot{\vartheta} = 0$$

$$Mg\sin\alpha\, r - M\ddot{\vartheta}r^2 - \frac{Mr^2}{2}\ddot{\vartheta} = 0$$

$$\ddot{\vartheta}\left(\frac{3}{2}r\right) = g\sin\alpha$$

$$\ddot{\vartheta} = \frac{2}{3R}g\sin\alpha = 18,50\ \frac{rad}{s^2}$$

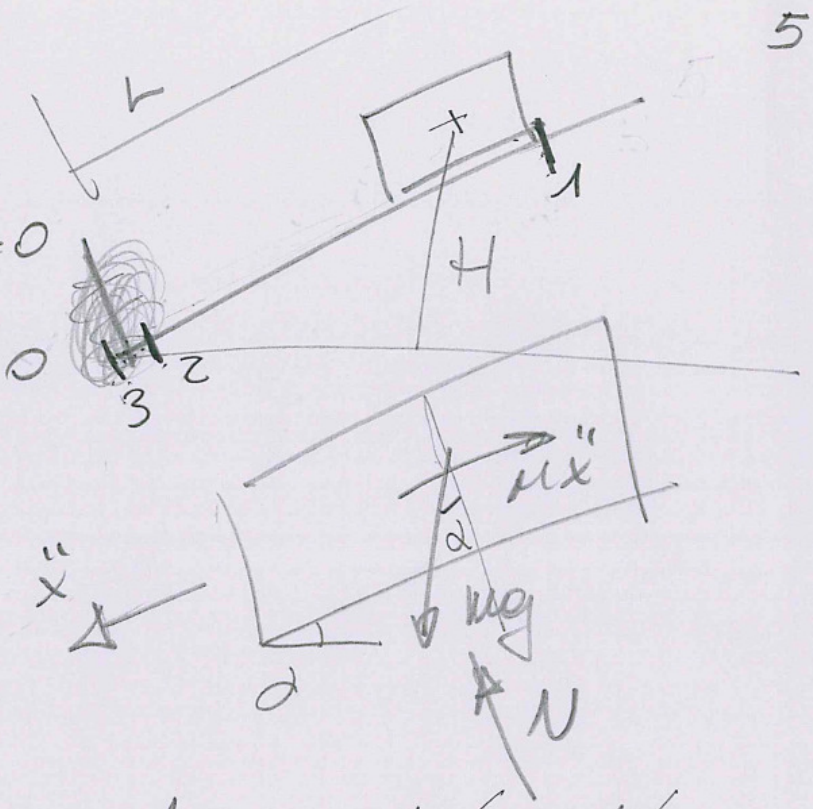
$$\ddot{y} = \ddot{\vartheta}r = 4,62\ m/s^2$$

$$L = \frac{1}{2}\ddot{y}t^2 \qquad t = 7,82\,s$$

$$V = \ddot{y}\,t = 36,16\ m/s$$

$$\omega = V/r = 144,66\ rad/s$$

NO
ΔΙΠΛΟ



$Mg\sin\alpha - M\ddot{x} = 0$

$Mg\cos\alpha - N = 0$

2-3

$$\cancel{L_e}^{=0} + L_i = \Delta E_c + \cancel{\Delta E_g}^{=0} + \cancel{\Delta E_k}^{=0}$$

$$L_i = -\frac{1}{2}MV^2$$

1-3

$$\cancel{L_e}^{=0} + L_i = \cancel{\Delta E_c}^{=0} + \Delta E_g + \cancel{\Delta E_k}^{=0}$$

$$L_i = -mgH$$

1-2

$$\cancel{L_e}^{=0} + \cancel{L_i} = \Delta E_c + \Delta E_g + \cancel{\Delta E_k}^{=0}$$

$$\Delta E_c + \Delta E_g$$

$$\frac{1}{2}MV^2 - MgH = 0$$

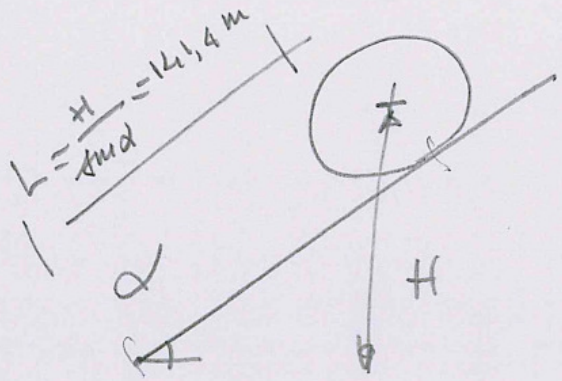
$M = 100\ kg$

$H = 100\ m$

$\alpha = 45°$

$R = 0{,}25\ m$

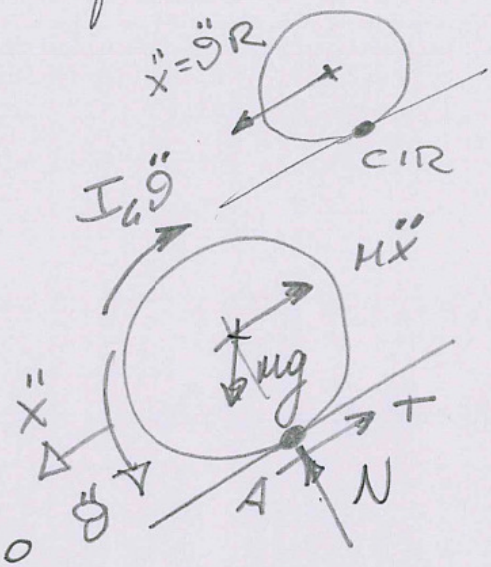
$f_{AD} = f = 0{,}1$



IPOTESI ADERENZA $T \leq f_{AD} N$

a) $\ddot{x} = R\ddot{\vartheta}$ DA VERIFICARE

$T \leq f_{AD} N$



b) $mg \sin\alpha - T - m\ddot{x} = 0$

c) $N - mg\cos\alpha = 0$

d) $mg \sin\alpha R - m\ddot{x}R - I_G\ddot{\vartheta} = 0$

$mg \sin\alpha R - mR^2\ddot{\vartheta} - \frac{mR^2}{2}\ddot{\vartheta} = 0$

$g \sin\alpha - R\ddot{\vartheta} - \frac{R}{2}\ddot{\vartheta} = 0$

$\ddot{\vartheta} = \frac{2}{3R} g \sin\alpha = \frac{2}{3}\frac{1}{0{,}25} 9{,}81 \sin 45° = 18{,}50\ \frac{rad}{s^2}$

$N = mg\cos\alpha = 100 \cdot 9{,}81 \cdot \cos 45° = 693{,}67\ N$

$T = mg \sin\alpha - m\ddot{\vartheta}R = m(g\sin\alpha - \ddot{\vartheta}R) = 231{,}17\ N$

$\frac{T}{N} \leq f_{AD}; \quad \frac{m(g\sin\alpha - \ddot{\vartheta}R)}{mg\cos\alpha} = \frac{g\sin\alpha - \ddot{\vartheta}R}{g\cos\alpha} = 0{,}33$

$T, \ddot{x}, N, \ddot{\vartheta}$

.) $mg \sin\alpha - T - m\ddot{x} = 0$

.) $N - mg\cos\alpha = 0$

.) $mg \sin\alpha R - m\ddot{x}R - I_G \ddot{\vartheta} = 0$

.) $T = fN$

$mg \sin\alpha R - m\ddot{x}R - \frac{mR^2}{2}\ddot{\vartheta} = 0$

$g \sin\alpha - \ddot{x} - \frac{R}{2}\ddot{\vartheta} = 0$

$mg \sin\alpha - f mg\cos\alpha - m\ddot{x} = 0$

$\ddot{x} = g(\sin\alpha - f\cos\alpha) = 6{,}24 \ m/s^2$

$\ddot{\vartheta} = \frac{2}{R}(g\sin\alpha - \ddot{x}) = 5{,}55 \ \frac{rad}{s^2}$

$L = \frac{1}{2}\ddot{x}t^2 \qquad t = \sqrt{\frac{2L}{\ddot{x}}} = 6{,}73 \ s$

$V = \ddot{x}t \qquad V = 42 \ m/s$

$\omega = \ddot{\vartheta}t \qquad \omega = 37{,}35 \ rad/s$

* $L_i = T \cdot \Delta S$

$\Delta S = L - R \cdot \vartheta$

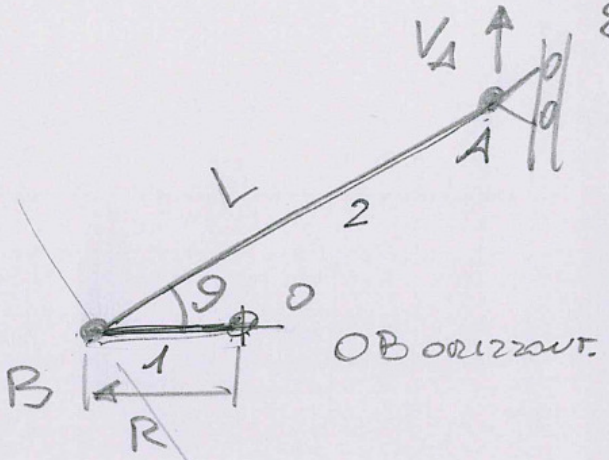
$\vartheta = \frac{1}{2}\ddot{\vartheta}t^2 = \frac{1}{2} 5{,}55 \cdot (6{,}73)^2 =$

$\vartheta = 30°$

$V_A = 1\ m/s$ COST

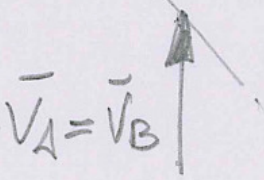
$R = 0{,}2\ m$

$L = 0{,}8\ m$



$\bar{V}_B = \bar{V}_A + \bar{V}_{B/A}$

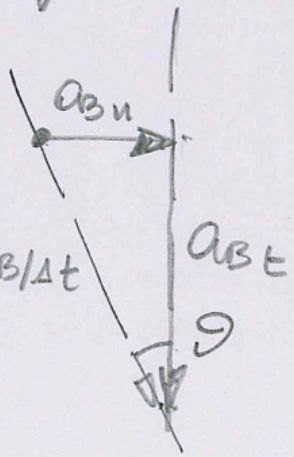
$\omega_1 R$?	$1\ m/s$	$\omega_2 L$?	M
$\perp OB$	$\parallel y$	$\perp AB$	D
?	↑	?	V



$\omega_2 = 0 \quad V_B = V_A = 1\ m/s \Rightarrow \omega_1 = \frac{V_B}{R} = \frac{1}{0{,}2} = 5\ \frac{rad}{s}$ (+k)

$a_{Bn} + a_{Bt} = a_A + a_{B/An} + a_{B/At}$

$\omega_1^2 R$ $5\ m/s^2$	$\dot{\omega}_1 R$?	0	$\omega_2^2 L$ 0	$\dot{\omega}_2 L$?	M
$\parallel OB$	$\perp OB$	A	A	$\perp AB$	D
$B \to O$	?	A	A	?	V



$a_{B/At} = \frac{a_{Bn}}{\tan\vartheta} = 10\ m/s^2$

$a_{Bt} = \frac{a_{Bn}}{\tan\vartheta} = 8{,}66\ m/s^2$

$\dot{\omega}_1 = a_{Bt}/R = 43{,}30\ \frac{rad}{s^2}$ (+k)

$\dot{\omega}_2 = \frac{a_{B/At}}{L} = 12{,}5\ \frac{rad}{s^2}$ (+k)