NUMERO: 1540A - ANNO: 2015

A P P U N T I

STUDENTE: Meli

MATERIA: Meccanica delle Macchine + Eserc. Prof.Pastorelli

ES 1 | 1,15

$a_o = 6\ m/s^2$

$g = 9\ m/s^2$

$\alpha = 15°$

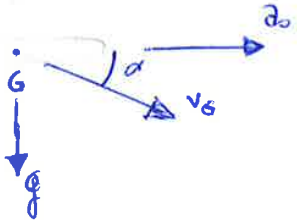
$V_G = 15000\ km/h = 4166{,}7\ m/s$

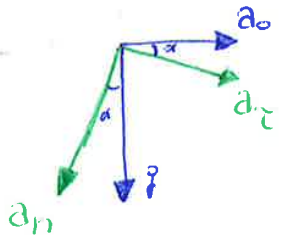
$\rho = ?$

$a_\tau = ?$

$\dot{\omega}?$

$\vec{\varepsilon}?$





C

$$\begin{cases} g = a_n \cos\alpha + a_\tau \operatorname{sen}\alpha \\ a_o = -a_n \operatorname{sen}\alpha + a_\tau \cos\alpha \end{cases} \Rightarrow g = a_n \cos\alpha + \operatorname{tg}\alpha\, a_o - a_n \frac{\operatorname{sen}\alpha \operatorname{sen}\alpha}{\cos\alpha}$$

$$a_\tau = \frac{a_o}{\cos\alpha} + a_n \operatorname{tg}\alpha$$

$$a_n = \frac{g - \operatorname{tg}\alpha\, a_o}{\cos\alpha - \operatorname{tg}\alpha \operatorname{sen}\alpha} = \frac{g - \operatorname{tg}\alpha\, a_o}{\frac{\cos^2\alpha - \operatorname{sen}^2\alpha}{\cos\alpha}} = 8{,}25\ m/s^2$$

$$a_\tau = \frac{a_o}{\cos\alpha} - a_n \operatorname{tg}\alpha = 4\ m/s^2$$

$$\begin{cases} g = a_n \cos\alpha + a_\tau \operatorname{sen}\alpha \\ a_o = -a_n \operatorname{sen}\alpha + a_\tau \cos\alpha \end{cases} \Rightarrow \begin{cases} g = a_n \cos\alpha + (a_o + a_n \operatorname{sen}\alpha)\operatorname{tg}\alpha \\ a_\tau = \frac{a_o + a_n \operatorname{sen}\alpha}{\cos\alpha} \end{cases} \Rightarrow a_n(\cos\alpha + \operatorname{sen}\alpha \operatorname{tg}\alpha) = g - a_o \operatorname{tg}\alpha$$

$$\Rightarrow a_n = 7{,}14$$

$$a_\tau = 8{,}12$$

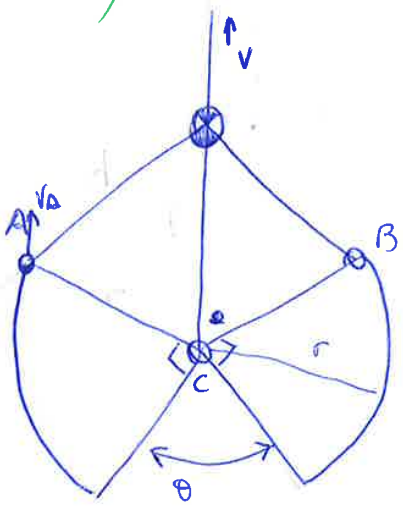
$$\vec{a} = \vec{a_n} + \vec{a_\tau}$$

$$a_n = -v^2/\rho \Rightarrow \rho = 2031{,}53\ km$$

$$a_\tau = \varepsilon \dot{\omega} \rho \Rightarrow \dot{\omega} = 3{,}339 \cdot 10^{-6}\ rad/s^2$$

$$\omega = V/\rho = 0{,}0017\ rad/s$$

ES 2 | 1,27



$V_o = 0{,}3\ m/s = V$

$\theta = 45°$

$\omega = ?$

$r = 0{,}5\ m$

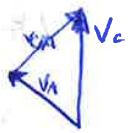
$AB = BO = d = 0{,}6\ m$

$\beta = 67{,}5$

$$V_C = V_A + V_{C/A}$$

$$/\!/ \ell \quad \perp AO \quad \perp AC$$

$$\alpha \quad V_A? \quad r\omega?$$



$$\frac{AB}{\operatorname{sen}\beta} = \frac{AC}{\operatorname{sen}\alpha} \Rightarrow \operatorname{sen}\alpha = 0{,}77 \Rightarrow \alpha = 50{,}35°$$

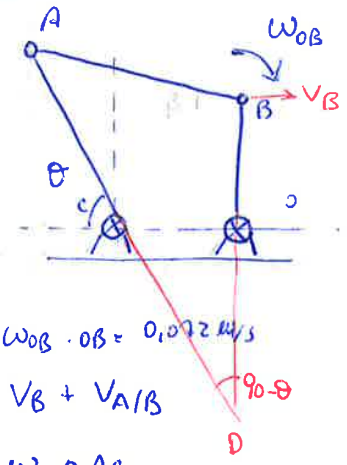
$$V_C = V_A \operatorname{sen}\alpha + V_{C/A} \operatorname{sen}\beta$$

$$V_C = V_A + \omega r$$

$$\frac{V_C}{\operatorname{sen}(\alpha+\beta)} = \frac{\omega \cdot r}{\operatorname{sen}\left(\frac{\pi}{2} - \alpha\right)} \Rightarrow \omega = 0{,}43\ rad/s$$

ES 04

1.42



$\omega_{OB} = 0,6$ rad/s

$\tan\theta = 4/3 \Rightarrow \theta = 53,1°$

$OB = 0,12$ m

$CA = 0,2$ m

$OC = 0,12$ m

$\omega_{AC} = ?$

$\dot{\omega}_{AC} = ?$

$AB = \sqrt{(AC\sin\theta - OB)^2 + (AC\cos\theta + OC)^2} = 0,243$ m

$\beta = \arctan\left(\frac{AC\sin\theta - OB}{AC\cos\theta + OC}\right) = 9,47°$

$V_B = \omega_{OB} \cdot OB = 0,072$ m/s

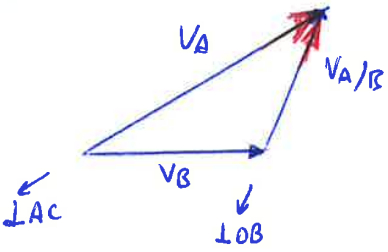
$V_A = V_B + V_{A/B}$

$V_A = \omega_{AC} \wedge AC$

$V_A = V_B + V_{A/B}$

$\perp AC \quad \perp OB \quad \perp AB$

$? \quad \omega_{OB}OB \quad ?$



$BD = OB + \frac{OC}{\tan(90-\theta)} = 0,28$ m

$V_B = DB\,\omega_{AB} \Rightarrow \omega_{AB} = 0,257$ rad/s

~~$V_A = V_B + \omega_{AB}$~~

$AD = AC + \frac{OC}{\sin(90-\theta)} = 0,4$

$V_A = AD\,\omega_{AB} = 0,1028$ m/s

$\omega_{AC} = V_{AD/OB} = 0,856$ rad/s

$V_A = V_B + \omega_{AB}\,AB$

$V_{A/B} = 0,0308$ m/s

$a_B = a_{Bn} = V_B^2/OB = 0,0432$

$a_{Bt} = \dot{\omega}_{OB}OB = 0$ perché $\dot{\omega}_{OB} = 0$

$a_A = a_{Bn} + a_{B/A}$

$a_n + a_t$

$\parallel BA \quad \perp BA$

$? \quad ?$

$V_A^2/AC \quad \dot{\omega}_{AC}CA$

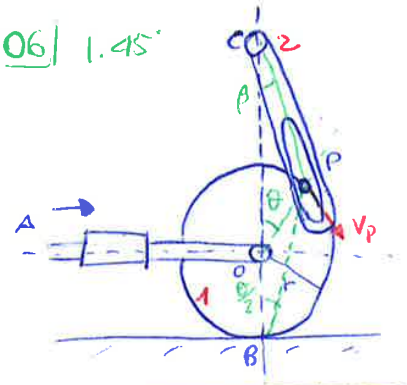
$a_{nB/A} + a_{tB/A}$

$\parallel BA \quad \perp BA$

$? \quad ?$

$V_{A/B}^2/AB \quad \dot{\omega}_{BA}BA$

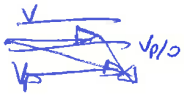
06 | 1.45'



$V = 2\ m/s$
$r = 0,1\ m$
$OC = 0,2\ m$
ω_2? ← $\theta = 30$
$\dot{\omega}_1$ = ?

$v = v_0 = \omega_1 r \Rightarrow \omega_1 = 20\ rad/s$

~~$V_p = V_0 + V_{p/0}$~~
~~$\perp CP \quad \perp \omega \cdot OP$~~
~~$? \quad V \quad \omega_1 \cdot OP$~~



$V_p =$

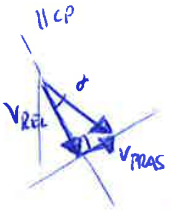
$CP = \sqrt{r^2 + OC^2 - 2 r\, OC \cos\theta} = 0,123\ m$

β: $\frac{r}{\sin\beta} = \frac{CP}{\sin\theta} \Rightarrow \sin\beta = 0,406 \Rightarrow \beta = 23,98°$

$BP: 2r\cos\theta_2 = 0,193\ m$

$V_p = \omega_1 BP = 3,86\ m/s$

$V_p = V_{REL} + V_{TRASC}$
$\perp BP \quad \parallel CP \quad \perp CP$
$OK \quad ? \quad \omega_2 CP$

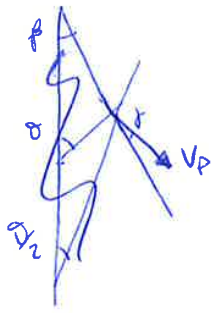


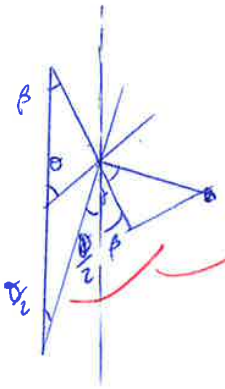
$\gamma = 90 - \frac{\theta_2}{2} - \beta = 54,02°$

$\Rightarrow V_{TR} = V_p \sin\gamma = 3\ m/s$

$\Rightarrow V_{TR} = \omega_{1CP} \Rightarrow \omega_2 = 24,4\ rad/s$

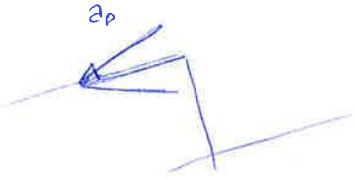
$V_{rel} = V_p \cos\gamma = 2,13\ m/s$

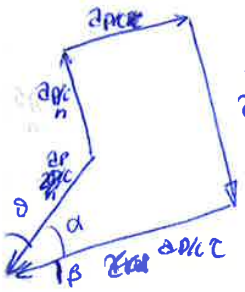




$a_P = a_{REL} + a_{TR} + a_C$

$a_P + a_{P/On} + a_{P/OT}$ | $a_{P/Cn} + a_{P/CT}$ | $2\omega_2 v_{rel}$
$\omega_1^2 OP \quad \dot{\omega}_1 = 0$ | $\parallel CP \quad \perp CP$ | $\perp CP$
? | $\omega_2^2 CP \quad \dot{\omega}_2 CP$ |



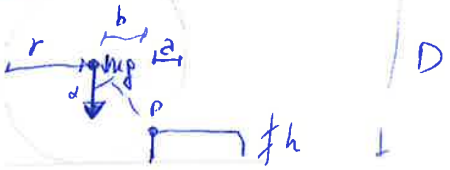


$\alpha = 90 - \beta - \gamma = 36,02°$

$a_{P/CT} = a_P \cos\alpha + a_{PC} = 150,9$

$\dot{\omega}_2 = \frac{a_{P/CT}}{PC} = 1227,1\ rad/s$

ES 0,9 (2.31)



$D = 0.9\,m$
$m = 30\,kp$
$C = ?$
$h = 0,09\,m$
$f_a = ?$

P): $C - mp\,b = 0$

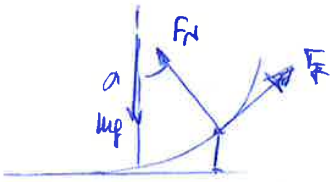
$\Rightarrow C = 79.38\,Nm$

$(r-h)^2 + (r-a)^2 = r^2$

$= 0,1296 + r^2 + a^2 - 2ra = r^2$

$a^2 - 2ra + 0,1296 = 0$

$P = (0,27; 0,09)$



$\frac{2r \pm \sqrt{4r^2 - 4 \cdot 0,129}}{2} =$

$\frac{0,9 \pm 0,54}{2} \Rightarrow a = 0,18 \Rightarrow b = 0,27$

$\alpha = \arctg\left(\frac{b}{r-h}\right) = 36,87°$

ok!

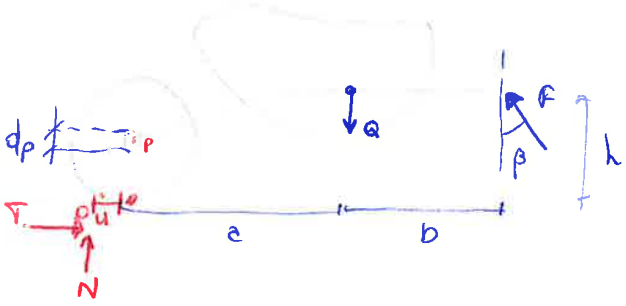
$F_N = mp\cos\alpha$

$F_T = mp\,\sin\alpha$

$f_T = F_N f$

$\Rightarrow mp\,\sin\alpha = mp\cos\alpha \cdot f \Rightarrow f = tg\alpha = 0,75$

ES 10) (2.37)



$Q = 400\,N$
$a = 0.6\,m$
$b = 0,5\,m$
$h = 0,8\,m$
$D = 0.4\,m$
$u = 0,01\,m$
$q_p = 25\,mm \Rightarrow r_p = 12,5$
$f_p = 0.18$
$F = f \setminus V = cost$
$\beta = ?$

P) $N - Q = F\cos\beta = 0$

P) $F\,\sin\beta = T$

O) $Q(a+u) + F\cos\beta(a+b) - F\sin\beta\,h = 0$

P) $T_r - N(\rho+u) = 0 \Rightarrow T = N(\rho+u)/r$

$Q(a+u) + (N-Q)(a+b) - N(\rho+u) = 0$

$\Rightarrow N = 424,1\,N$

$T = 25,9\,N$

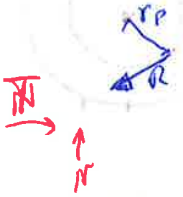
$F = 476,6\,N$

$\beta = 3.12$

$\rho = r_p \sin\varphi$

$\varphi = \arctg_p f =$

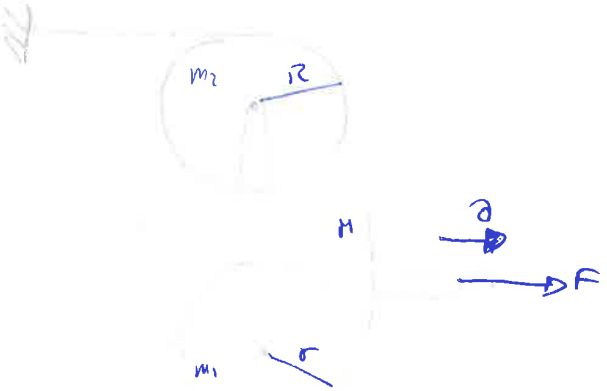
$\Rightarrow \rho = 2,21\,mm$



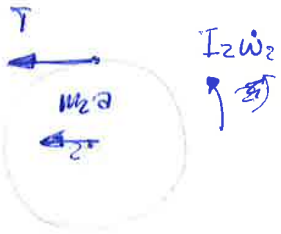
P) $T_r - N(\rho+u) = 0$

Es 13 (3.35)

$R = 0{,}5\,m$
$m_2 = 50\,kg$
$\rho_2 = 0{,}42\,m$
$M = 100\,kg$
$m_1 = 15\,kg$
$\rho_1 = 0{,}3\,m$
$F = 1400$
$r = 0{,}4\,m$
$a = ?$



$\dot\omega_1 = a\,r$
$\dot\omega_2 = a\,R$



$F - T - (m_2 + M + 2m_1)a - 2f_T = 0$

2) $TR = \frac{1}{2} m_2 \rho_2^2 \dot\omega_2$

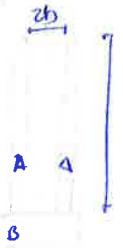
1) $2f_T r = 2\left(\frac{1}{2} m_1 \rho_1^2 \dot\omega_1\right)$

$F - \frac{m_2 \rho_2^2 \dot\omega_2 R}{R} - (m_2 + M + 2m_1)a - \frac{2m_1 \rho_1^2 \dot\omega_1}{r} = 0$

($\dot\omega_2 R \to a$, $\dot\omega_1 r \to a$)

$$\Rightarrow a = \frac{F}{kg\left[\frac{m_2 \rho_2^2}{R^2} + (m_2 + 2m_1 + M) + \frac{2m_1 \rho_1^2}{r^2}\right]} = \frac{1400}{252{,}5} \approx 1{,}77\ m/s^2$$

Es 14 (3.39)



$l = 0{,}3\,m$
$m_A = 1{,}5\,kg$
$m_B = 4\,kg$
$\rho_B = 0{,}04\,m$
$n_0 = 300\,giri/min$
$b = 0{,}06\,m$

$\frac{1}{2}\left(m_B \rho_B^2\right) n_0^2 + \frac{1}{2}\cdot 2\left(\frac{1}{12} m_A b^2\right) n_0^2 + 2 m_A g \frac{l}{2} =$

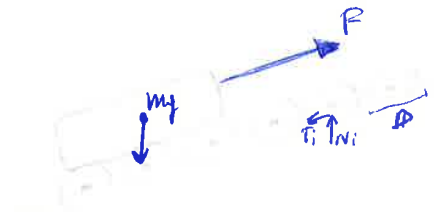
$\frac{1}{2} m_B \rho_B^2 n^2 + \frac{1}{2}\cdot 2 \cdot \frac{1}{12} m_A \left(\frac{l^2}{12} + \left(\frac{l}{2} + b\right)^2\right) =$

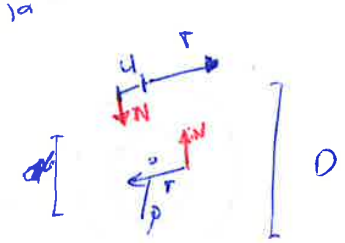
$\Rightarrow n = 164{,}8\ giri/min$

$\frac{1}{2}\left(m_B \rho_B^2\right) n_0^2 + \frac{1}{2}\cdot 2 \cdot \left(m_A b^2\right) n_0^2 + 2 m_A g \frac{l}{2} =$

$= \frac{1}{2} m_B \rho_B^2 n^2 + \frac{1}{2}\cdot 2 m_A \left(\frac{l^2}{12} + \left(\frac{l}{2} + b\right)^2\right) \Rightarrow$

Problema 18 (4.9)





$\alpha = 5°$
$D = 0.3\,m$
$d = 0,05\,m$
$f = 0.08$
$u = 1.25\,mm$
$\eta = ?$

$\eta = \frac{L_{utile}}{L_{svolto}} = \frac{mg\sin\alpha\, V}{F V} = \frac{0,85\,W}{1.06\,W} = 80.10\%$

$F - \cancel{mg\sin\alpha} - \cancel{\Sigma T_i} = 0$
$\Sigma N_i - mg = 0$

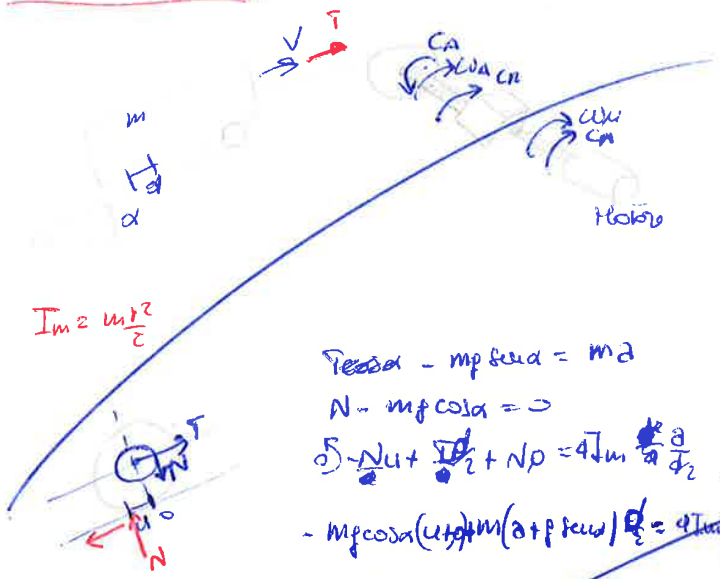
$f - mg\sin\alpha - \Sigma T_i = 0$
$\Sigma N_i - mg\cos\alpha = 0$

$\varphi = \arctan(f)$
$\rho = \frac{d}{2}\sin\varphi$

$\sum M_i: Nu + N\rho - T\frac{D}{2} = 0 \Rightarrow T = N\left(\frac{u+\rho}{D/2}\right)$
$T = N \cdot 0,0 \cdots 216$

$N = mg\cos\alpha \Rightarrow T = m \cdot 0,\cdots 211$
$F = m\,0,85 - m\,0,\cdots 34$ $F = m\,(\cdots)$
$F = m\,0.85 - m\,0.2\,m$

Es 19 (4.13)



$m = 2000\,kg$
$d = 10°$
$D = 1.28\,m$
$I_A = 25\,kg\,m^2$
$I_M = 0.15\,kg\,m^2$
$\tau = \frac{\omega_A}{\omega_M} = 1/36$
$d = 0,7\,m$
$\rho = \cdots 3\ 900\,kg/m$
$u = 15\,mm$
$\eta = 0,75$

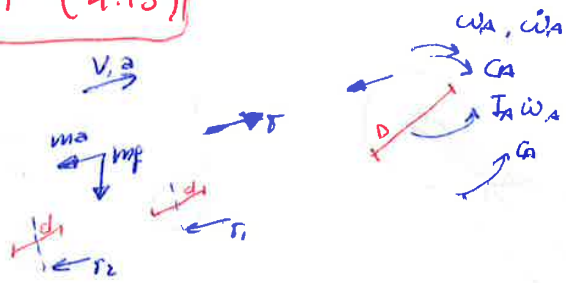
$T_{resa} - mg\sin\alpha = ma$
$N - mg\cos\alpha = 0$
$\sum M: -Nu + T\frac{D}{2} + N\rho = 4 I_m \frac{a}{d} \frac{d}{2}$
$-mg\cos\alpha(u+\rho) + mg\sin\alpha\frac{d}{2} = 4 I_m \frac{a}{d}\frac{d}{2} \Rightarrow$
$\Rightarrow mg\cos\alpha(u+\rho) + mg\sin\alpha\frac{d}{2} = \left(4\frac{I_m}{d^2} + m\right)a \Rightarrow a = \cdots\,m/s^2 \Rightarrow T = \cdots\,N$

1) $V = 18\,km/h$ P?
2) $\omega_M = ?$
$T_0 = ?$ \ $C_0 = 2C_R$

1,406
7458,6W

$P_A = T\frac{D}{2}V = \cdots\,kW = 25,483\,kW$
$\omega_A = V/\frac{D}{2} \Rightarrow C_R = \frac{P_A}{\omega_A} = 326,88\,Nm$
$\omega_M = \frac{\omega_A}{\tau} = 180\,rad/s$
$P_M \frac{P_R}{P_M} = \eta \Rightarrow P_M = \frac{P_A}{\eta} = \cdots\,kW \Rightarrow C_M = 188,76\,Nm$
INV: $P_A = \eta P_M \Rightarrow T_0 V = \eta 2\pi\omega \Rightarrow T_0 = 1019\cdots,52\,N$

Es 19 (4.13)



$m = 2400\ kg$ $\alpha = 0$

$D = 1.28\ m$

$I_A = 25\ kg\,m^2$

$I_M = 0.15\ kg\,m^2$

$\tau = \frac{\omega_A}{\omega_M} = \frac{1}{36}$ $\eta = 0.75$

$d = 0.7\ m$

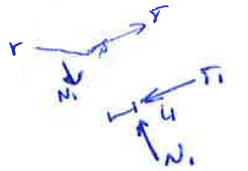
$\rho = 5\ mm$

$u = 15\ mm$

$P_M = ?$ $\vartheta = 0$ $V = 18\ km/h$

$\omega_M = ?$

$T_0 \setminus C_0 = 2C_M$, $V = 0$



$$\begin{cases} T_1 = \frac{2(\rho+u)}{d} N_1 \\ T_2 = \frac{2(\rho+u)}{d} N_2 \\ T - T_1 - T_2 - mp \sin\alpha = ma \\ N_1 + N_2 - mp\cos\alpha = 0 \end{cases}$$

$$\Rightarrow T = mp\left[\sin\alpha + \frac{2(\rho+u)\cos\alpha}{d}\right] + ma$$

~~$T = \frac{2(\rho+u)}{d} N_M$~~

$C_A = T_A \frac{D}{2} + I_A \dot{\omega}_A$

$\dot{\omega}_A = a/(D/2)$

~~$C_M = \frac{C_A}{\eta} + I_M \dot{\omega}_M$~~ ~~$P_A = P_M \eta$~~

~~$C_A \omega_A = \eta C_M \frac{\omega_A}{\tau}$~~

$\dot{\omega}_M = \frac{\dot{\omega}_A}{\tau}$

$P_A = \eta P_M$

~~$C_A \omega_A = \eta [C_M \frac{\omega_A}{\tau} \Rightarrow C_M = C_A \frac{\tau}{\eta}$~~

$C_A \omega_A = \eta [C_M - I_M \dot{\omega}_M] \omega_A/\tau \Rightarrow \frac{C_A \tau}{\eta} + I_M \dot{\omega}_M = C_M \Rightarrow \frac{C_A \tau}{\eta} + I_M \frac{\dot{\omega}_A}{\tau} = C_M$

$\Rightarrow \left(T_A \frac{D}{2} + I_A \dot{\omega}_A\right)\frac{\tau}{\eta} + I_M \frac{\dot{\omega}_A}{\tau} = C_M$ se $\dot{\omega}_M = 0$ se ~~$V = 18\ km/h$~~ $V = 5\ m/s$

$\Rightarrow C_M = mp\left[\sin\alpha + \frac{2(\rho+u)\cos\alpha}{d}\right]\frac{D}{2}\cdot\frac{\tau}{\eta} = 125.1\ Nm$

$\omega_M = \frac{\omega_A}{\tau}$ $\omega_A = V/(D/2) \Rightarrow \omega_M = 281.25\ rad/s$

$C_0 = \left(T_A \frac{D}{2} + I_A \dot{\omega}_A\right)\frac{\tau}{\eta} + I_M \frac{\dot{\omega}_A}{\tau} = mp\left[\sin\alpha + \frac{2(\rho+u)\cos\alpha}{d}\right]\frac{D}{2}\frac{\tau}{\eta} + I_M \frac{\dot{\omega}_M}{\tau} + (ma + I_A \dot{\omega}_A)\frac{\tau}{\eta}$

$\downarrow 2C_M$

$\Rightarrow$

$\omega_A = 0.88\ rad/s^2 \Rightarrow a = 0.563\ m/s^2 \Rightarrow T_0 = 6626.7\ N$

$2C_0 = \frac{\tau}{\eta}\left\{ I_A \dot{\omega}_A + \frac{D}{2}\left(mp\left[\sin\alpha + 2\frac{(\rho+u)\cos\alpha}{d}\right] + ma\right)\right\} + I_M \frac{\dot{\omega}_A}{\tau}$

$250.2 = 126.1 + 5.4\dot{\omega}_A + 0.23\dot{\omega}_A + 90\dot{\omega}_A \Rightarrow \omega_A = 1281.29 \Rightarrow a = 203\ m/s^2 \Rightarrow T = 101499\ N$

ES 1.1

$a = 5 - 0{,}2v^2$

$t_f = ?$

$V = 7{,}5\ m/s$

$S_f =$

$v_0 = 0$

$a = (5 - 1.25) = 3{,}75\ m/s^2$

$v = v_0 + at \rightarrow t_f = 0{,}67\ s$

$S_f = v t_f + \frac{1}{2} a t_f^2 = 0{,}833\ m$

$a = \frac{dv}{dt} \rightarrow dt = \frac{dv}{a(v)}$

$t_f = \int_0^{v_f} \frac{dv}{5 - 0{,}2v^2} =$

$= \left[\text{tgh}(0{,}2v)\right] - \frac{0{,}2v^3}{3}$

$a_0 = 5\ m/s^2 \quad 0{,}2\ m^{-1} = c$

$t_f = \int_0^{v_f} \frac{dv}{a_0 - cv^2} = \int_0^{v_f} \frac{dv}{\left(\frac{a_0}{c} - v\right)}$

$\sqrt{\frac{a_0}{c}} = v$

1.2

$a = 4 - 0{,}5t$

$S = 100\ m$

$t = ?$

$V_0 = 0$

$t = \frac{-a + 4}{0{,}5}$ Considero l'istante in cui $a = 0 \rightarrow t^* = 8\ s$

$V^* = \int_0^8 a(t)\,dt = \int_0^{t^*} (4 - 0{,}5t)\,dt = \left(4t - 0{,}5\frac{t^2}{2}\right)_0^8 = 32 - 16 = 16\ m/s$

$S^* = \int_0^{16.8} v(t)\,dt = \int_0^8 \left(4t - \frac{t^2}{4}\right) dt = \left(2t^2 - \frac{t^3}{12}\right)_0^8 =$

$= 128 - \frac{128}{3} = \frac{256}{3} = 85{,}33\ m$

$S - S^* = 14{,}67\ m = \Delta S \rightarrow \Delta t = V^* t \rightarrow t = 0{,}916\ s$

$\rightarrow t_{tot} = t^* + t = 8{,}916\ s$

1.7

$v_0 = 1.2\ m/s$

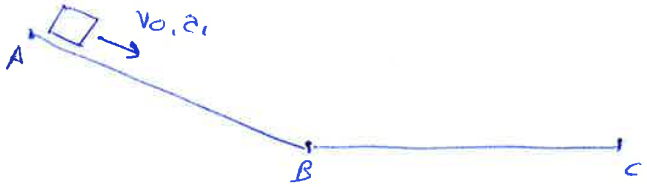
$a_1 = 3\ m/s^2$

$a_2 = ?$

$t_2 = ?$

$s_1 = 3\ m$

$s_2 = 3.6\ m$



AB: $\begin{cases} s_1 = \frac{1}{2} a_1 t^2 + v_0 t \\ v_1 = v_0 + a_1 t \end{cases} \Rightarrow t \Rightarrow 3 = 1.5t^2 + 1.2t \Rightarrow 1.2t + 1.5t^2 - 3 = 0$

$\frac{-1.2 \pm 4.4}{3} = 1.06\ s$

$4.007\ m/s = v_1$

BC: $\begin{cases} s_2 = \frac{1}{2} a_2 t_2^2 + v_2 t_2 \\ v_2 = v_1 + a_2 t_2 \Rightarrow v_2 = 0 \end{cases} \Rightarrow v_0 - \frac{v_1}{a_2} = t_2$

$s_2 = \frac{1}{2} a_2 \frac{v_1^2}{a_2^2} + v_1 \left(-\frac{v_1}{a_2}\right) \Rightarrow s_2 = \frac{1}{2}\frac{v_1^2}{a_2} - \frac{v_1^2}{a_2} \Rightarrow$

$\Rightarrow s_2 = -\frac{1}{2}\frac{v_1^2}{a_2} \Rightarrow a_2 = -\frac{1}{2}\frac{v_1^2}{s_2} = -2.7\ m/s^2$

$t_2 = 1.632\ s$

1.12

$d = 0.02\ m$

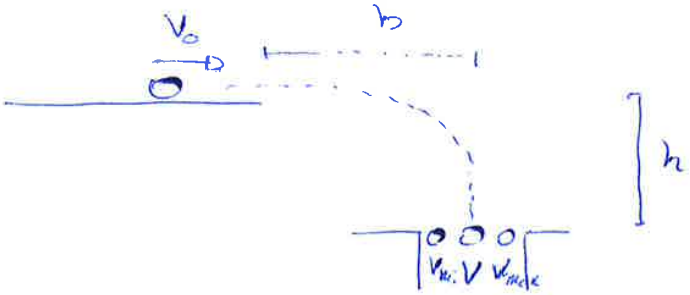
$D = 0.08\ m$

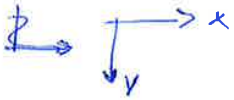
v_{min}?

v_{max}?

$h = 0.09\ m$

$b = 0.12\ m$





$\rightarrow: \begin{cases} x = v_{0x} t \end{cases}$

$\downarrow: \begin{cases} y = v_{0y} t + \frac{1}{2} g t^2 \end{cases}$

$\begin{cases} x = v_{0x} t \\ y = v_{0x} t \tan\alpha + \frac{1}{2} g t^2 \end{cases}$

$v_{0x} = \frac{v_{0y}}{v_x} = \tan\alpha$

$\frac{h}{b} = \tan\alpha \Rightarrow t \tan\alpha$

$t\tan\alpha = 0.7\ s$

Se $x = \left(\frac{D}{2} - \frac{3}{2}d\right) \Rightarrow \begin{cases} \frac{D}{2} - \frac{3}{2}d = v_{0x} t \\ h = t v_{0x} \tan\alpha + \frac{1}{2} g t^2 \end{cases}$ c_1

$t = \frac{c_1}{v_{0x}}$ $v_{0x} = \frac{c_1}{t}$

$h = v_{0x} t \tan\alpha + \frac{1}{2} g \left(\frac{c_1}{v_{0x}}\right)^2$

$h = \frac{c_1}{t} t + \frac{1}{2} g t^2 \Rightarrow$

$t = 0.277\ s \Rightarrow v_{0x} = 0.077\ m/s$

$0.129\ s$

$V = 0.098\ m/s$

Se $x = \frac{D}{2} + \frac{3}{2}d \Rightarrow c_2 = v_{0x} t$

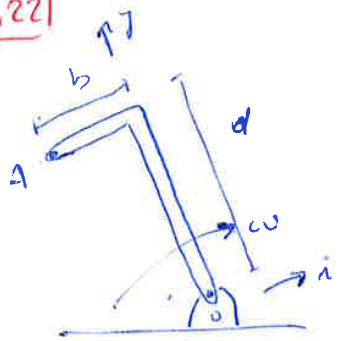
$h = t\, v_{0x} \tan\alpha + \frac{1}{2} g t^2 \Rightarrow$

$\Rightarrow h = t \cdot \frac{c_2}{t} \tan\alpha + \frac{1}{2} g t^2 \Rightarrow t = 0.0875\ s$

$\Rightarrow v_{0x} = 0.8\ m/s \Rightarrow V = 1\ m/s$

CINEMATICA CORPI RIGIDI

1.22



$\dot{\omega} = 2\ rad/s$

$V_A = ?$ | $\omega = 3\ rad/s$

$a_A = ?$

$b = 0{,}3\ m$

$d = 0{,}4\ m$

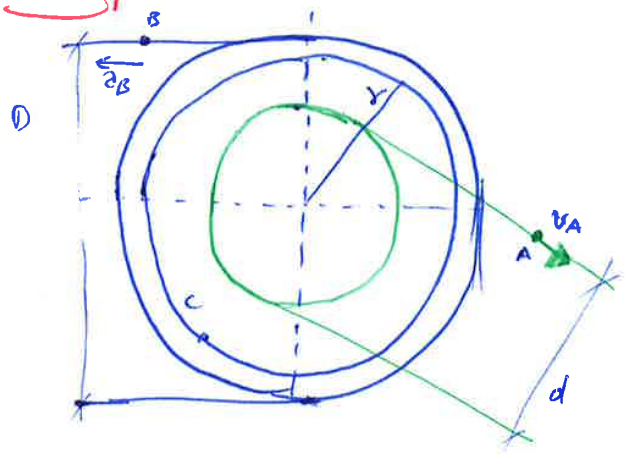
$OA = -b\,i + d\,j$

$V_A = \omega \wedge OA = -0{,}9\,i + 1{,}2\,j\ rad/s$

$a_A = \dot{\omega} \wedge OA + \omega^2(OA) = -0{,}6\,i + 0{,}8\,j + 2{,}7\,i + 3{,}6\,j$

$= 1{,}9\,i - 4{,}2\,j\ rad/s$

1.24



$V_A = 2\ m/s$

$a_B = 35\ m/s^2$

$a_C = ?$

$D = 0{,}8\ m$

$d = 0{,}15\ m$

$r = 0{,}36\ m$

c) ~~$a_t = a_B \cdot r = 12{,}6\ m/s^2$~~

~~$a_n = V_A^2/r =$~~

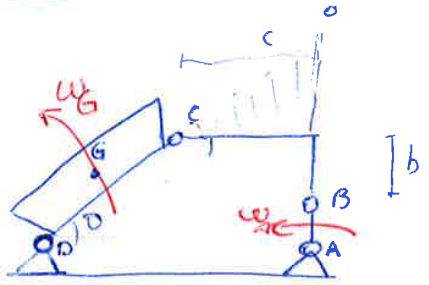
$\alpha_B = a_B / D/2 = 87.5\ rad/s^2$

$\omega_A = V_A / d/2 = 26.67\ rad/s$

→ c) $a_t = \alpha_B \cdot r = 31{,}5\ m/s^2$

$a_n = \omega_A^2 \cdot r = 256\ m/s^2$

1.36 CINEMATISMI ARTICOLATI

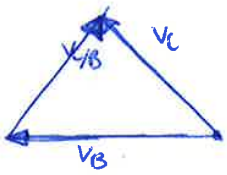


$DC = d = 0,36m$
$c = 0,24m$
$b = 0,1m$
$a = AB = 0,08m$
$\omega_A = 120$ giri/min
$\omega_G = ?$

$V_B = V_A + V_{B/A} = 1$ rad/s
$0 \quad \frac{2\pi n}{60} \cdot a$

$CB = \sqrt{c^2 + b^2} = 0,26m$

$V_C = V_B + V_{C/B}$
$\perp CD \quad \perp AB \quad \perp CB$
$\omega_G d \quad \omega_A a \quad ? \cdot CB$
$?$



$\omega_A : CB = \omega_{CB} : CB$
$\omega_{CB} = \omega_A \cdot \frac{CB}{AB} = 3,25$ rad/s
$V_C = \omega_G = \frac{\omega_A a + \omega_{CB} \cdot CB}{d} =$
$= 2,57$ rad/s

$\vartheta = \arcsen \frac{a+b}{d} = 30°$

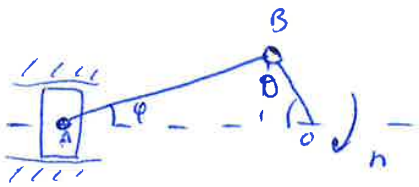
$OC = \frac{c}{\cos\vartheta} = 0,277m$

$OB = b + tg\vartheta \, c = 0,238m$

$V_C : OC = \omega_B : OB \rightarrow V_C = \frac{V_B \cdot OC}{OB} = 1,16$ m/s

$\rightarrow \omega_G = 3,22$ rad/s

1.37

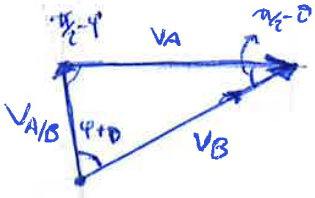


$AB = L = 0,35m$
$OB = r = 0,125m$
$n = 1500$ rpm $\quad \omega_{OB} = 157,07$ rad/s
$\vartheta = ? \quad \vartheta = 60°$
$V_A = ?$
$a_A = ?$
$\omega_{AB} ?$
$\alpha_{AB} = ?$

$V_B = V_O + \omega_{OB} r = 19,6$ m/s
0

$l \sen\varphi = r \sen\vartheta \rightarrow \varphi = 15,02°$

$V_A = V_B + V_{A,B}$
$\parallel AO \quad \downarrow \quad \perp AB$
$\perp OB \quad \omega_{B/A} \cdot AB$
$\omega_{OB} r$

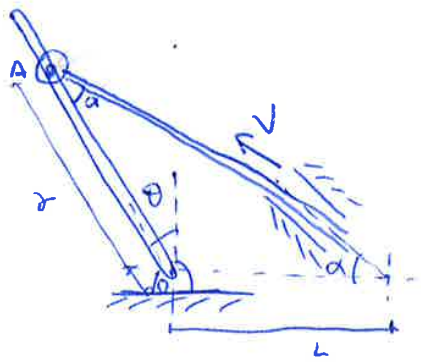


$29,44$ rad/s $= \omega_{BA} \leftarrow V_{B/A} = 10,3$ m/s $\quad \frac{V_{B/A}}{\sen(\frac{\pi}{2}-\vartheta)} = \frac{V_B}{\sen(\frac{\pi}{2}-\varphi)} = \frac{V_A}{\sen(\varphi+\vartheta)} \rightarrow V_A = 20,17$ rad/s

$\rightarrow$

$\omega_{BA} = \frac{V_B - V_A}{AB} = -7,77$ rad/s

1.44



$\alpha = 30$

$V = 4\ m/s = cost$

$\dot{r}$? , $\ddot{r}$?

$\ddot{\theta}$? $|\theta = 30°$

$L = 0{,}3\ m$

~~$V_A = V_{rr} + V_t$~~

~~V_{rr}~~ $= V \cdot \cos\alpha = \dot{r} = V_r$

$V_t = V \cdot \sin\alpha$

$V_A = V_r + V_t$

$V_r = V\cos\alpha = 3{,}464\ m/s$

$V_t = V\sin\alpha = 2\ m/s \rightarrow V_t = \omega r \rightarrow \omega = 6{,}67\ rad/s$

~~$a_A = a_t + a_n$~~

$a_A = 0 = a_r + a_t + a_c$ ($a_c \rightarrow 2\omega \wedge V_r$)

$a_r \rightarrow \omega^2 r$

$a_t \rightarrow \dot{\omega} \wedge OA - \omega^2 OA$ (a_t / a_n)

$0 = \omega^2 r + \dot{\omega} \wedge OA - \omega^2 OA + 2\omega \wedge V$

$\rightarrow \dot{\omega} r = 2\omega V$

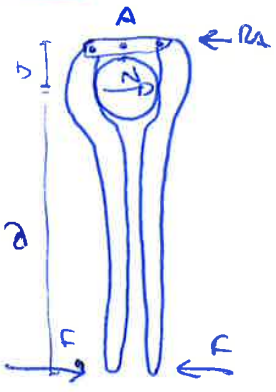
$\rightarrow \dot{\omega} = \frac{2\omega V}{r} = 153{,}96\ rad/s^2$

$a_n = \omega^2 OA \simeq 13{,}3\ m/s^2$

~~$\ddot{r} = 2 r \omega^2$~~

EQUILIBRIO STATICO DELLE FORZE.

2.1



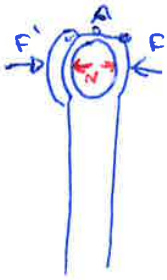
$F = 20N$

$a = 0.125\ m$

$b = 0{,}02\ m$

$N = ?$

$R_A = ?$



A) $F(a+b) = Nb \rightarrow N = \frac{F(a+b)}{b}$

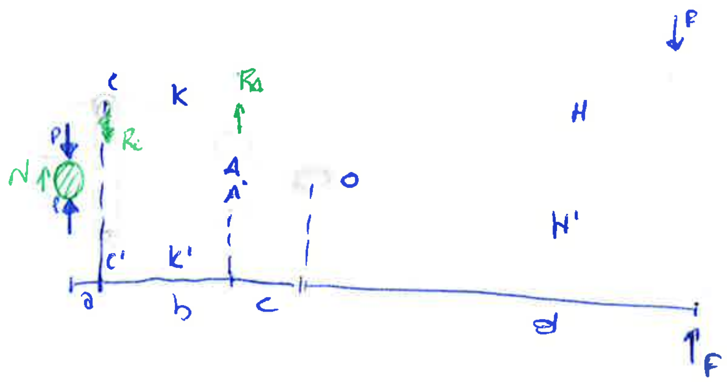
$\rightarrow N = 105N$

~~$R_A = -F$~~

$R_A + F - N = 0 \rightarrow R_A = 125N$

2.20

$a = 0{,}02\,m$
$b = 0{,}06\,m$
$c = 0{,}03\,m$
$d = 0{,}18\,m$
$P = ?$
$F = 150\,N$



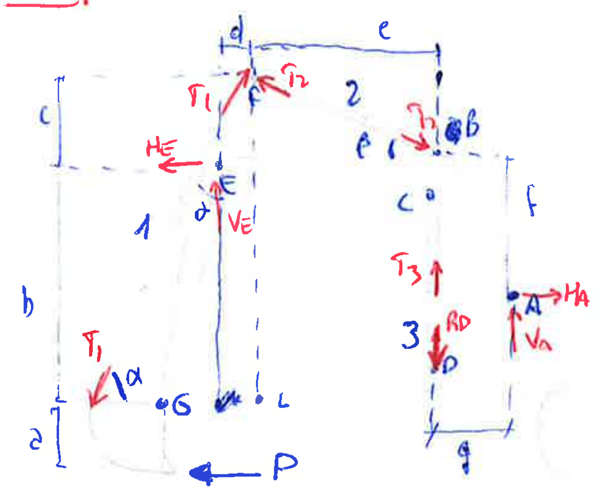
~~$N = P/2$~~
$N a = R_c b$
~~$R_c b =$~~

$P a = R_A b$ ~~c c~~ $\rightarrow P_a = \frac{F d}{c} \frac{b}{a} = 2700\,N$

$F d = R_A c \rightarrow R_A = \frac{F d}{c}$

2.21

$P = 10\,kN$ $b = 2{,}4\,m$ $d = 0{,}3\,m$
$a = 0{,}9\,m$ $c = 1{,}2\,m$ $e = 2{,}1\,m$
$f = 1{,}5\,m$ $g = 0{,}8$ $T_1?$ $T_2?$ $T_3?$
$R_A?$ $R_E?$



$\alpha = \arctan \frac{c + d b}{a + \frac{d}{c}(b + c)} = \arctan(2) = 63{,}43°$

$\beta = \arctan\left(\frac{c}{e}\right) = 29{,}74°$

T_1 ~~$\cos\alpha$~~ $\sin\alpha\, a = P a \rightarrow T_1 =$ ~~22,36 kN~~ $11{,}18\,kN$

A): $P(a + b - f) + R_D\, g = 0 \rightarrow R_D = -20000\,N$

$\rightarrow$ $H_A - P = 0$ $H_A = 10\,kN$ $\rightarrow R_A =$ ~~22,36 kN~~ $22{,}36\,kN$

$\uparrow$ $V_A + R_D = 0 \rightarrow V_A = 20\,kN$

$T_3 - R_D = 0 \rightarrow T_3 = 20000\,N$

E) $T_2(d\cos\beta + c\sin\beta) - P(a + b) = 0$

$\rightarrow T_2 = 27713\,N$

$V_E = F_2 \sin\beta = 13747\,N$

$H_E = P + F_2 \cos\beta = 34063\,N$

$\rightarrow R_E = 36{,}732\,kN$

~~E) $T_1(\cos\alpha + \sin\alpha)$~~

~~E) $T_1 c \sin\alpha + T_1 \cos\alpha\, d - T_2 d\cos\beta - T_2 c \sin\beta = 0$~~

~~$T_1(c\sin\alpha + d\cos\alpha) = T_2(e\cos\beta + c\sin\beta) \rightarrow T_2 =$~~

$\rightarrow T_2 =$

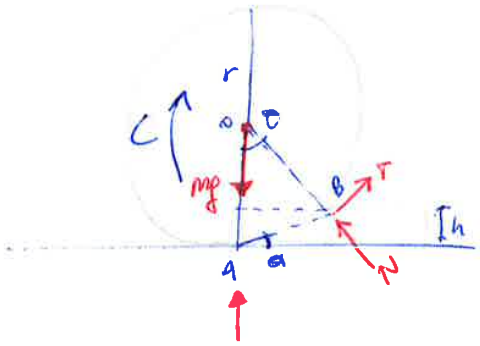
2.31

$r = 0{,}45\ m$ $\quad C\ ?$

$m = 30\ kg$

$h = 0{,}09\ m$

f_{min} \ no slittamento ?



~~sen α = AB/r~~ $\quad \theta = \arccos\left(\frac{r-h}{r}\right) \Rightarrow \theta = 36{,}87$

$$\begin{cases} mg(\sin\theta)\cdot r = C = 79{,}38\ Nm \\ mg\sin\theta - T = 0 \\ mg\cos\theta - N = 0 \end{cases} \rightarrow fN = T \rightarrow f = \frac{\sin\theta}{\cos\theta} = 0{,}75$$

2.32

$R = 0{,}750\ m$

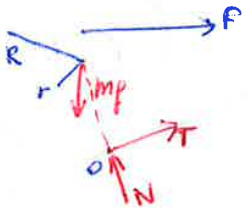
$r = 0{,}45\ m$

$m = 200\ kg$

$\alpha = 15°$

$F = ?$ $\quad f_a = 0{,}4$

$T = ?$



1d

$$\begin{cases} \rightarrow\ F\cos\alpha - mg\sin\alpha + F_T = 0 \\ \uparrow\ N - mg\cos\alpha - F\sin\alpha = 0 \quad \cancel{N = F_T} \\ \cancel{N f = F_T} \end{cases} \rightarrow N = mg\cos\alpha + F\sin\alpha \rightarrow F_T = f(mg\cos\alpha + F\sin\alpha)$$

$$\rightarrow F\cos\alpha - mg\sin\alpha + f\,mg\cos\alpha + fF\sin\alpha = 0$$

$$F(\cos\alpha + f\sin\alpha) = mg(\sin\alpha - f\cos\alpha) \rightarrow F = 1182{,}1\ N$$

$\rightarrow$ 1) $F(r + R\cos\alpha) - mgR\sin\alpha$

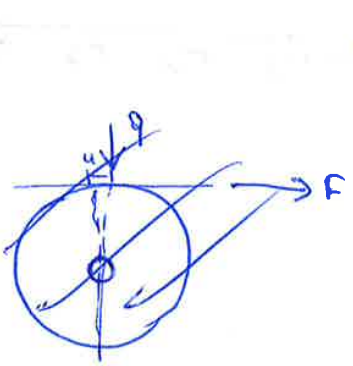
$\rightarrow F = 324{,}2\ N$ $\rightarrow$ ~~$F = 1182{,}1\ N$~~

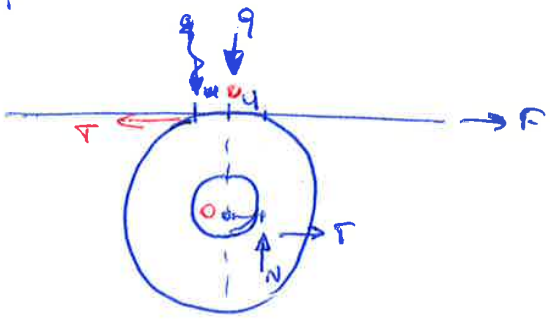
$\Rightarrow N = 1978{,}3\ N$

$\Rightarrow T = 194{,}4\ N < fN$

2.36

$l = 90\,m$
$D = 0{,}12\,m$
$d_p = 0{,}03\,m$
$f_p = 0{,}035$
$q_m = 20\,kg/m$
$u = 0{,}0004\,m$
$F = ?$





$F =$

$N - fql = 0 \rightarrow N = 17640\,N$

$N f_p = T$

$\rho = \frac{d_p}{2} \sin\varphi$

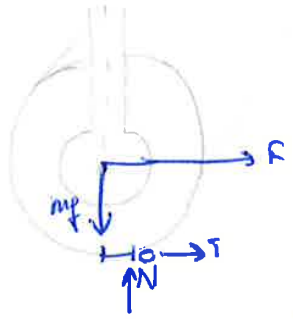
$\varphi = \arctg(f_p)$

$\Rightarrow \rho = 0{,}0005247\,m$

$\circlearrowleft \; F\frac{D}{2} - 98l(u+\rho) = 0 \rightarrow F = 271{,}86\,N$

2.38

$L = 2{,}5\,m$
$d = 1{,}5\,m$
$m = 8000\,kg$
$u = 0{,}02\,m$
$f = 0{,}4$
$F = ? \;\backslash\; \omega = 0$
$C = ?$



$\circlearrowleft \; F\frac{d}{2} - Nu = 0 \rightarrow F = 2090{,}69\,N$

~~$F = T$~~

$N - mg = 0$

~~$fN = T$~~

~~$\arctg f = \varphi = 0{,}38 =$~~

$fN = T$

~~$F = T$~~

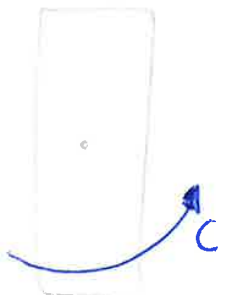
$N = uL\rho$ $\quad dA = \frac{L}{2}\,d\sigma\,d\theta$

$dM = f\frac{N}{uL}\rho\frac{L}{2}\,i\frac{L}{2}\,d\sigma\,d\theta =$

$M = f\frac{N}{uL}\cdot\frac{L^3}{4\pi}\cdot 2\pi = 5{,}131\cdot 10^6\,Nm$

$F_A = f\frac{mg}{2}$

$C = F_A \cdot \frac{L}{2} = 19612\,Nm$



~~ESAME~~

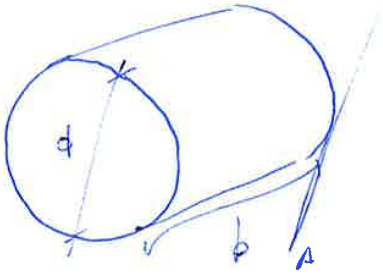
3.1

$\rho = 7750\ kg/m^3$

$d = 0{,}2\ m$

$b = 0{,}03\ m$

$J_A = ?$



$m = \rho \cdot \pi \frac{d^2}{4} \cdot b$

$J_C = \left(m \frac{d^2}{4}\right) \cdot \frac{1}{8}$

$J_A = \rho \frac{\pi d^4}{32} b + m \frac{d^2}{4}$

$= 0{,}0129 + 0{,}0259$

$= 0{,}0388\ kg\,m^2$

3.4

$m = 75\ kg$

$m_t = 780\ kg$

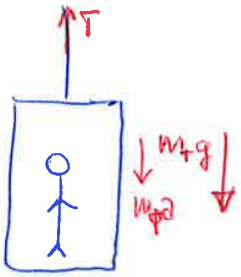
$\Delta t = 35$

$V_0 = ?$

$T_0 = 8300\ N$

$R = ?$

$V = ?$



$R = T - m_t g = m a \rightarrow 950\ N \rightarrow a = 1{,}267\ m/s^2$

$\Rightarrow V = V_0 + a t = 3{,}8\ m/s$

$R = m(a + g) = 830\ N$

3.10

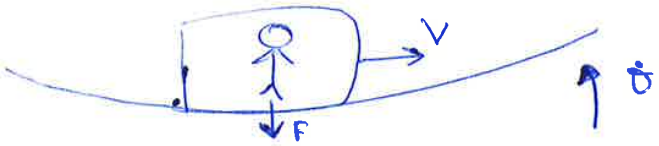
$m = 55\ kg$

$V = 266{,}67\ m/s$

$r = ?$

$\dot{\theta} = ?$

$F = 800\ N$



$F = m(g + a_n) \rightarrow a_n = 4{,}75\ m/s^2$

$a = V^2/r \rightarrow r = 14985{,}47\ m \rightarrow \dot{\theta} = V/r = 0{,}0178\ rad/s$

3.13

$m = 150\,kp$

$\alpha = 30°$

$V_0 = 4\,m/s$

$\Delta t = 4\,s$

$\Delta P = 600\,N$

$P_0 = 0$

P_{cost}

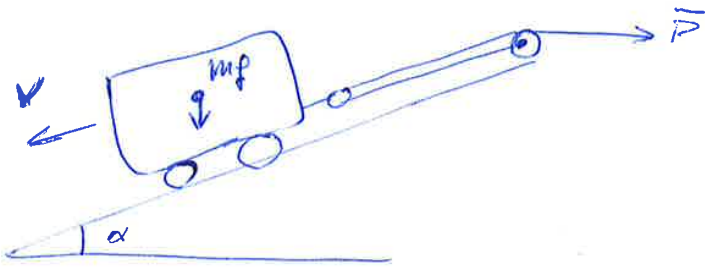
$t_1 = ? \;\backslash\; V_0 = 0$

$t_2 = 4s \quad V = ?$

p varia linearmente nel tempo

$P_0 = 0 \quad P_4 = 600 \quad p = c\,\Delta t$

$c = 150 \frac{N}{s}$



$$\bar{P} = \frac{1}{\Delta t}\int_0^4 P\,dt = \bar{P} = \frac{1}{\Delta t}\int_0^4 ct\,dt = \frac{1}{4}\cdot c\frac{t^2}{2} = \frac{1}{4}\cdot c\frac{4^2}{2} = 300N$$

~~$t_0 = 4s$~~

$\vec{P} + \vec{N} + \vec{F}_{fr} = m\vec{a} \rightarrow$

$P - m_f \sin\alpha = ma$

$a = \frac{P}{m} - f\sin\alpha$

~~$\vec{P} + \vec{N} + \vec{F}_{fr} = 0$~~ $\quad P - m_f \sin\alpha = 0 \quad a_4 = 3{,}1\,m/s^2$

$V = V_0 + \int_0^t \left(\frac{P}{m} - f\cos\alpha\right)dt = \frac{Pt}{m} - f\cos\alpha \cdot t$

3.17

$M = 0.5\,kp$

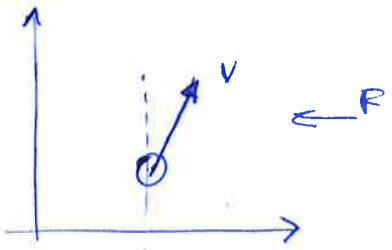
$V = 3\,m/s$

$\alpha = 30°$

$\theta = 60°$

$F = 0.6N$

$t = ? \;\backslash\; x = 0$



↑: ~~mg~~ $V\cos\alpha\, t = 0$

→ $V\sin\alpha\, t - \frac{1}{2}\left(\frac{F}{m}\right)t^2 = 0$

$1{,}5t - 0{,}6t^2 =$

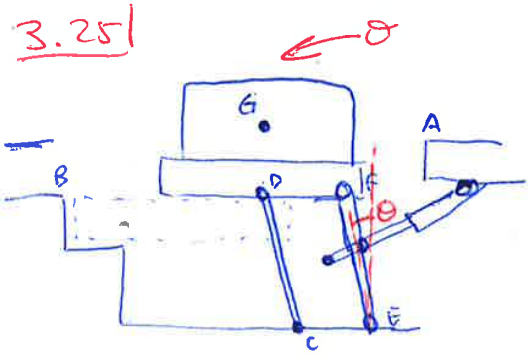
~~$t = 1{,}58\,s$~~

~~$y = 4{,}108\,m$~~

$t\left(V\sin\alpha - \frac{1}{2}\cdot\frac{F}{m}\cdot t\right)$ $\quad t = 0$, $\quad t = 2{,}5s$

$t = 2{,}5s \quad y = 6{,}495\,m$, $\quad x = 0$

3.25



$\theta(t) = \frac{\pi}{6}\left(1 - \cos\frac{\pi}{2}t\right)$

$F_D = ?$ in $t = 0$, $\theta = 0$

$t = 1$

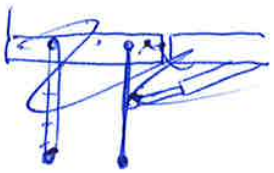
$m = 200\,kg$

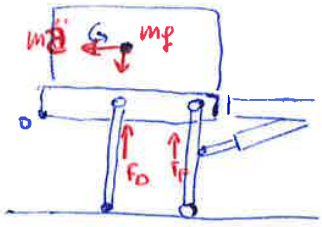
$DC = FE = \ell = 1{,}2\,m$

$CE = DF = b = 0{,}6\,m$

$h = DG = 0{,}48\,m$

1) $t = 0$, $\theta = 0$ $\quad 0 = \frac{\pi}{6}(1-1) = 0 \rightarrow \theta = 0$





~~a) $F_D b + F_F 2b - mgb = 0$~~

~~$\uparrow F_D + F_F = mg$~~

~~$\rightarrow mgb + F_F b = mgb = 0$~~

$\dot\theta = \frac{\pi}{6} \cdot \frac{\pi}{2}\sin\frac{\pi}{2}t = \frac{\pi^2}{12}\sin t\frac{\pi}{2}$

$\ddot\theta = +\frac{\pi^2}{12}\cdot\frac{\pi}{2}\cos\frac{\pi}{2}t = \frac{\pi^3}{24}\cos t\frac{\pi}{2}$

$a = \ell\ddot\theta = 1{,}55\,m/s^2$

b) $F_D b + F_F 2b - mgb + Fh = 0$

$\rightarrow ma = F$

$\uparrow F_D + F_F = mg$

$\rightarrow mgb + F_F b - mgb + Fh = 0$

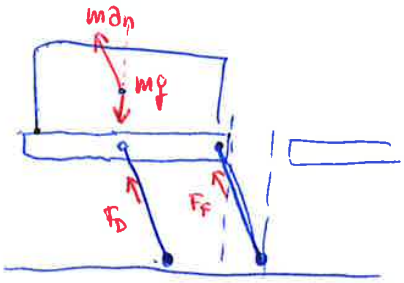
$\rightarrow F_F = \frac{Fh}{b} = 247{,}67\,N$

$\rightarrow F_D = 1712{,}33\,N$

2) $t = 1 \rightarrow \theta = \frac{\pi}{6}\left(1 - \cos\frac{\pi}{2}t\right) = \frac{\pi}{6}$

$\dot\theta = \frac{\pi^2}{12}\sin\frac{\pi}{2} = \frac{\pi^2}{12}\,rad/s \rightarrow v = 0{,}99\,m/s$

$\ddot\theta = \frac{\pi^3}{24}\cos\left(t\frac{\pi}{2}\right) = 0 \rightarrow a_t = 0$ $\quad a_n = \dot\theta^2\ell = 1{,}17\,m/s^2$



$\rightarrow F_D \sin\theta + F_F \sin\theta + \cancel{ma_t} - ma_n \sin\theta = 0$

$\uparrow F_D\cos\theta + F_F\cos\theta - \cancel{mg} + ma_n\cos\theta = mg$

F) $= F_D\cos\theta\, b - mgb + ma_n\cos\theta\, b - ma_n\sin\theta\, b = 0$

$F_D\cos\theta - 1960 + 2032{,}64 - 117 = 0 \rightarrow F_D = 2164{,}0\,N$

FFE

3.49

$r = 0{,}375\,m$

$m = 4\,kg$

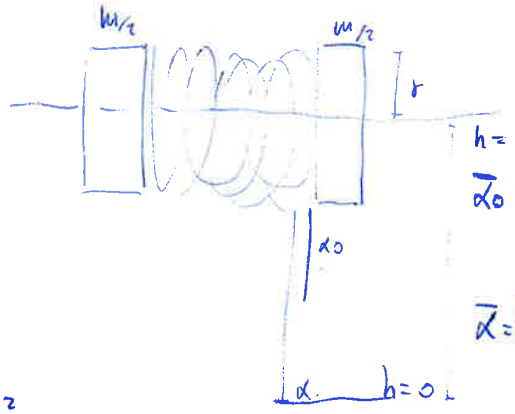
$\rho = 0{,}3\,m$

$l = 1\,m$

$q = 3{,}08\,kg/m$

$x_0 = 0{,}6\,m$

$x = 6\,m \rightarrow \omega = ?$



Intro:

$E_{pot} \quad q x_{0q} \cdot \bar{x}_0$

$\bar{x}_0 = (h - r - x_{q/2})$

fine: $q x_{0q} g x_q \bar{x} + \frac{1}{2} I \omega^2$

$\bar{x} = (h + r_{/2})/2$

$I_m = m \rho^2 = 3{,}69\,kg\,m^2$

$I_{m'} = q l \cdot r^2 = 7{,}79\,kg\,m^2$

$m' = q l$

$m_{tot} = q l + m$

$g m_{tot} h + g(x_{0q}) \bar{x}_0 = g(x_q) \bar{x} + \frac{1}{2} I \omega^2 \rightarrow \omega^2 \frac{2g(x_{0q}\bar{x}_0 - x_q \bar{x})}{I}$

$\frac{2g(m_{tot} h + x_{0q}\bar{x}_0 - x_q \bar{x})}{I} = \omega \rightarrow \omega = \text{stima rad/s}$

$g m_{tot} h + g m_0 \bar{x}_0 = g m_x \bar{x} + \frac{1}{2} I \omega^2 + \frac{1}{2} q (l - \Delta)(\omega r)^2$?

3.55

$m = 1500\,kg$

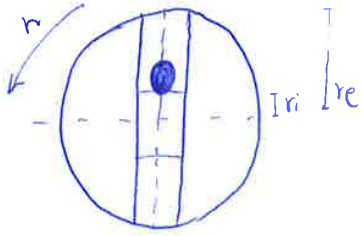
$x = 0{,}15\,m$

$v_0 = 1{,}11\,m/s$

$k_{12} = ?$

$\frac{1}{2} m v_0^2 = \frac{1}{2} k_{12} x^2 \rightarrow k_{12} = 8\,2288 \rightarrow \begin{cases} k_1 = 41144\,N/m \\ k_2 = 41144\,N/m \end{cases}$

363



$r_e = 0{,}2\ m$

$n = 1000\ giri/min$

$r_i = 0{,}05\ m$

$v_i = 0$

$v_e = ?$

$\omega = \frac{1000}{60} \cdot 2\pi = 104{,}72\ rad/s$

$a_n = \omega^2 r_e \rightarrow F = m a_n \rightarrow L = \int_{r_i}^{r_e} m a_n = r_e^2 \omega^2 m$

$L = \frac{1}{2} m \omega^2 r_e^2 = r_e^2 \omega^2 m$

$\rightarrow (r_e^2 - r_i^2) \omega^2 m = \frac{1}{2} \omega^2 r_e^2 m$

$L = \Delta E_c \Rightarrow m \frac{r_e^2 - r_i^2}{2}$

$L = \int_{r_i}^{r_e} m \omega^2 r\, dr \rightarrow m \omega^2 \frac{r_e^2 - r_i^2}{2}$

$\Delta E_c = m \frac{v_n^2}{2}$

$\rightarrow m \frac{\omega^2 (r_e^2 - r_i^2)}{2} = m \frac{v_n^2}{2} \rightarrow$

$\rightarrow v_n = 20{,}28\ m/s$

4.1 TRASMISSIONE DEL MOTO

$f = 400\ Hz$

$i = poli = 8$

$n = 6000\ giri/min \rightarrow \omega = 628{,}31\ rad/s$

$C_H = \frac{\Delta p_0}{2\pi} - k\omega^2$

$\Delta = cilindrata$?

$p_0 = 21\ MPa$

$k = 0{,}0001\ N\,ms^2/rad^2$

Δ_1 ? \ $W_1 = 30\ kW$

Δ_2 ? \ $W_2 = 10\ kW$

$W = C_H \cdot \omega = \left(\frac{\Delta p_0}{2\pi} - k\omega^2\right)\omega$

$W_1 = \left(\frac{\Delta p_0}{2\pi} - k\omega^2\right)\omega \rightarrow$

$W_1 = (\Delta\, 33422538 - 39.477)\omega$

$48.797 = \Delta\, 33422538 - 39{,}477 \rightarrow$

$\rightarrow \Delta = 7{,}60973 \cdot 10^{-5}\ m^3$

$W_2 = (\Delta\, 33422538 - 39{,}477)\omega$

$15{,}916 + 39{,}477 = \Delta\, 33422538 \rightarrow$

$\rightarrow \Delta = 1{,}6573 \cdot 10^{-5}\ m^3$

4.7

$C_1 = (C_0 - k\omega_1)$

$C_0 = 30\ Nm$

$k = 0{,}1\ Nms^2/rad$

$C_2 = 100\ Nm$

$\tau = ?$ \ $W_H = max$ < C_1? / ω_1?

$(C_0 - k\omega_1)\omega_1 = C_2\omega_2$

$C_0\omega_1 - k\omega_1^2 = C_2\tau\omega_1$

$C_0 - k\omega_1 = \tau C_2$

$\omega_1 = \frac{C_0}{k} - \frac{C_2\tau}{k}$

$\omega_2 = \tau\omega_1$

$\frac{C_1}{C_2} = \tau$

$C_1 = \tau C_2$

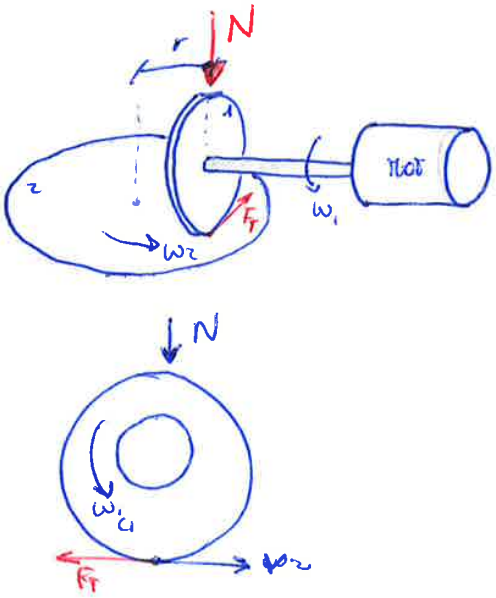
$W = \frac{C_2\tau}{k}(C_0 - C_2\tau)$ → W è max se $\frac{dW}{d\tau} = 0$

→ $W = \frac{C_2C_0\tau - C_2^2\tau^2}{k}$ → $\frac{1}{k}(C_2C_0 - 2C_2^2\tau) = 0$ → $C_2C_0 = 2C_2^2\tau$ → $\tau = 0{,}15$

$C_1 = \tau C_2$ → $= 15$ → $(30 - 0{,}1\omega_1) = 15$ → $2 - \frac{0{,}1}{15}\omega_1 = 0$ → $\omega_1 = 300\ rad/s$

→ $300 \cdot \frac{60}{2\pi}$ $\omega_1 = \frac{C_0}{k} - \frac{C_2\tau}{k} = \omega_1 = 150\ rad/s$ → $n_1 = 1432{,}4$ giri/min

4.5



$N = 1000N$

$d_1 = 0{,}1\ m$

$W = 368\ W$ cost

$C_2 = k\omega_2^2$

$k = 9\cdot10^{-4}\ Nms^2/rad^2$

$f = 0{,}2$

$r = ?$ \ $F_T \le fN$

Suppongo $\eta = 1$

$W = C\omega_1 = k\omega_2^3$

$\omega_2 = \sqrt[3]{\frac{W}{k}}$ → $\omega_2 = 74{,}72\ rad/s$

$V_2 = r\omega_2$

$368 = k\omega_2^3$ → $\omega_2 = 74{,}72\ rad/s$

$F_T V_2 = N$

$Nr = F_T \cdot d_1/2$

$F_T V = W$ → $f\omega_2 r = W$ → $F_T = \frac{W}{\omega_2 r}$

$Nr = \frac{W}{\omega_2 r} d_1/2$ → $r^2 = \frac{Wd_1}{2\omega_2 N} = 0{,}00024\ m$

$F_T r = C_2$ → $F_T = \frac{k\omega_2^2}{r}$ →

$F_T \le fN$ → $fN = \frac{k\omega_2^2}{r}$ → $r = \frac{k\omega_2^2}{fN} = 0{,}02478\ m$

F_V $mg - F_L \sin\gamma + F_K \sin\alpha + F_a \sin\beta = 0$

$\rightarrow F_K \cos\alpha + F_a \cos\beta - F_L \cos\gamma = 0$

$F_L = (F_K \cos\alpha + F_a \cos\beta) \cdot \frac{1}{\cos\gamma} \rightarrow mg - tg\gamma (F_K \cos\alpha + F_a \cos\beta) + F_K \sin\alpha + F_a \sin\beta = 0$

F_K

413

$m = 2400\ kg$

$\alpha = 10°$

$D = 1{,}28\ m$

$I_M = 0{,}15\ kg\,m^2$

$\tau = \omega_A/\omega_M = 1/36$

$\eta = 0{,}75$

$d = 0{,}7\ m$

$\rho = 0{,}003\ m$

$u = 0{,}015\ m$

$V = 5\ m/s$

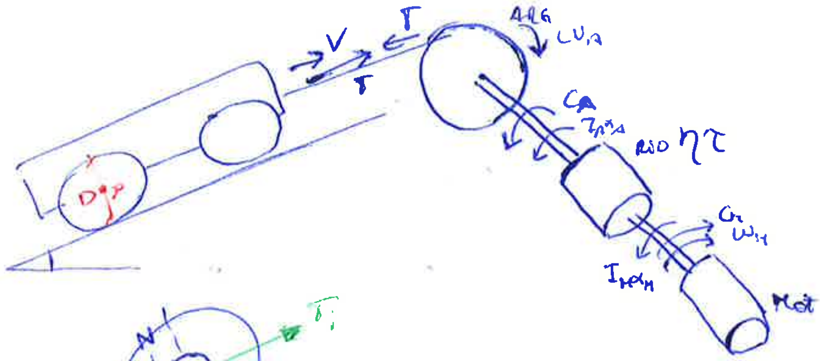
$P\ \omega_M \setminus V = cost$

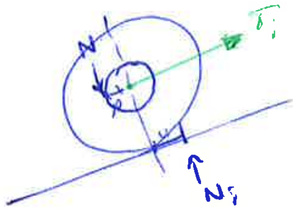
$\omega_M = ?$

$T_0 = ?$

$C_0 = 2C_M$

$I_A = 25\ kg\,m^2$





$T\frac{d}{2} = N(u+\rho)$

$C_A = T\frac{D}{2}$

$(C_A + I_A \alpha_A)\tau = \eta(-I_M \alpha_M + C_M)$

$T - mg\sin\alpha - T_i = ma$

$N_i - mg\cos\alpha = 0$

$\rightarrow T = mg\left[\sin\alpha + \frac{2(\rho+u)\cos\alpha}{d}\right] + ma$

$\alpha_A = a/(D/2)$ $\quad \alpha_M = \frac{\alpha_A}{\tau}$

$\omega_A = V/(D/2)$ $\quad \omega_M = \omega_A/\tau$

$\left[T\frac{D}{2} + 2I_A\frac{a}{D}\right]\tau = \eta\left[-2I_M\frac{a}{D\tau} + C_M\right] \rightarrow$

$\rightarrow \left\{\left(mg\left[\sin\alpha + \frac{2(\rho+u)}{d}\cos\alpha\right] + ma\right)\frac{D}{2} + \frac{2I_A a}{D}\right\}\tau = \eta\left[-2\frac{I_M a}{D\tau} + C_M\right]$

calcolo regime $\rightarrow V = cost,\ a = 0 \rightarrow \frac{\tau}{\eta} mg\frac{D}{2}\left(\sin\alpha + \frac{2(\rho+u)}{d}\cos\alpha\right) = C_M = 125{,}047\ Nm$

~~$P_M = C_M \cdot \frac{V}{D/2}$ 976,23 W~~ $\quad P_M = C_M \cdot \frac{V}{D/2} \cdot \frac{1}{\tau} = 125{,}047\left(\frac{5}{0{,}64} \cdot 36\right) = 35168{,}46\ W$ $\quad \omega_M = 281{,}25\ rad/s$

$\left\{\left(mg\left[\sin\alpha + \frac{2(\rho+u)}{d}\cos\alpha\right] + ma\right)\frac{D}{2} + 2\frac{I_A a}{D}\right\}\tau = \eta\left[C_0 - \frac{2I_M a}{D\tau}\right]$

$C_0 = 2C_M$

$50{,}085a = 94{,}11 \rightarrow$

$\rightarrow a = 1{,}88\ m/s^2$

$\Rightarrow T_0 = 5257{,}43 + 2400 \cdot 1{,}88 = 9767\ N$

4.20

$C_0 = 120\ Nm$

$C_M = k\omega_1^2$

$k = 7\ mNs^2$

$\tau = 1/16$

$J_1 = 0{,}0045\ kgm^2$

$J_2 = 0{,}7\ kgm^2$

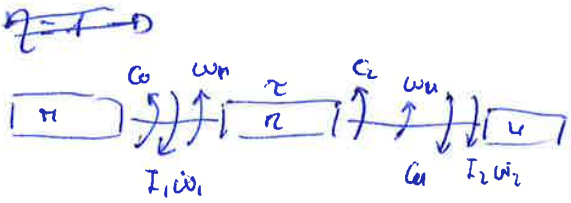
Hp $\begin{cases} J_R \approx 0 \\ \eta = 1 \end{cases}$

$\omega_M = ?$ } regime

$\omega_U = ?$

$\Delta\theta_A = ?$ $\omega_0 = 0$ $\omega_A = \omega_M/2$

$C_M = ?$ $\omega_A = \omega_M/2$



$\eta = 1 \rightarrow \frac{C_1}{C_2} = \tau = \frac{\omega_2}{\omega_1} = \frac{\dot{\omega}_2}{\dot{\omega}_1}$

$C_1 = C_M - J_1\dot{\omega}_1$

$C_2 = C_M + J_e\dot{\omega}_2$ in condizioni di regime

$\frac{d\omega}{dt} = 0 \rightarrow \dot{\omega} = 0$

$C_2 = C_0/\tau = 1920\ Nm$

$C_2 = k_M\dot{\omega}_2^2 = \frac{C_1}{\tau} \rightarrow \omega_2 = \sqrt{\frac{C_1}{\tau k}} = 16{,}56\ rad/s$

$\omega_1 = \tau^{-1}\cdot\omega_2 = 265\ rad/s$

~~$\Delta\theta = \omega_0\Delta t + \frac{1}{2}\dot{\omega}_1\Delta t^2$~~ ~~$\rightarrow \Delta t =$~~

$\frac{\omega_M}{2} = \dot{\omega}_1\Delta t \rightarrow \dot{\omega}_1 = \frac{\omega_M}{2\Delta t}$

~~$\dot{\omega}_2 = \frac{d\omega_2}{dt}$~~ 

~~$d\theta = \omega dt$~~ $= \quad C_2 = C_M + J_2\dot{\omega}_2$

$\tau = \frac{C_1}{C_M} = \frac{\dot{\omega}_M}{\dot{\omega}_1} = C_1\dot{\omega}_1 = C_M\dot{\omega}_M \rightarrow J_1\dot{\omega}_1^2 = J_M\dot{\omega}_M^2 \rightarrow J_M = J_1\left(\frac{\dot{\omega}_1^2}{\dot{\omega}_M^2}\right)$ $\uparrow \frac{1}{\tau^2}$

$J_e = \frac{J_1}{\tau^2} + J_2 = 1{,}852\ kgm^2$

$C_2 - C_M = J_e\frac{d\omega}{dt} \qquad d\theta = \omega dt$

$dt = \frac{J_e d\omega}{C_2 - C_M} \rightarrow d\theta = \frac{k\omega\, d\omega}{C_2 - C_M} \rightarrow \theta = \int_0^{\omega_A} \frac{J_e\omega\, d\omega}{C_2 - C_M} = \frac{k\omega\, d\omega}{C_2 - k\omega_1^2} \rightarrow$

$\rightarrow \frac{J_e}{2k}\ln\left(C_2 - k\omega_A^2\right)_0^{\omega_f} \rightarrow \frac{J_e}{2k}\ln\left[\frac{C_2}{C_2 - k\left(\frac{\omega_M}{2}\right)^2}\right] = 0{,}0388$

$\omega_f = \omega_M/2$ $\qquad \theta_1 = \theta/\tau = 0{,}608\ rad$

$\dot{\omega} = \frac{C_2 - k\omega_1^2}{J_e} = 237.6\ rad/s^2 \rightarrow$ ~~$\dot{\omega}_1 =$~~ $\omega_1/\tau = 12441.\ rad/s^2$

$C_1 = C_0 - J_1\dot{\omega}_1 = 64\ Nm$

4.27

$C_R = 15000 + 3665 \sin(3\theta)$ Nm

$C_u = 15000 + 2000 \sin\theta$ Nm

$I = 1000$ kgm^2

$\omega = 62{,}8$ rad/s quando $\theta = \frac{\pi}{2}$ rad

$\frac{d\omega}{d\theta} = ?$

$\bar{P} = ?$

$\theta = \frac{\pi}{2}$ rad $\rightarrow$ $C_R = 11335$ Nm

$C_u = 13000$ Nm

$\Delta L = 1665$ Nm

$\varepsilon = \frac{\Delta L}{I\omega^2} = 0{,}000168$

$\omega = \sqrt{\frac{(3665\sin(3\theta) - 2000\sin\theta)}{I\varepsilon}}$

$\frac{d\omega}{d\theta} = \frac{1}{\sqrt{I\varepsilon}} \cdot \frac{1}{2}(10995\cos(3\theta) - 2000\cos\theta)^{-\frac{1}{2}}$

$= \frac{1}{2\sqrt{I\varepsilon}} \cdot (10995\cos(3\theta) - 2000\cos\theta)^{-\frac{1}{2}}$

$\frac{d\omega}{dt} = \frac{C_R - C_u}{I} \Rightarrow$

$\Rightarrow 3665\sin(3\theta) - 2\sin\theta \Rightarrow \frac{d\omega}{\frac{d\theta}{\omega}} = 3665\sin 3\theta - 2\sin\theta \rightarrow$

$d\theta = \omega dt$.

$\rightarrow \int_{\omega_0}^{\omega} \omega d\omega = \int_{\frac{\pi}{2}}^{\theta} (1{,}665\sin(3\theta) - 2\sin\theta)\, d\theta \Rightarrow \frac{\omega^2}{2} - \frac{\omega_0^2}{2} = -1{,}555\cos(3\theta) + 2\cos\theta$

$\bar{P} = \bar{C}_R \cdot \omega_0 \rightarrow 15000 \cdot 62{,}8 = 942{,}5$ kW

4.28

$\tau = 30:1 \rightarrow \frac{C_1}{C_2} = \frac{1}{30}$

$C_u = n_u^2 (3048 - 381\sin(2\theta_u) + 763\cos(2\theta_u))$ Nm

$C_r = 500 - 0{,}026\, n_r^2$ Nm

$I_r = 10$ kgm^2

$I_u = 1000$ kgm^2

$n_u = 2$ giri/s se $\theta_u = k\pi$

$\frac{d\omega_u}{d\theta_u} = ?$

Hp $\varepsilon \ll 1 \rightarrow n_r \approx n_u$

4,35

$p = 2{,}4\ m$

$h = 0{,}8\ m$

$b = 1{,}1\ m$

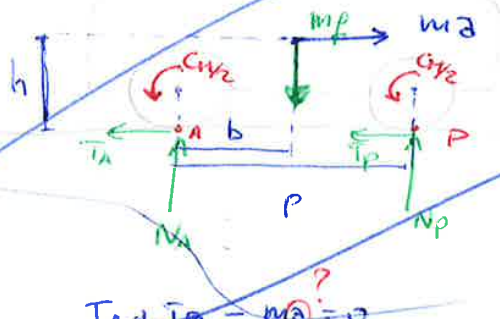
$f_s = 0{,}5$

a_{max}? \ a) moti motrici a)

a_{max}? \ moti motrici aux b)

a_{max}? \ moti motrici post b)

a)



$T_A + T_P - ma = 0$?

$T = fN$

$N_A + N_P - mg = 0$

A) $C_M - mgb - ma\,h + N_P p$

4,37

$m = 500\ t = 5 \cdot 10^5\ kg$

$V = cost = 20\ m/s$

$tg\vartheta = 0{,}01 \rightarrow \vartheta = 0{,}573$

$R = R_0 + kV^2$

$R_0 = 18000\ N$

$k = 25\ Ns^2/m^2$

$T = ?$

$W = ?$

$\eta = 1$

$T = 0 \rightarrow \dot{x}$?

$\Delta s \rightarrow V = 0$

$T - R - mg\sin\vartheta = 0 \rightarrow T = 76997{,}5\ N \rightarrow W = 1539{,}95\ kW$

$R = 18000 + 10000 = 28000$

$T = 0$ ~~$R - mg\sin\vartheta = ma \rightarrow a = -0{,}15\ m/s^2$~~

$$\frac{1}{\Delta V}\int_0^{\Delta V} R\,dV = \frac{1}{\Delta V}\int (R_0 + kV^2)\,dV = \frac{1}{\Delta V}\left(R_0 V + k\frac{V^3}{3}\right)_V^0$$

$$= \left(R_0 V + k\frac{V^3}{3}\right)_{\Delta V} = (18000 + 3333{,}33)\ N = 21333{,}33\ N$$

$-\bar{R} - mg\sin\vartheta = ma \rightarrow a = -0{,}14067\ m/s^2$

$\Delta s = v_0 t + \frac{1}{2}at^2$

$0 = v_0 + at \rightarrow t = 142{,}17\ s \rightarrow \Delta s = 1421{,}87\ m$

$\ell V^2 \frac{d}{2} + \frac{mpd}{2} f_v V^2 + \frac{12 k}{\tau d} V = \frac{\eta}{\tau} C_0 - \frac{mpd}{2} f_{v0}$

$0{,}1338 V^2 + 0{,}01784 V^2 + 9{,}31 V = 665 - 161{,}442 \rightarrow V = 33{,}15\ m/s$

$a = ?$ $\quad V_0 = 0 \longrightarrow \forall R = 0 \;,\; u = \frac{d}{2} f_{v0}$

$tg\,\theta = 0{,}06 \rightarrow \theta = 3{,}434°$

$\tau = 0{,}075$

~~$C_R = mgu\cos\theta = mg\frac{d}{2} f_{v0}\cos\theta$~~

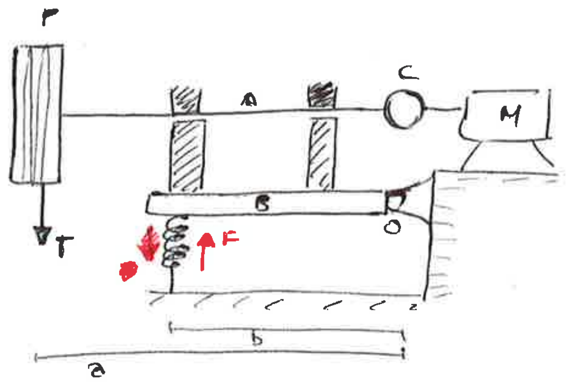
$C_R = mg\,\mathrm{sen}\theta \frac{d}{2} + m\ddot{x}\frac{d}{2} + mg\frac{d}{2} f_{v0}\cos\theta \rightarrow \frac{\tau C_1}{\eta}$ ~~$= mg\,\mathrm{sen}$~~

$C_R = \frac{\tau \eta C_M}{\eta \tau} = 1766{,}67 \longrightarrow \ddot{x} = \frac{830{,}43}{455} = 1{,}825\ m/s^2$

$= \frac{\tau C_M}{\eta d}$

GIUNTI

S.1



$k = 40\ N/mm \rightarrow 40000\ N/m$

$T = 2500\ N$

$a = 1{,}2\ m$

$b = 1\ m$

$\Delta\omega = \omega_{max} - \omega_{min}$

$n_M = 3000\ giri/min \rightarrow 314\ rad/s$

$Fb = Ta \rightarrow F = 3000\ N$

$\rightarrow F = k\Delta x \rightarrow \Delta x = 0{,}075\ m$

$\Delta x : b = \Delta e : a \rightarrow \Delta e = 0{,}09\ m$

$\alpha = \arcsin \Delta x \rightarrow \alpha = 4{,}3°$

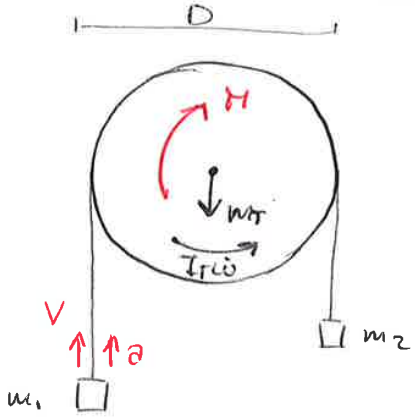
$\omega_{max} = \frac{\omega_M}{\cos\alpha} = 315\ rad/s$

$\omega_{min} = \omega_M \cos\alpha = 313{,}12\ rad/s$

$\Delta\omega = 1{,}94\ rad/s$

5.6 FLESSIBILI

$m_1 = 500\ kg$
$m_T = 150\ kg$
$D = 1.2\ m$
$\rho = 0,5\ m$
$m_2 = 300\ kg$
$M = ?$ \ $a_1 = 1.2\ m/s^2$
$W = ?$ se $V_1 = 2.4\ m/s$
$C_R = 80\ Nm$



~~$m_1 f \frac{D}{2} + m_2 f \frac{D}{2} =$~~

$-C_R + M - m_1 f \frac{D}{2} + m_2 f \frac{D}{2} = \frac{1}{2}(m_T \rho^2)\dot{\omega} + (m_1 - m_2)a$

$\dot{\omega} = 2a/D/2 \Rightarrow M = $ ~~1363 Nm~~ $1363\ Nm$

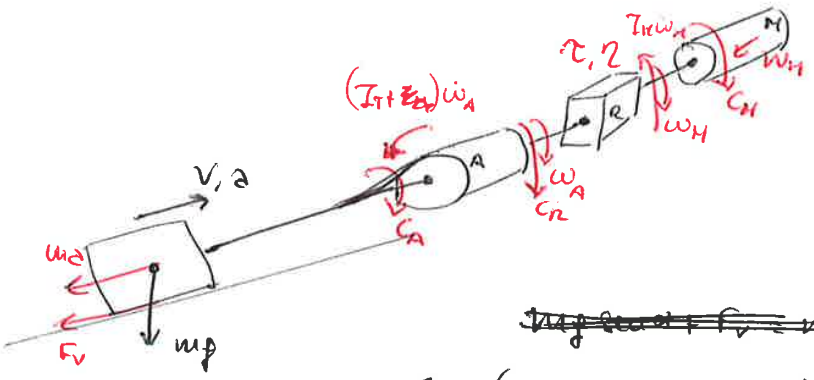
$W = M V = $ ~~1363~~ $5452\ W$

$D/2$

$M - C_R - m_1 f \frac{D}{2} + m_2 f \frac{D}{2} - 2 m_T \rho^2 \frac{2a}{D} + (m_1 + m_2)a = 0 \rightarrow M = 1907\ Nm \rightarrow W = 7628\ W$

5.7

$m = 1\ t$
$\alpha = 3°$
$a = 1\ m$
$\tau = 1/40$
$\eta = 0.85$
$J_T = 230\ kg\,m^2$
$J_M = 1.8\ kg\,m^2$
$F_V = 1150\ N$
C_M? W_M?
$V = 1.5\ m/s$
$a = 0.1\ m/s^2$



~~$m_p f \cos\alpha + F_V = m_0 a$~~

$C_A = (m_0 + F_V + m_p f \cos\alpha) D/2 = 1865,24\ Nm$

$\dot{\omega}_1 = \frac{2a}{D\tau}$

~~$C_R = C_A + (I_T + I_M)\frac{a}{D/2} =$~~ ~~$1911\ Nm$~~

~~$C_M = \frac{\tau}{\eta} C_R \rightarrow C_R = 144,46\ Nm$~~

$\omega_R = 3\ rad/s \Rightarrow W_M =$ ~~$433,38$~~

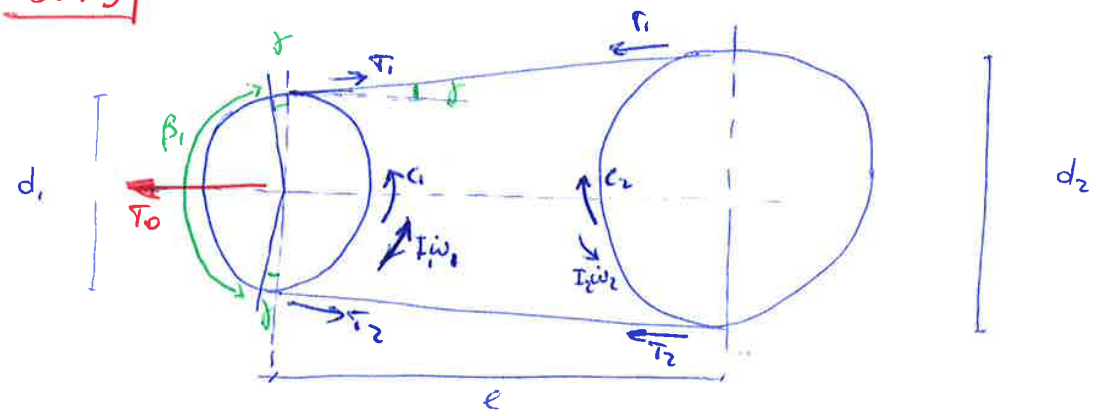
~~$\Rightarrow \omega_M = 120\ rad/s$~~

$C_R = C_A + J_T \frac{2a}{D} = 1911,24\ Nm$

~~$\eta C_M = \left(C_R \tau + I_M \frac{2a}{D\tau}\right) \tau =$~~ $\eta C_M = C_R \tau + I_M \frac{2a}{D\tau} = 161,4\ Nm$

$\omega_M = 120\ rad/s \Rightarrow W = 161,419 \cdot 120 = 19368,73\ W$

5.13



$d_1 = 1\,m$
$d_2 = 1{,}8\,m$
$e = 7{,}6\,m$
$f = 0{,}17$
$I_1 = 40\ kgm^2$
$I_2 = 65\ kgm^2$
$\eta = 1$
$a_{MAX1} = ?$ se ho C_1
$a_{MAX2} = ?$ se ho C_2
$T_0 = 60000\,N$
$C_R = 0 \rightarrow \alpha = 0 \quad a \geq 0$
$\alpha_2 \geq 0 \quad C_2 \geq 0$

$\gamma = \arcsen\left(\frac{d_2}{2} - \frac{d_1}{2}\right)\frac{1}{e} = 3{,}018°$

$\beta = \pi - 2\gamma = 173{,}966°$

$T_1 \cos\gamma + T_2 \cos\gamma = 2T_0$

$\begin{cases} \frac{T_1}{T_2} = e^{f\beta} \\ \sum_0 - T_1 \cos\gamma \frac{d_1}{2} + T_2 \cos\gamma \frac{d_1}{2} + I_1\dot{\omega}_1 = 0 \end{cases}$

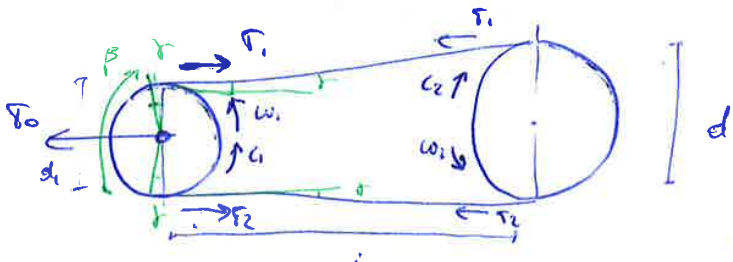
$T_2 e^{f\beta}\cos\gamma + T_2\cos\gamma = T_0 \rightarrow T_2 = \frac{T_0}{\cos\gamma}\left(1 + e^{f\beta}\right)^{-1}$

$T_2 = 26936{,}58\,N$
$T_1 = 7{,}527 \cdot 10^4\,N$

$\rightarrow \dot{\omega}_1 = 378{,}64\ rad/s^2$

$\dot{\omega}_2 = 419{,}38\ rad/s^2$

5.14



$d_1 = 0{,}3\,m$
$d_2 = 0{,}9\,m$
$i = 1{,}2\,m$
$q = 0{,}6\ kg/m$
$f = 0{,}26$
$T_0 = 1200\,N$
$\beta = ?$
$W_{max} = ?$
$\omega_1 = 78{,}54\ rad/s$

$\gamma = \arcsen\left(\frac{d_2 - d_1}{2i}\right) = 14{,}48°$

$\beta = 151{,}04°$

$V = \omega \cdot \frac{d_1}{2} = 11{,}78\ m/s$

$\begin{cases} \frac{T_1 - qV^2}{T_2 + qV^2} = e^{f\beta} \rightarrow T_1 = qV^2\left(\frac{T_2 + qV^2}{e^{f\beta}}\right) \\ T_1\cos\gamma + T_2\cos\gamma = 2T_0 \end{cases}$

$W_{out} - T_1 V + T_2 V = 0$

$\rightarrow \left[qV^2\left(\frac{T_2 + qV^2}{e^{f\beta}}\right)\right]\cos\gamma + T_2\cos\gamma = 2T_0 \rightarrow T_2 =$

$T_2\left[\left(e^{f\beta} + 1\right)\cos\gamma\right] = 2T_0 - qV^2\left(1 + e^{f\beta}\right)\cos\gamma \rightarrow T_2 = 854{,}94\,N$

$\rightarrow T_1 = 1614{,}22\,N$

$\rightarrow W = 11590{,}88\,W$
$8944{,}9\,W$

5.21

$z_1 = 18$

$C_1 = 50\ Nm$

$C_2 = k\omega_2^2$

$k = 0{,}02\ N\,s^3/rad^2$

$z_2 = ?$ | $n_2 \approx 800$ giri $\Rightarrow 83{,}77$ rad/s

$z_2 \rightarrow n_2 = ?\ W = ?$

$\eta_p = \eta = 1$

$$\tau = \frac{\omega_2}{\omega_1} = \frac{C_1}{C_2} = \frac{z_1}{z_2}$$

$$C_1 = \tau C_2 \rightarrow C_1 = \tau k \omega_1^2$$

$$\tau = 0{,}3562 = \frac{z_1}{z_2} = 50{,}53 \approx 51$$

$$\Rightarrow C_1 = \tau k \omega_1^2 \rightarrow \omega_2 = \sqrt{\frac{C_1}{k\tau}} = 84{,}16\ rad/s$$

$$W = k\omega^3 = 11923\ W$$

In planeggio

5.22

$W = 7\ kW$

$n_1 = 1800$ giri/min

$\tau = 0{,}1$

$m = 3\ mm$

$\Theta = 20°$

$i = 0{,}2425\ m$

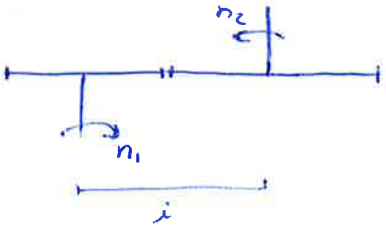
$z_1 = ?$

$z_2 = ?$

$z_p = ?$

$b = ?$

$f_{max} = 120\ N/mm = 120 \cdot 10^3\ N/m$



$$\omega_1 = n_1 \frac{2\pi}{60} = 188{,}5\ rad/s$$

$$\Rightarrow C_1 = 37{,}136\ Nm$$

$$Q = C_1/r_1 = 1650{,}495\ N$$

$$Q = F\cos\delta \rightarrow F = 1756{,}42\ N$$

$$b \cdot f = F \Rightarrow b = \frac{F}{f} = 0{,}0146\ m$$

$$m = \frac{p}{\pi} = \frac{2\pi r}{\pi z_2} \Rightarrow p =$$

$$\Rightarrow p = 9{,}420\ mm$$

$$= 2\pi \frac{r_1}{z_1} = 2\pi \frac{r_2}{z_2}$$

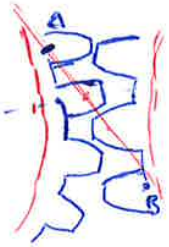
$$\begin{cases} \frac{r_1}{r_2} = \frac{1}{10} \\ r_1 + r_2 = 247{,}5\ mm \end{cases} \Rightarrow$$

$$i = \frac{11}{10} \Rightarrow r_2 = 225\ mm$$

$$\Rightarrow r_1 = 22{,}5\ mm$$

$$\Rightarrow z_1 = \frac{2r_1}{p} = 15$$

$z_2 = 150$



$y // B)$ $R d_{z_2} - A r_1 - R_{Az} d = 0 \rightarrow R_{Az} = -1953{,}8N$

$z // B)$ $\theta d_{z_2} + R_{Ay} d = R_{Ay} = 5189{,}8$

$R_A = 5545{,}9N$ $R_B = 8174{,}8N$ $R_x = -A = -5892{,}7N$

5.28

$r_1 = 44mm$

$r_2 = 260 mm$

$\alpha = 25°$

$\vartheta_n = 20°$

$f = 0{,}05$

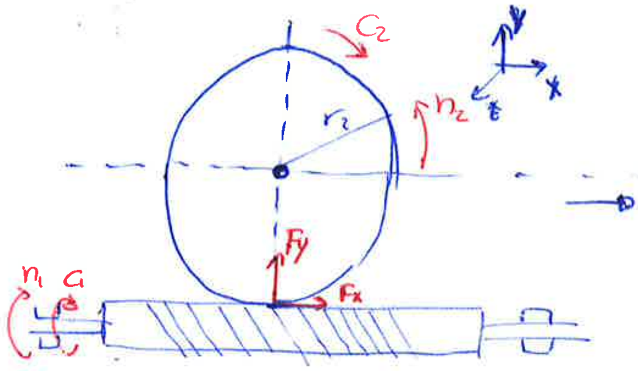
$b = 115 mm$

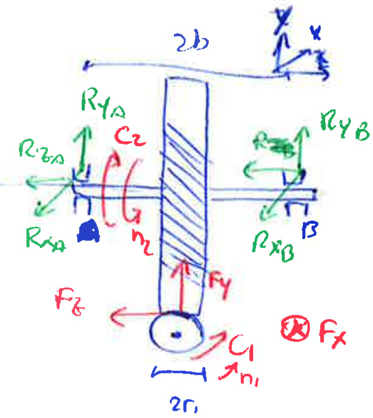
$R_A = ?$

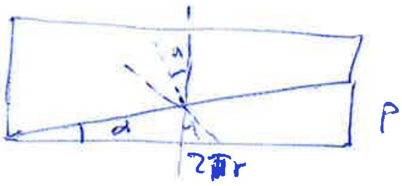
$R_B = ?$

$W = 40kW$

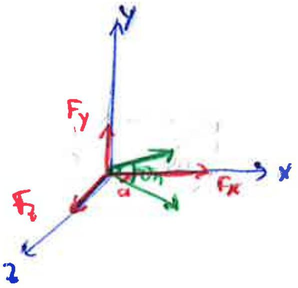
$n_1 = 1000 giri/min$







$$\begin{cases} F_x = F(\cos\vartheta_n \cos\alpha - f \operatorname{sen}\alpha) \\ F_y = F \operatorname{sen}\vartheta_n \\ F_z = F(\cos\vartheta_n \operatorname{sen}\alpha + f\cos\alpha) \end{cases}$$



$F_z = \frac{W}{\omega_1}$

$C_1 = \frac{W}{n\frac{2\pi}{60}} = 381{,}97Nm$

$F_z = C_1 / r_1 = 8681{,}18N$

$\rightarrow F_y = \frac{F_z \operatorname{sen}\vartheta_n}{(\cos\vartheta_n \operatorname{sen}\alpha + f\cos\alpha)} = 6710{,}73N$

$F_x = \frac{F(\cos\vartheta_n \cos\alpha - f\operatorname{sen}\alpha)}{(\cos\vartheta_n \operatorname{sen}\alpha + f\cos\alpha)} = 16295{,}51N$

$A) // y)$ $-R_{x_B} 2b + F_x b = 0 \rightarrow R_{xB} = 8147{,}5N$

$B) // y)$ $+R_{x_A} 2b - F_x b = 0 \rightarrow R_{xA} = 8147{,}5N$

$A) // x)$ $R_{y_B} 2b - F_z r_2 + F_y b + C_1 = 0 \rightarrow R_{y_B} = ~~-675{,}5~~ ~~11037{,}6N~~ 6458{,}5N$

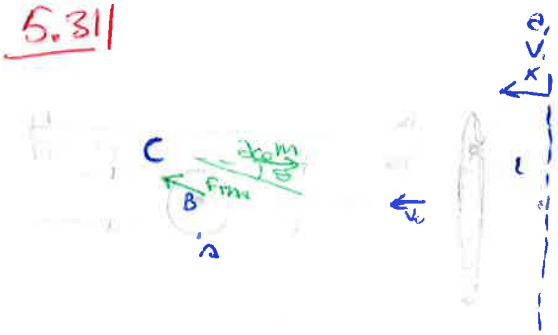
$B) // x)$ $+R_{y_A} 2b + F_y b + F_z r_2 - C_1 = 0 \rightarrow R_{y_A} = -6031{,}13N$ 13170N

$F_z + R_{zA} = 0 \rightarrow R_{zA} = -8681{,}18N$

$R_A =$ ~~15486,42N~~ $17753{,}7N$

$R_B = 10396{,}83N$

5.31



$x = l \sin(\omega t)$ ~~$x = \cos$~~

$\omega = 31.4$ rad/s

$\theta_0 = 20°$

$m = 50$ kg

$V_0 = 0.1$ m/s → V_{MAX} → ~~$\sin(\omega t) = 1$~~

$x_{C0} = ?$

$V_{C0} = ?$

$a_{C0} = ?$

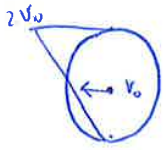
$F_{MAX\,CB} = ?$

$F_{MAX\,H} = ?$

$x = l \sin(\omega t)$

$V = \omega l \cos(\omega t)$ $V_{MAX} \rightarrow \cos = 1 \rightarrow \omega t = 0 \rightarrow t = 0$

$a = -\omega^2 l \sin(\omega t)$



$\rightarrow$

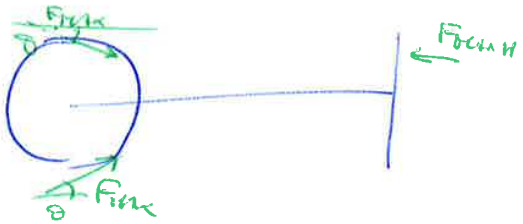
$x_{C0} = 2l = 2\frac{V_0}{\omega} = 6.366 \cdot 10^{-3}$ m

$V_{C0} = 2V = 2\omega l = 0.2$ m/s

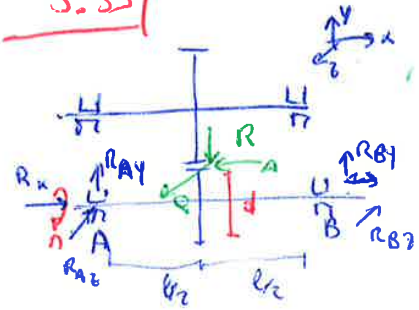
$a_{C0} = -2\omega^2 l = -2\omega V_0 = 6.28$ ~~m/s~~ m/s²

$F_{MAX} = a_{C0} m / \cos\theta = 334.32$ N

$F_{MAX\,H} = $ ~~$F_{MAX} \cos\theta / 2$~~ $2F_{MAX} / \cos\theta = 628.3$ N



5.33



$W = 15$ kW

$\omega = 94.2$ rad/s

$d = 0.048$ m

$\theta_n = 20°$

$\alpha = 16.6°$

$l = 0.08$ m

$C = W/\omega \rightarrow Q = 2C/d \rightarrow A = Q \tan\theta \rightarrow R = \frac{\sqrt{A^2 + Q^2}}{\cos\theta_n}$

$Q = 6639.87$ N

$A = 1976.8$ N

$R = 2518.5$ N

$R_x - A = 0 \rightarrow R_x = 1976.8$ N ~~2518.5 N~~

$3315.6\,N = R_{A2} \leftarrow B)\ \Sigma M_y: \quad R_{z\,A} \cdot l - Q \frac{l}{2} = 0 \rightarrow R_{zA} = \frac{Q}{2}$

$3315.6\,N = R_{B2} \leftarrow A)\ \Sigma M_y: \quad R_{z\,B} \cdot l - Q \frac{l}{2} = 0 \rightarrow R_{zB} = \frac{Q}{2}$

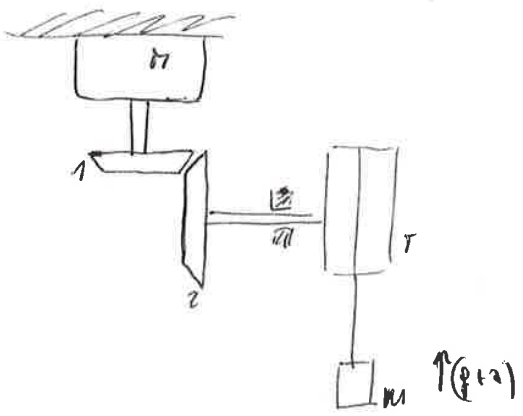
$1852.3\,N = R_{Ay} \leftarrow B)\ \Sigma M_z: \quad A\frac{d}{2} + R\frac{l}{2} - R_{Ay} l = 0$

$666.2\,N$ ~~R_{By}~~ $= R_{By} \leftarrow A)\ \Sigma M_z: \quad R_{By} l - R\frac{l}{2} + A\frac{d}{2} = 0$

$R_A = \sqrt{R_x^2 + R_{Ay}^2 + R_{Az}^2} = 4781.6$ N

$R_B = \sqrt{R_{By}^2 + R_{Bz}^2} = 3381.9$ N

5401



$h = 0{,}8\,m \rightarrow V = 0 \rightarrow 2\,m/s$

$\varphi_1 \; ? \quad \varphi_2 = ?$

$a = ?$

$C_M = ?$

$z_1 = 17$

$z_2 = 46$

$d = 0{,}8\,m$

$I_T = 9\,kgm^2$

$m = 50\,kg$

$V = at \rightarrow a = \frac{V}{t}$

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

$= h = \frac{1}{2}\frac{V}{t} t^2 \Rightarrow t = 0{,}8\,s$

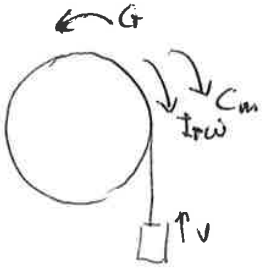
$\Rightarrow a = 2{,}5\,m/s^2$

$\dot{\omega}_T = 6{,}25\,rad/s^2$

$C_M \; C_2$

$C_T = m(g+a)\frac{d}{2} + I_T \dot{\omega}_T =$

$= 302{,}25\,Nm$



$\dot{\omega}_2 = \dot{\omega}_T$

$\tau = \frac{z_1}{z_2} = 0{,}369 \rightarrow \dot{\omega}_1 = 16{,}91\,rad/s^2$

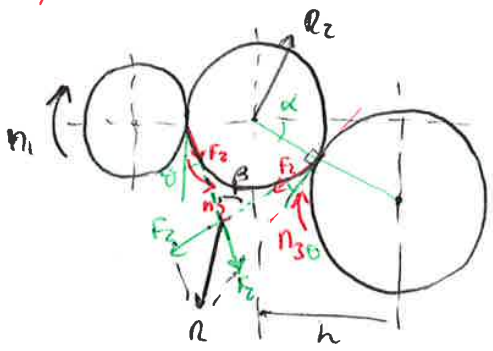
$\frac{z_1}{z_2} = \frac{\operatorname{sen}\varphi_1}{\operatorname{sen}\varphi_2} \Rightarrow \frac{\operatorname{sen}\varphi_1}{\operatorname{sen}(\pi_2 - \varphi_1)} \Rightarrow \frac{\operatorname{sen}\varphi_1}{\cos\varphi_1} \Rightarrow \operatorname{tg}\varphi_1 \rightarrow \varphi_1 = 20{,}25°$

$\varphi_2 = 69{,}75$

$\varphi_2 = \pi_2 - \varphi_1$

$\frac{C_1}{C_T} = \tau \rightarrow C_M = \tau C_T = 111{,}53\,Nm$

ROTISMI



$W = 3\,kW$

$n_1 = 1725\,giri/min$

$z_1 = 16$

$z_2 = 18$

$z_3 = 22$

$\vartheta = 20°$

$h = 0{,}055\,m$

$n_2 = ?$

$n_3 = ?$

$V = ?$

$m = 3\,mm$

$\frac{n_2}{n_1} = \frac{z_1}{z_2} \Rightarrow n_2 =$

$n_2 = 1533{,}33\,giri/m$

$\frac{n_3}{n_2} = \frac{z_2}{z_3} \Rightarrow n_3 = 393\,giri/m$

V_2

$r_1 = \frac{m z_1}{2} = 24\,mm$

$\Rightarrow V = \frac{n_1 2\pi}{60} r_1$

$= 4{,}33\,m/s$

$r_3 = 0{,}108\,m$

$r_2 = \frac{m z_2}{2} = 27\,mm$

$C_2 = W/\omega_2 = 18{,}69\,Nm$

$\Rightarrow F_2 = C_2/r_2 \cos\vartheta = 736{,}76\,N$

$\alpha = \arccos\frac{r_2 + r_1}{r_1 + r_3}\frac{h}{} \Rightarrow 65{,}96°$

$\beta = -[(180-\alpha) + 2(90-\vartheta)] + 360 \rightarrow \beta = 105{,}96°$

$R = n_2 = 2 F_2 \cos\beta/2 = 887{,}2\,N$

5.48

$n_p = 800$ giri/min $= 83{,}73$ rad/s

$W = 8$ kW

$z_1 = 20$

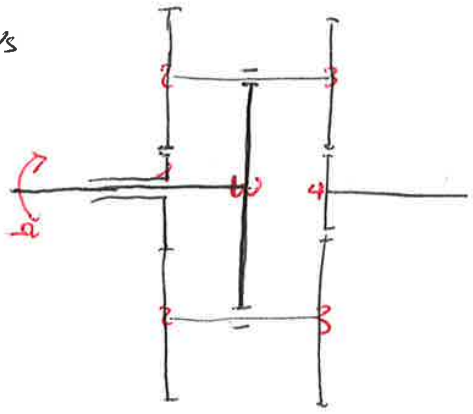
$z_2 = 24$

$z_4 = 24$

$\omega_4 = ?$

$C_1 = ?$

$\omega_1 = 0$



$z_1 + z_2 = z_3 + z_4$

$\Rightarrow z_3 = 20.$

$$\tau = \frac{\omega_4 - \Omega}{\omega_1 - \Omega} = \left(-\frac{z_1}{z_2}\right)\left(-\frac{z_3}{z_4}\right)$$

$\omega_1 = 0 \rightarrow \tau = 0{,}6944$

$\Rightarrow \tau = \frac{\omega_4 - \Omega}{-\Omega} \Rightarrow$

$\Rightarrow \omega_4 = 25{,}58$ rad/s

$$C_p = \frac{W}{\Omega} = 95{,}54 \text{ Nm}$$

$C_p \Omega = C_4 \omega_4 \Rightarrow 312{,}74$ Nm $= C_4 \rightarrow C_1 = C_4 - C_p = 217{,}2$ Nm

5.49

$z_1 = 40$

$z_3 = 14$

$z_4 = 18$

$\Omega = 418{,}65$ rad/s

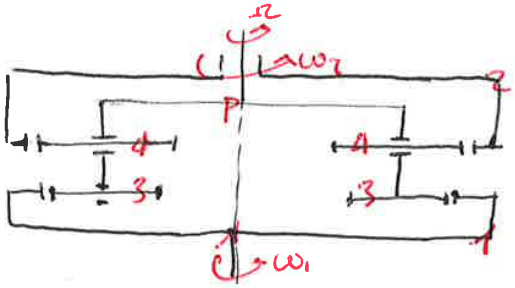
$W = 4000$ W

$z_2 = ?$

$\omega_2 = ?$ Se $\omega_1 = 0$

$\omega_1 = ?$ Se $\omega_2 = 0$

$C_1 = ?$ $C_2 = ?$



$z_1 - z_3 = z_2 - z_4 \rightarrow z_2 = 44$

$$\tau = \frac{\omega_2 - \Omega}{\omega_1 - \Omega} = \left(-\frac{z_1}{z_3}\right)\left(-\frac{z_4}{z_1}\right)$$

$\tau = 1{,}1688$

~~$C_4 = C_p = W/\Omega = 9{,}55$ Nm~~

~~$C_2 + C_1 + C_p = 0$~~

~~$\omega_1 = 0 \rightarrow \omega_2 = 358{,}21$ rad/s~~

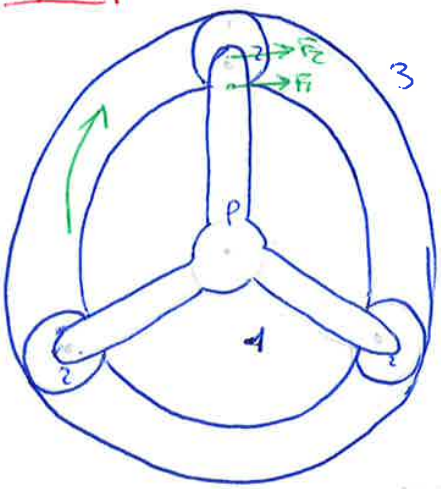
Se $\omega_2 = 0 \rightarrow \omega_1 = -$ ~~$358{,}21$~~ rad/s

Se $\omega_1 = 0 \rightarrow$ ~~$\omega_2 = 489{,}67$~~

$\omega_2 = 70{,}69$ rad/s

Se $\omega_2 = 0 \rightarrow \omega_1 = 60{,}46$ rad/s

5.56

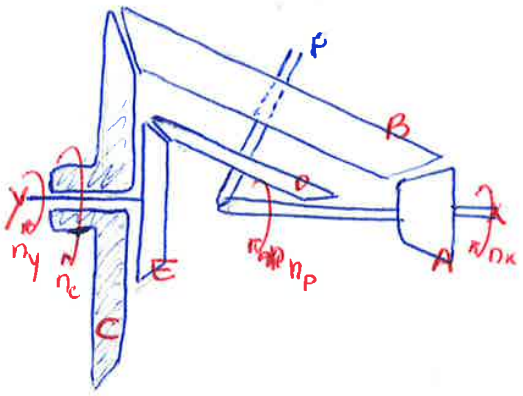


$z_1 = 19$
$C_1 = 16\ Nm$
$z_2 = 21$
$\omega_3 = 0$
$m = 4\ mm$
$\tau = ?$
$F_2 = ?$
$C_3 = ?$

$r_1 = \frac{z_1 m}{2} = 38\ mm$
$r_2 = 42\ mm$
$\rightarrow r_p = 70\ mm$
$r_3 = 112\ mm$

$\left(-\frac{z_1}{z_2}\right)\left(\frac{z_2}{z_3}\right) = \tau_w = \frac{\omega_3 - \Omega}{\omega_1 - \Omega} \rightarrow$
$-0,75$
$\rightarrow \frac{\Omega}{\omega_1} = \frac{\tau_w}{\tau_w - 1} = 0,2$
$C_1 \omega_1 = C_p \Omega \rightarrow C_p = 80\ Nm$
$F_2 = -\frac{C_1}{r_2} = 380,45\ N/m$

5.57



$n_c = 0$
$n_x = 650\ giri/min$
$z_A = 18$
$z_B = 55$
$z_C = 60$
$z_D = 24$
$z_E = 28$
$n_y = ?$

$\tau_{w_1} = \frac{n_c - n_p}{n_A - n_p} = -\frac{z_A}{z_B}\cdot\frac{z_B}{z_C} = -0,3$

$\tau_{w_A} - \tau_{w_p} = -n_p \rightarrow$
$\rightarrow n_p = \frac{\tau_{w_A}}{(\tau_w - 1)} = 150\ giri/min$

$\tau_{w_2} = \frac{n_y - n_p}{n_x - n_p} = \left(-\frac{z_A}{z_B}\right)\left(\frac{z_D}{z_E}\right) = -0,2805$

$\tau_{w_x} - \tau_{w_p} + n_p = n_y = -1,75\ giri/min$

$n_p = \frac{\tau_{w_1}}{\tau_{w_1} - 1} n_x \qquad n_y = (1 - \tau_{w_2}) n_p + \tau_{w_2} n_x \rightarrow n_y = \left(\frac{\tau_{w_1}}{\tau_{w_1} - 1} - \frac{\tau_{w_2}\tau_{w_1}}{\tau_{w_1} - 1} + \tau_{w_2}\right) n_x$

$= \frac{(\tau_{w_1} - \tau_{w_2}\tau_{w_1} + \tau_{w_2}\tau_{w_1} - \tau_{w_2})}{\tau_{w_1} - 1} n_x \rightarrow n_y = \frac{\tau_{w_1} - \tau_{w_2}}{\tau_{w_1} - 1} n_x$

per far sì che n_y giri in senso opposto a $n_x \rightarrow n_y < 0 \rightarrow \tau_{w_1} - \tau_{w_2} > 0$

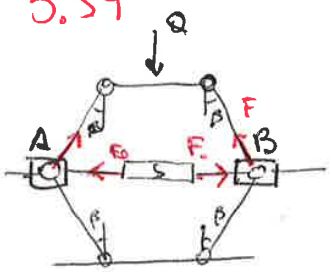
$\rightarrow -\frac{z_A}{z_C} + \left(+\frac{z_A}{z_B}\frac{z_D}{z_E}\right) > 0 \rightarrow \frac{z_A}{z_C} > \frac{z_A z_D}{z_B z_E} \rightarrow z_E > \frac{z_C z_D}{z_B} \rightarrow z_E < \frac{z_C z_D}{z_B}$

$\rightarrow z_E < 26,18 \rightarrow$ Np $z_E = 26 \rightarrow \Delta z_E = z_D - z_E = 2$

$\tau_1' = \left(-\frac{z_A}{z_B}\right)\left(\frac{z_D}{z_E}\right) = -0,30209 \rightarrow \tau_{w_2} = \frac{\tau_{w_1} - \tau_{w_1}'}{\tau_{w_1} - 1} = 1,0489\ giri/min$

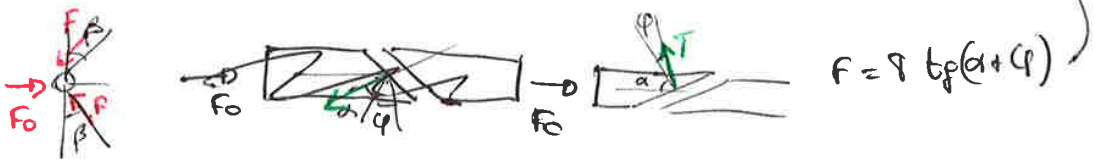
$F = P/\cos(\alpha+\varphi)$
$C = rF\,\mathrm{sen}(\alpha+\varphi)$
$\Rightarrow C = \dfrac{Pr\,\mathrm{sen}(\alpha+\varphi)}{\cos(\varphi+\alpha)} \Rightarrow Pr\,tg(\alpha+\varphi)$ ok!

5.59



$Q = 10000\,N$
$P = 4\,mm$
$d = 19\,mm$
$f = 0{,}15$
$\beta = 35°$
$C_s = ?$

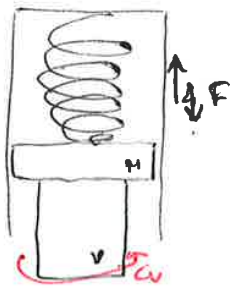
$Q - 2F\cos\beta = 0 \Rightarrow F = 6103{,}87\,N$
$F_0 - 2F\,\mathrm{sen}\beta = 0 \Rightarrow F_0 = 2F\,\mathrm{sen}\beta = 7002{,}1\,N$
$C = 2F_0\frac{d}{2}\,tg(\alpha+\varphi) = 29.16\,Nm$
$\arctg f = \varphi = 8{,}531°$
$\alpha = \arctg\left(\frac{P}{\pi d}\right) = 3{,}834°$



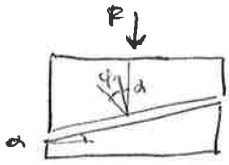
$F = T\,tg(\alpha+\varphi)$

5.61

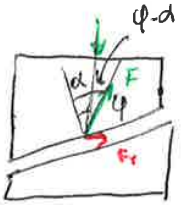
$k = 8\cdot10^3\,N/m$
$d = 18\,mm$
$p = 7\,mm$
$f = 0.16$
$F = 140N$, $n = ?$
$C_v = ?$
$C_{statico}$



$F = k\Delta x \Rightarrow \Delta x = 0{,}0175\,m \Rightarrow h = 0{,}3095\cdot2\pi$
$2\pi r = 0{,}0565\,m$

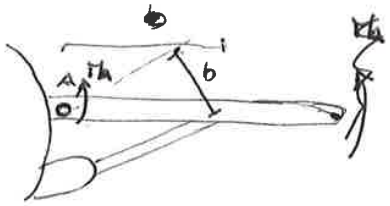


$\alpha = \arctg\frac{P}{\pi d} = 7{,}956°$
$\varphi = \arctg(f) = 9{,}09°$
$C_V = P\frac{d}{2}\,tg(\alpha+\varphi) = 0{,}365\,Nm$



$F_T = F\,tg(\varphi-\alpha)$
$C_{statico} = P\frac{d}{2}\,tg(\varphi-\alpha) = 0{,}0447\,Nm$

5.68



$p = 10\,mm$
$\eta = 0{,}90$
$l = 480\,mm$
$t = 65°$, $V = cost$
$\eta_R = 0{,}92$
$C_H = 20\,Nm$
$b = 1{,}25\,m$
$M_A = 2000\,Nm$
$\tau = ?$
$\omega_H = ?$
$W = ?$

$V = l/t = 0{,}08\,m/s$

$V : \omega = p : 2\pi \rightarrow \omega = 50{,}265\,rad/s$

$F = \frac{M_A}{b} = 1600\,N$

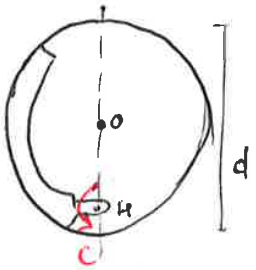
$W_H = \frac{F V}{\eta_R \eta} = 1545{,}1\,W$

$\rightarrow \omega_H = 77{,}29\,rad/s$

$\rightarrow \tau = \frac{\omega}{\omega_H} = 0{,}6503$

FRENI

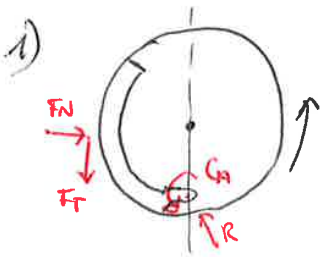
5.69



$d = 0{,}6\,m$
$OH = 0{,}2\,m$
$f = 0{,}25$
$C_O = ?$
$C_A = ?$
$M_f = 2000\,Nm$

$C = f \frac{h}{b - fe} \left(F \frac{d}{2}\right)$ ($F\frac{d}{2} = M_f$)

$h = 2\,OH$

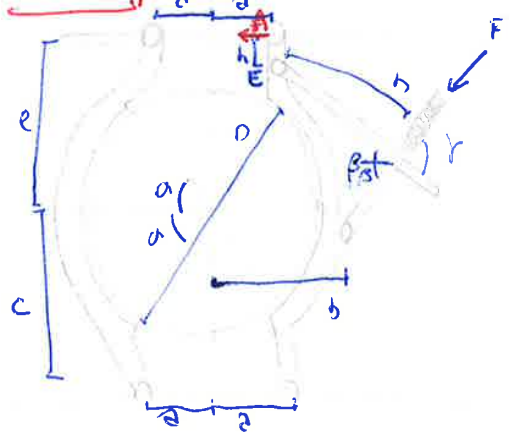


$M_f = F_T \frac{d}{2} \rightarrow F_T = 6666{,}67\,N \rightarrow F_N = 26666{,}67\,N$

A↑ $C_A - F_N\,OH + F_T \frac{d}{2} = 0 \rightarrow C_A = 3333{,}33\,Nm$

A↓ $C_A + F_N\,OH - F_T \frac{d}{2} = 0 \rightarrow C_O = 7333{,}33\,Nm$

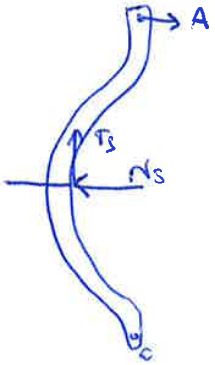
5.77



$f = 0{,}3$
$a = 114\,mm$
$b = 0{,}3\,m$
$c = 0{,}228\,m$
$D = 0{,}38\,m$
$e = 0{,}33\,m$
$h = 0{,}0886\,m$
$\alpha = 45°$
$\beta = 30°$
$\gamma = 90°$
$F = ? \setminus M = 340\,Nm$
verso orario

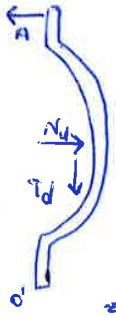
~~Bocco~~ $F b \cos\beta + F b \sin\beta = Ah$

E) $F b \cos\beta + F b \sin\beta - Ah = 0$



o) $T_S\left(\frac{D}{2}-a\right) - N_S c + A(e+c) = 0 \rightarrow T_S\left(\frac{D}{2}-a-c_f\right) = -A(e+c)$

$\frac{T_S}{f} = N_S$



o') $T_d\left(\frac{D}{2}-a\right) + N_D c - A(e+c) = 0 \rightarrow$

$\rightarrow T_d = f N_d$

$\Rightarrow T_d\left(\frac{D}{2}-a+c_f\right) = A(e+c)$

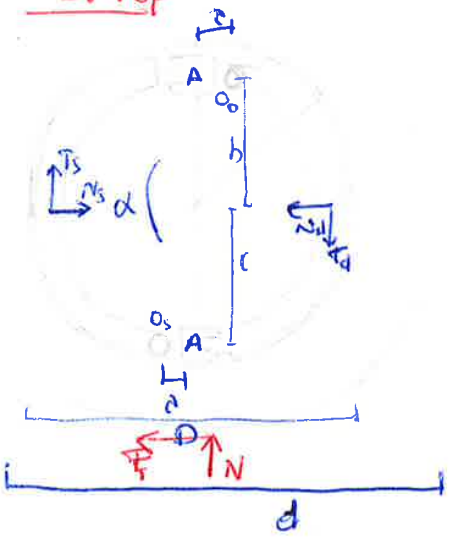
$M = (T_d + T_S)\frac{D}{2} \Rightarrow$

$\Rightarrow \left[\frac{A(e+c)}{\left(\frac{D}{2}-a+c_f\right)} - \frac{A(e+c)}{\frac{D}{2}-a-c_f}\right]\frac{D}{2}$

$M = \frac{b}{h}(e+c) F \frac{D}{2}\left[\left(\frac{1}{\frac{D}{2}-a+c_f}\right) - \left(\frac{1}{\frac{D}{2}-a-c_f}\right)\right]$

$\Rightarrow 0{,}898 M = F \rightarrow f = 305{,}42\,N$

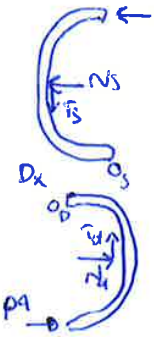
5.78



$d = 0{,}166\,m$
$N = 2000\,N$
$f_c = 0{,}25$
$d_A = 0{,}025\,m$
$D = 0{,}228\,m$
$f = 0{,}3$
$a = 0{,}038\,m$
$b = 0{,}086\,m$
$c = 0{,}082\,m$
$\alpha = 90°$
$P_a = ?$
$P_b = ?$

~~Orario~~

ANTI ORARIO



o_s) $pA(b+c) + N_S c - T_S\left(\frac{D}{2}-a\right) = 0$

$\frac{T_S}{f} = N$

$\rightarrow T_S\left(\frac{D}{2}-a-c_f\right) = pA(b+c)$

o_d) $pA(b+c) + N_d(b) + T_d\left(\frac{D}{2}-a\right) = 0$

$T_d f = N$

$\rightarrow T_d\left(\frac{D}{2}-a+b_f\right) = -pA(b+c)$

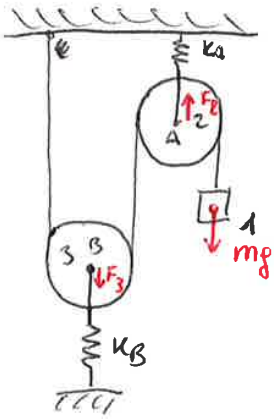
$M = (T_d + T_S)\frac{D}{2} = -R_f f N \frac{d}{2}$

$\left[\frac{pA(b+c)}{\left(\frac{D}{2}-a-c_f\right)} - \frac{pA(b+c)}{\left(\frac{D}{2}-a+b_f\right)}\right]\frac{D}{2} = -495 \rightarrow p = ~~0{,}12\,MPa~~$

$p = 5{,}30\,MPa$

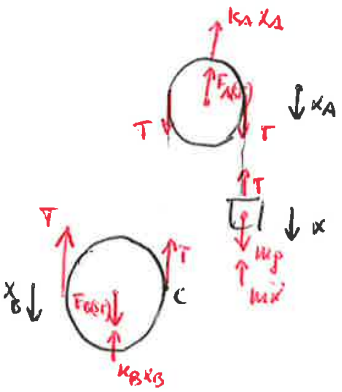
VIBRAZIONI LIBERE

6.1



$m_1 = 10\,kg$
$k_A = 1000\,N/m$
$k_B = 700\,N/m$
$\omega_n = ?$

$m_1 g = F_2 + F_3 = 0$



$x_C = 2\,x_B$
$x_A = \frac{x_C + x}{2}$

$$\begin{cases} T + m\ddot{x} = 0 \\ 2T - k_A x_A = 0 \rightarrow x_A = \frac{2T}{k_A} \\ 2T + k_B x_B = 0 \rightarrow x_B = -\frac{2T}{k_B} \end{cases}$$

$$\frac{2T}{k_A} = -\frac{4T}{k_B} + x \quad /2$$

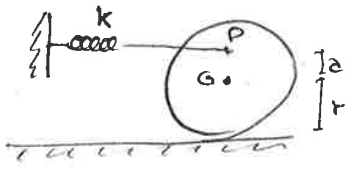
$$\Rightarrow x = \frac{4T}{k_A} + \frac{4T}{k_B}$$

$$\Rightarrow T = x \cdot \left(\frac{4}{k_A} + \frac{4}{k_B}\right)^{-1}$$

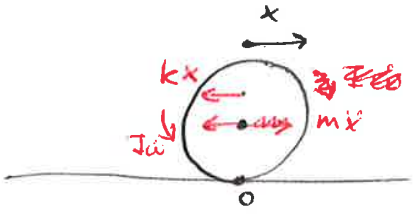
$$\Rightarrow \frac{x}{\frac{4}{k_A} + \frac{4}{k_B}} + m\ddot{x} = 0 \rightarrow \ddot{x} + 4\left(\frac{k_A + k_B}{k_A k_B}\right) x m = 0$$

$$4\,\frac{k_A + k_B}{k_A k_B} = \frac{1}{\omega_n^2} \rightarrow \omega_n = \sqrt{\frac{1}{4m\left(\frac{k_A + k_B}{k_A k_B}\right)}} = 3{,}208\ rad/s$$

6.2



$I = 0{,}5\,kg\,m^2$
$m = 20\,kg$
$k = 500\,N/m$
$r = 0{,}2\,m$
$a = 0{,}1\,m$
$f_n = ? = 2\pi\omega_n$



$\dot{\omega} = \ddot{x}\,r$

$$0 = I\frac{\ddot{x}}{r} + rm\ddot{x} - k x (a + x) \rightarrow \left(\frac{I}{r} + rm\right)\ddot{x} - k x (a+r) = 0 \rightarrow \left(\frac{I}{rk} + \frac{m}{k}\right)\ddot{x} - x = 0$$

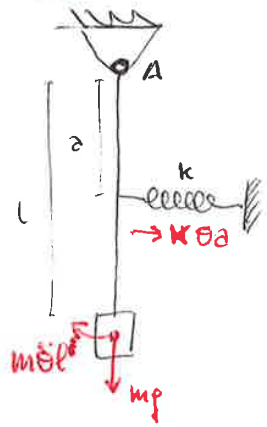
$$\left(\frac{I}{rk} + \frac{m}{k}\right) = \frac{1}{\omega_n^2} \rightarrow \omega_n = \frac{1}{\sqrt{\frac{I}{rk} + \frac{m}{k}}} =$$

$$\frac{I}{r}\ddot{x} + mr\ddot{x} - k(a+r)x \rightarrow \left(\frac{I}{r} + mr\right)\ddot{x} = x \rightarrow \omega_n = \sqrt{\frac{k(a+r)}{\frac{I}{r} + mr}} = 9.804\ rad/s$$

$$\Rightarrow f_n = 3{,}0 + 0{,}3\ Hz$$

$$m\ddot{x} + \frac{k \cdot \Delta e}{r}\,(r+a) + J_G\frac{\ddot{x}}{r} = 0 \rightarrow \omega_n = \sqrt{\frac{k(r+a)^2}{mr^2 + J_G}} = 5{,}88\ rad/s \rightarrow f = 0{,}936\,Hz$$

6.5



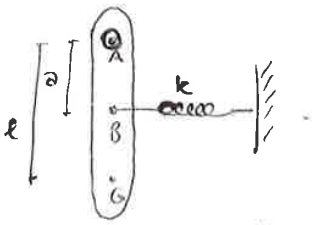
$T_s = ?$
$m = 100\ kg$
$k = 130\ N/m$
$a = 0.2\ m$
$l = 1\ m$

~~A) $m\ddot{\theta}l^2 - k\theta a^2 = 0 \rightarrow$~~
~~$\rightarrow ml^2\ddot{\theta} = \theta \rightarrow \omega_n^2 = \frac{ka^2}{ml^2} = 0,2285\ rad/s$~~
~~$T = \frac{2\pi}{\omega_n} = 27,55\ s$~~

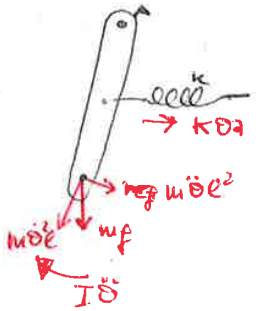
A) $m\ddot{\theta}l^2 + ka^2\theta + mgl\theta = 0$
$ml^2\ddot{\theta} + (ka^2 + mgl)\theta = 0 \rightarrow$
$\rightarrow \frac{1}{\omega_n} = \sqrt{\frac{ml^2}{ka^2+mgl}} = 3,14\ rad/s$
$\Rightarrow T_s = 2\pi/\omega_n = 2\ s$

6.6

$m = 3\ kg$
$\rho_G = 0,2\ m$
$k = 200\ N/m$
$a = 0.5\ m$
$l = 1\ m$
$f = ?$



$I = \rho^2 m + \cancel{\ldots}$



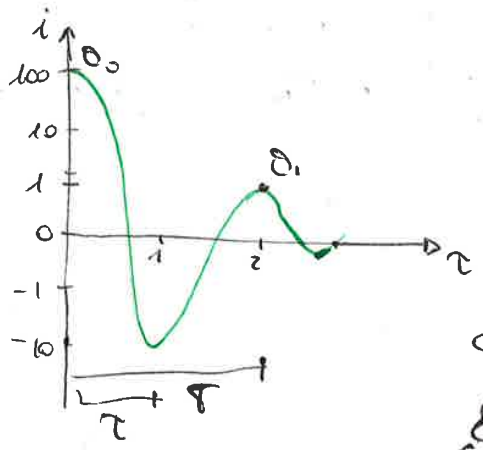
~~A) eq~~
A) $k\theta a^2 + m\ddot{\theta}l^2 + mf\theta l - I\ddot{\theta} = 0$
$(ml^2 + I^{\cancel{2}})\ddot{\theta} + \theta(ka^2 + mgl) = 0$
$\frac{1}{\omega_n} = \sqrt{\frac{ml^2 + I}{ka^2 + mgl}} = \cancel{5,045\ rad/s}\ \cancel{25,12\ rad/s}$
~~$f = \ldots = 161,62\ Hz$~~
$f = \frac{\omega_n}{2\pi} = 0,803\ Hz$

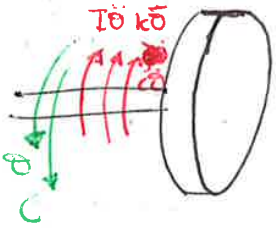
Hp: piccole oscillazioni $\sin\theta \approx \theta$

6.7

~~dati~~
$i = 100$
$\theta_0 = 40' = i$
$C = 1,2746\ Nm$

$i' = -10$
$i'' = +1$
~~$\Delta t = 42\ s$~~
$\tau = 2\ s$
$\zeta = ?$
$T_0 = ?$ & $T = ?$
$T = ?$





$I\ddot{\theta} + k\theta + c\dot{\theta} = 0$

$\theta(t) = \theta_0 e^{-\zeta\omega_n t}\cos\left(\omega_n\sqrt{1-\zeta^2}\,t\right)$

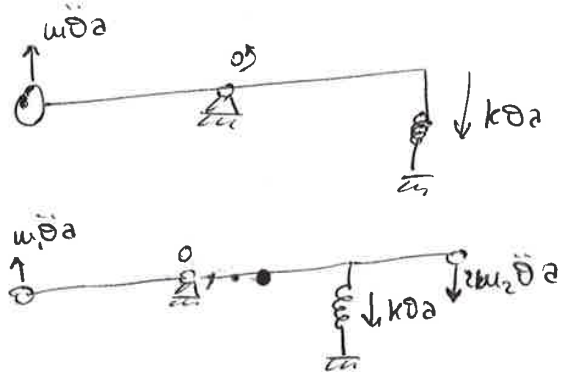
$\delta = \ln\frac{\theta_1}{\theta_0} = \ln\frac{1}{100} = -4,605$

$\delta = -\frac{2\pi\zeta}{\sqrt{1-\zeta^2}} \rightarrow \zeta = \sqrt{\frac{\delta^2}{4\pi^2+\delta^2}} = 0,591$

$T = \cancel{4s} = \frac{2\pi}{\omega_n\sqrt{1-\zeta^2}} \rightarrow \omega_n = 1,947\ rad/s$

$k = \frac{C}{\theta_0} = 1,826\cdot10^6\ Nm/rad$ (C in rad)

dal confronto con l'equazione del moto ~~$k\theta$~~ e più in forma canonica $\omega_n = \sqrt{\frac{k}{I}} \rightarrow I = 0,482\cdot10^6\ kgm^2$



$\circlearrowleft_O$: $m\ddot{\vartheta}a^2 + k\vartheta a^2 = 0$

$\frac{m}{k}\ddot{\vartheta} + \vartheta = 0 \rightarrow \omega_n = \sqrt{\frac{k}{m}}$

$\circlearrowleft_O$ $m_1\ddot{\vartheta}a^2 + k\vartheta a^2 + 4m_2\ddot{\vartheta}a^2 = 0$

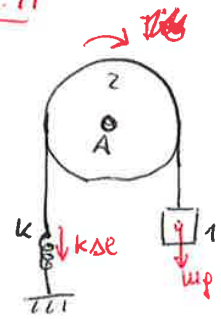
$\omega_n = \sqrt{\frac{k}{m_1+m_2}} = \frac{1}{2}\sqrt{\frac{k}{m_1}}$

$\frac{4k}{m_1+4m_2} = \frac{k}{m_1} \rightarrow 4m_1 = m_1 + 4m_2$

$\rightarrow 3m_1 = 4m_2 \rightarrow C = \frac{3}{4}$

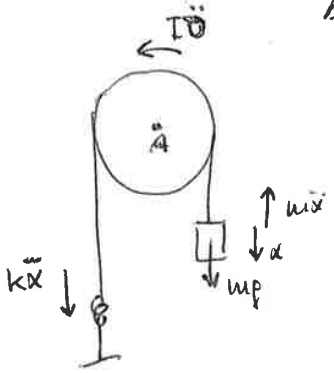
Fobbi Til.

6.91



$m_a = 0.8\ kg$
$M_a = 2\ kg$
$d = 0,1\ m$
$\rho = 0,04\ m$
$k = 5000\ N/m$
$T_s = ?$
Δe_{st}

STATICO: $k\Delta e \frac{d}{2} = mg \frac{d}{2} \rightarrow \Delta e = 1.57\ mm$



$\frac{d}{2}\vartheta = x$

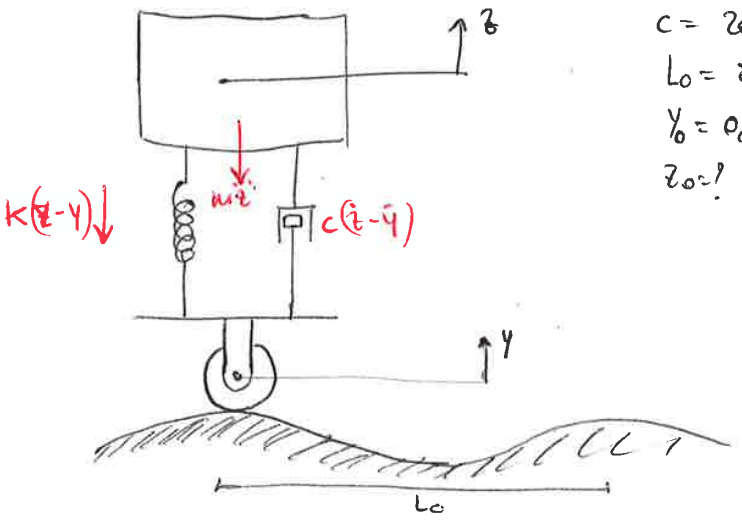
$\Delta\circlearrowleft$: $kx\frac{d}{2} + m\ddot{x}\frac{d}{2} + M\rho^2\ddot{\vartheta} \rightarrow kr^2\vartheta + mr^2\ddot{\vartheta} + M\rho^2\ddot{\vartheta} = 0$

$(mr^2 + M\rho^2)\ddot{\vartheta} + kr^2\vartheta = 0$

$\rightarrow \omega_n = \sqrt{\frac{kr^2}{mr^2 + M\rho^2}} = 49\ rad/s$

$T = 0.128\ s$

6.12



$m = 1000\,kg$

$k = 300000\,N/m$

$c = 20000\,Ns/m$

$L_0 = 8\,m$

$y_0 = 0{,}02\,m$

z_0? se $V = 70\,km/h = 19{,}44\,m/s \rightarrow \omega_1 =$

se $V = 120\,km/h = 33{,}33\,m/s$

$$\omega_n = \sqrt{\frac{k}{m}} = 17{,}32\ rad/s$$

$$c = 2\xi\sqrt{km} \rightarrow \xi = 0{,}577$$

$z(t) =$

$$k z + c\dot{z} + m\ddot{z} = ky + c\dot{y}$$

$$\frac{z_0}{y_0} = \frac{\sqrt{1 + \frac{4\xi^2\Omega^2}{\omega_n^2}}}{\sqrt{\left(1-\left(\frac{\Omega}{\omega_n}\right)^2\right)^2 + 4\xi^2\left(\frac{\Omega}{\omega_n}\right)^2}} =$$

$f\,[Hz] = V/L_0 \rightarrow \Omega = 2\pi f =$

se $V = 19{,}44\,m/s$

$\rightarrow \Omega_1 = 15{,}27\ rad/s$

$\Omega_2 = 76{,}177\ rad/s$

$\rightarrow$ $z_1 =$ ~~0,0075 m~~ $0{,}0274\,m$

$z_2 =$ ~~12,04~~ $y_0 \frac{2{,}91}{1{,}63} =$ ~~0,0453 m~~ $\rightarrow z_0 = 0{,}01858\,m$

6.13

$f_n = 3\,Hz$

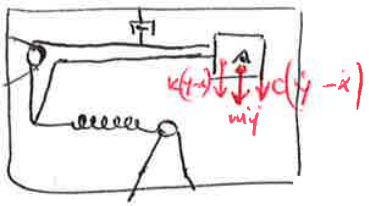
$\xi = 0{,}5$

~~$\omega_n = 18{,}84\ rad/s$~~

$z_0 = 0{,}0025\,m$

$K_0 = ?$

$\Omega = 180\,giri/min \cdot 3\,poli \rightarrow 56{,}55\ rad/s$



~~$\omega_n = 2\pi f$~~ $\omega_n = 2\pi f_n = 18{,}84\ rad/s$

$z = y - x$

$\ddot{z} = \ddot{y} - \ddot{x}$

$$m\ddot{y} + c(\dot{y}-\dot{x}) + k(y-x) = 0 \rightarrow$$

$$\frac{m}{k}\ddot{z} + \frac{m}{k}\dot{x} + \frac{c}{k}\dot{z} + z = 0$$

($\frac{m}{k} = \frac{1}{\omega_n^2}$, $\frac{c}{k} = \frac{2\xi}{\omega_n}$)

$$\frac{\ddot{z}}{\omega_n^2} + \frac{2\xi}{\omega_n}\dot{z} + z = -\frac{m}{k}\ddot{x}$$

$$\frac{\ddot{z}}{\omega_n^2} + \frac{2\xi}{\omega_n}\dot{z} + z = \frac{\Omega^2}{\omega_n^2} z_0 \sin(\Omega t)$$

$z = z_0 \cos(\Omega t)$

$\dot{z} = -\Omega z_0 \sin(\Omega t)$

$\ddot{z} = -\Omega^2 z_0 \cos(\Omega t)$

$$-\frac{\Omega^2}{\omega_n^2} z_0 \cos(\Omega t) + \frac{2\xi}{\omega_n}\Omega z_0 \sin(\Omega t) + z_0 \cos(\Omega t) = \frac{\Omega^2}{\omega_n^2} K_0 \sin(\Omega t)$$

6.15

$m = 9000\ kg$

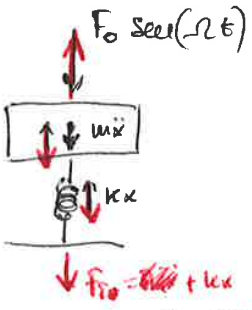
$F_0 = 20000\ N$

$f_0 = 1\ Hz$

$\beta \approx 0 \quad \xi = 0$

$k = ?$ \ ~~$kx = 2000\ N$~~

$F_{T0} = 2000\ N$ =



~~$x = x_0 \cos(\Omega t) + \varphi$~~

~~$\ddot{x} = -\Omega^2 x \cos(\Omega t)$~~

$F_0 \sin(\Omega t) = m\ddot{x} + kx \rightarrow$

$\rightarrow \frac{F_0}{k} \sin(\Omega t) = \frac{m\ddot{x}}{k} + x \rightarrow$ ($\frac{1}{\omega_n^2}$)

$F_T = kx + c\dot{x} \rightarrow$

$\Rightarrow F_T = kx = k x_0 \sin(\Omega t) = F_{T0} \sin(\Omega t) \rightarrow \frac{F_{T0}}{F_0} =$

$$\frac{F_{T0}}{F_0} = \frac{1}{\left|1 - \frac{\Omega^2}{\omega_n^2}\right|}$$

ma si richiede $F_{T0}/F_0 < 1 \rightarrow \Omega > \sqrt{2}\,\omega_n$

$\Rightarrow \frac{F_{T0}}{F_0} = \frac{1}{\frac{\Omega^2}{\omega_n^2} - 1} \rightarrow \omega_n = 358{,}87\ rad/s$

$\rightarrow k = \omega_n^2 m = 322983\ N/m$

6.16

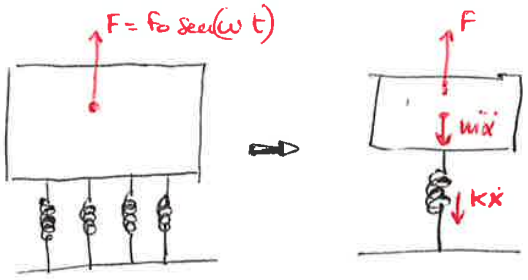
$m = 180\ kg$

4 molle

$F_i \propto v^2$

$n_1 = 800\ giri/min$

$F_0 = 310\ N$



$F_{T0} = 22\ N \rightarrow k = ?$

$A = ?$ Se $n = 600\ giri/min$

$F_0 \sin(\omega t) = kx + m\ddot{x}$

$\frac{F_0 \sin(\omega t)}{k} = x + \frac{m\ddot{x}}{k}$ ($\frac{1}{\omega_n^2}$)

$n_1 = 800\ giri/min \rightarrow \omega = 84{,}2\ rad/s$

$F_T = kx = F_{T0} \sin(\omega t)$

kx_0

$$\frac{F_{T0}}{F_0} = \frac{1}{\left|1 - \frac{\omega^2}{\omega_n^2}\right|}$$ ma $F_{T0}/F_0 < 1 \rightarrow \omega > \sqrt{2}\,\omega_n$

$\Rightarrow \frac{F_{T0}}{F_0} = \frac{1}{\left(\frac{\omega^2}{\omega_n^2} - 1\right)} \rightarrow \frac{\omega^2}{\omega_n^2} - 1 = 1/0{,}071$

$\omega^2 = (14{,}09 + 1)\,\omega_n^2$

$\rightarrow \omega_n = 24{,}25\ rad/s$

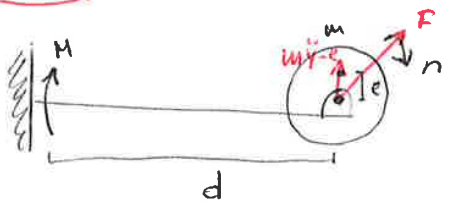
$\rightarrow \omega_n = \sqrt{\frac{k}{m}} \rightarrow k =$

$\Rightarrow k = 1058422{,}2\ N/m$

$F_0' = F_0 \frac{n_2^2}{n_1^2} = 137{,}78\ N$

$\Rightarrow A = \frac{F_0'/k}{\left(\frac{\omega'}{\omega_n}\right)^2 - 1} = \frac{90013}{5{,}706} = 0{,}0000728\ m$

6.18



$k = 1940\ N/mm \rightarrow 1.94 \cdot 10^6\ N/m$
$m = 160\ kg$
$e = 0.0025\ m$
$d = 0.203\ m$
$A = ?$
$M = ?$
$n = 1000\ giri/min$

$F = F_0 \operatorname{sen}(\omega t)$

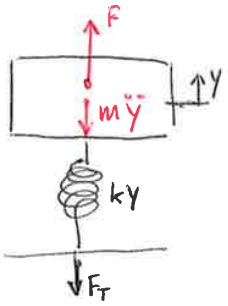
$F_0 = m\omega^2 e = 4386.5\ N$

$\omega = \frac{2\pi n}{60} = 104.72\ rad/s$

$\frac{F_0 \operatorname{sen}(\omega t)}{k} = \frac{m}{k}\ddot{y} + y \rightarrow \omega_n = 110,13\ rad/s > \omega \rightarrow A = \frac{F_0/k}{\left(\frac{\omega^2}{\omega_n^2}+1\right)}$ $= 0,0212\ cm$

$M_{max} = kyd = 291,22\ Nm$

6.19



$h = 0,00086\ m$
$f_r = ?$
$m = 1200\ kg$
$n = 450\ giri/min \rightarrow 47,1\ rad/s$
$F_0 = 7300\ N$
$Y_0 = ?$
$F_{T0} = ?$

Inizialmente $mg = kh \rightarrow k = 1.367 \cdot 10^7\ N/m$
$\rightarrow \omega_n = \sqrt{\frac{k}{m}} = 106,75\ rad/s \rightarrow f_0 = 17\ Hz$

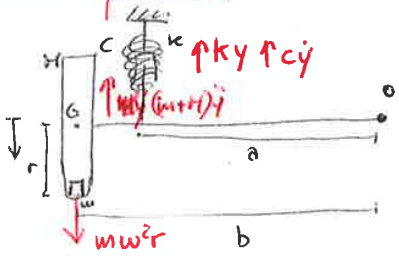
$F_0 \cos \frac{f_0 \operatorname{sen}(\omega t)}{k} = \frac{m}{k}\ddot{y} + y$

$Hp: \xi = 0 \ ; \ \omega_n > \omega \rightarrow$

$\Rightarrow Y_0 = \frac{(F_0/k)}{\left[1-\left(\frac{\omega}{\omega_n}\right)^2\right]} = 0,2089\ mm$

$F_{T0} = k \cdot Y_0 = 2856\ N$

6.20 // 6.21



$M = 45\ kg$
$I_G = 1.4\ kgm^2$
$k = 8750\ N/m$
$c = 2600\ Ns/m$
$m = 0,25\ kg$
$r = 0,35\ m$
$a = 0,6\ m$
$b = 0,8\ m$
$\omega_n = ?$
$\xi = ?$

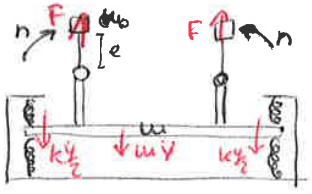
$\frac{(I_G + Mb^2)}{ka^2}\ddot{\vartheta} + \frac{c}{k}\dot{\vartheta} + a\vartheta = 0$

$\frac{2\xi}{\omega_n} \rightarrow \xi = 1517$

$\omega_n^2 = 0 \rightarrow \omega_n = 10,13\ rad/s$

6.23

$m_0 = 1\,kg$
$e = 0{,}012\,m$
$k = ?$ \ $F_{T0} = 1500\,N$, $\omega = 188{,}4\,rad/s$
$m = 10\,kg$
$\xi = 0$



$F = F_0 \sin(\omega t)$

$F_0 = 2\,m\,\omega^2 e = 851{,}87\,N$

$\frac{F}{k} = \frac{m\ddot{y}}{k} + y$

$\frac{F_{T0}}{F_0} = \frac{1}{\left|1 - \left(\frac{\omega}{\omega_n}\right)^2\right|} \rightarrow \frac{F_0}{F_{T0}} = 0{,}568 = \left|1 - \frac{\omega}{\omega_n}\right| \Rightarrow$

$\rightarrow \omega_n > \omega \rightarrow 0{,}568 = 1 - \frac{\omega}{\omega_n} \rightarrow \omega_n = \frac{\omega}{0{,}432} = 436{,}02\,rad/s \rightarrow k = 1{,}901 \cdot 10^5\,N/m$

$\rightarrow \omega_n < \omega \rightarrow 0{,}568 = \frac{\omega}{\omega_n} - 1 \Rightarrow \omega_n = \frac{\omega}{1{,}568} \rightarrow \omega_n = 120{,}15\,rad/s \rightarrow k = 1{,}404 \cdot 10^5\,N/m$

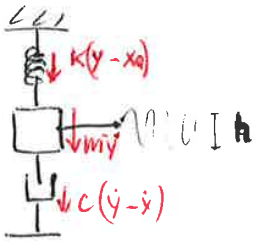
$\frac{F_{T0}}{F_0} = \underbrace{\frac{1}{\left|1 - \left(\frac{\omega}{\omega_n}\right)^2\right|}}_{e} \rightarrow e = \frac{1}{F_{T0}/F_0} = 0{,}568 = \left|1 - \left(\frac{\omega}{\omega_n}\right)^2\right|$

$\omega_n > \omega \rightarrow 0{,}568 - 1 = -\left(\frac{\omega}{\omega_n}\right)^2 \rightarrow \omega_n = \sqrt{\frac{\omega^2}{0{,}432}} = 286{,}6\,rad/s \rightarrow k = 8{,}216 \cdot 10^5\,N/m$

$\omega_n < \omega \rightarrow 0{,}568 + 1 = \left(\frac{\omega}{\omega_n}\right)^2 \rightarrow \omega_n = \sqrt{\frac{\omega^2}{1{,}568}} = 150{,}45\,rad/s \rightarrow k = 7{,}26 \cdot 10^5\,N/m$

6.24

$f_0 = 5\,Hz \rightarrow \omega = 31{,}4\,rad/s$
$x_0 = 0{,}009\,m$
$m = 2\,kg$
$k = 1.5 \cdot 10^3\,N/m$
$h = 0{,}024\,m$
$c = ?$ $\quad h = 2\gamma_0$



$\sum F = k y + c\dot{y} + m\ddot{y} = c\dot{x} + kx$

$y + \frac{c}{k}\dot{y} + \frac{m}{k}\ddot{y} = \frac{c}{k}\dot{x} + x$

$\frac{1}{\omega_n^2} \rightarrow \omega_n = 27{,}35\,rad/s$

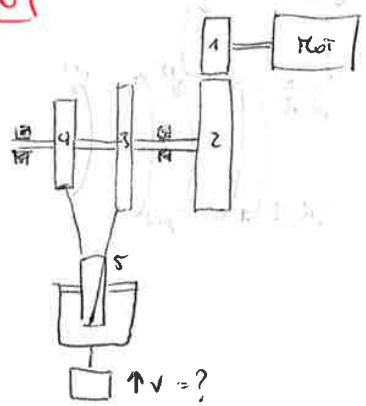
$x = x_0 \sin(\omega t)$
$\dot{x} = \omega x_0 \cos(\omega t)$
$\ddot{x} =$
$y = y_0 \sin(\omega t + \varphi)$
$\dot{y} = \omega y_0 \cos(\omega t + \varphi)$
$\ddot{y} = -\omega^2 y_0 \sin(\omega t + \varphi)$

$\Rightarrow y + \frac{2\xi}{\omega_n}\dot{y} + \frac{y}{\omega_n^2} = \frac{2\xi}{\omega_n}\dot{x} + x$

$y_0 \sin(\omega t + \varphi) + \frac{2\xi}{\omega_n}\left(-\omega y_0 \cos(\omega t + \varphi)\right) - \frac{\omega^2}{\omega_n^2} y_0 \sin(\omega t + \varphi) =$

$= -\frac{2\xi}{\omega_n}\left(x_0 \omega \cos(\omega t)\right) + x_0 \sin(\omega t)$

5.96



$d_5 = 0{,}305\,m$

$d_4 = 0{,}3\,m$

$z_2 = 61$

$z_1 = 19$

$C_0 = 3{,}5\,Nm$

$I_1 = 0{,}7\,kgm^2$

$I_2 = 0{,}9\,kgm^2$

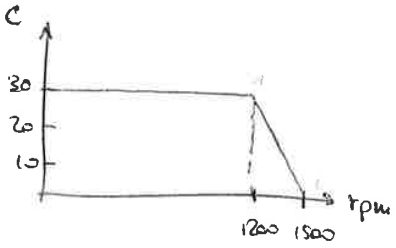
$I_5 \approx 0$

$d_3 = ?$

$v = ?$ ~~se $n_r = 1400$ rpm~~

$m = ?$ se $n_r = 1400\,rpm \rightarrow \omega_1 = 146\,rad/s$

$a = ?$

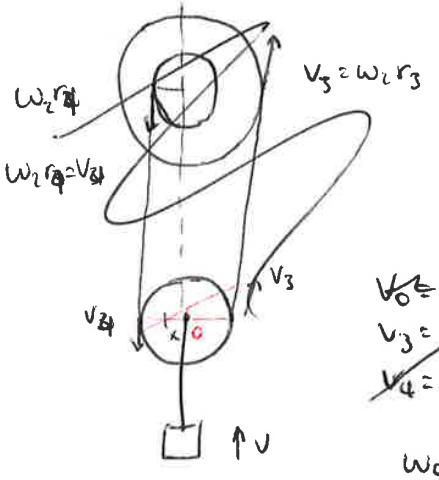


~~$C_r = \frac{30 \cdot 1200}{1400} = 25{,}714\,Nm$~~

$\frac{y - y_1}{y_2 - y_1} = m \frac{x - x_1}{x_2 - x_1} \Rightarrow$

$\Rightarrow C_r = 10\,Nm$

$\tau_{12} = \frac{z_1}{z_2} = 0{,}311$



$V_0 =$

$V_3 = \omega_2 r_3 = (r_5 + x)\,\omega_0$

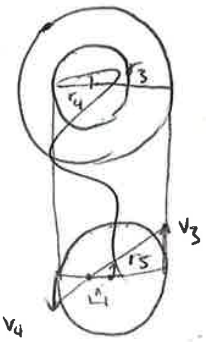
$V_4 = \omega_2 r_4 = (r_5 - x)\,\omega_0$

$\omega_0 = \frac{\omega_2 r_3}{r_5 + x} = \frac{\omega_2 r_4}{r_5 - x}$

$V_0 = \frac{V_4}{\omega_0} \times \frac{\omega_2 r_4}{\omega_0} x = \frac{\omega_2 r_3}{\omega_0} x$

$V_0 = \frac{V_3}{\omega_0} x$

$V_3 = \omega_2 r_5 =$



$d_5 = r_4 + r_3 \rightarrow r_3 = 0{,}305 \rightarrow d_3 = 0{,}316\,m$

$\omega_2 = \omega_1 \tau = 45{,}571\,rad/s$

$V_4 = \omega_2 r_4 = 6{,}835\,m/s = \omega_0 (r_5 - x) \rightarrow \omega_0 = V_4/(r_5 - x)$

$V_3 = \omega_2 r_3 = 7{,}2\,m/s = \omega_0 (r_5 + x) \rightarrow V_3 = \frac{V_4}{(r_5 - x)} \cdot (r_5 + x)$

$\Rightarrow V_3 (r_5 - x) = V_4 (r_5 + x) \Rightarrow$

$x = 0{,}0041\,m$

$\rightarrow \omega_0 = 45{,}594\,rad/s$

$V_0 = x \omega_0 = 0{,}187\,m/s$

$C_1 = C_M - I_1 \dot{\omega}_1 - C_0 \qquad C_2 = \frac{C_1}{\tau_{12}} \qquad C_e = C_2 - I_2 \dot{\omega}_2 \rightarrow$ ~~$F = \frac{2 C_e}{r_5} = m(g + a_2)$~~

71,43

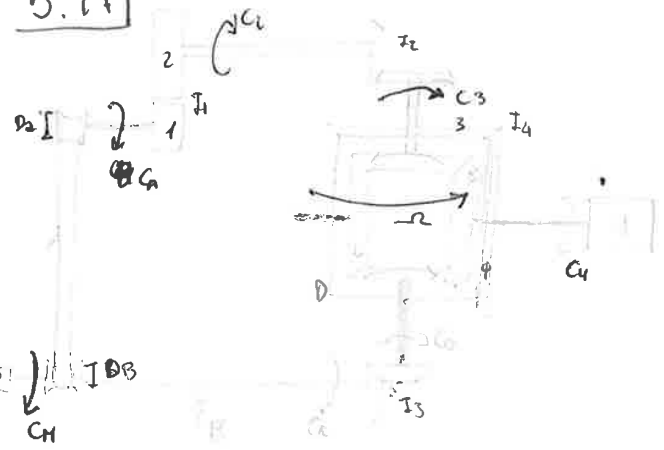
~~$C_e = \eta \left(\frac{1}{\tau} (C_M - I_1 \dot{\omega}_1 - C_0) - I_2 \tau \dot{\omega}_1 \right) \cdot \frac{1}{r_5} = F$~~ in condizioni di $\omega = cost \rightarrow \dot{\omega}_1 = 0$

$\Rightarrow F = 1073{,}79\,N \rightarrow m = 109{,}96\,kg$

$\eta = 0{,}9$

$F = \frac{C_e}{(r_5 - x)} + \frac{C_e}{(r_5 + x)} = 1074{,}52\,N \rightarrow$ ~~$m = 109{,}65\,kg$~~ $m = 94{,}72\,kg$

5.97



$I_1 \begin{cases} z_1 = 15 \\ z_2 = 31 \end{cases}$ $\tau_1 = 1$ $\quad I_2 : \tau_2 = 1$ $\quad I_3 : \tau_3 = 1$

$z_4 = 44$, $z_3 = 21$ $\Big\}$ I_4 Hp $\eta = 1$ $\quad \tau_D = 1$

$C_H = 100 Nm$ $\quad C_4 = ?$

$\tau_1 = \frac{z_1}{z_2} = 0,4838$

$\tau_2 = 1$ $\quad$ Hp: $\tau_{AB} = 1$

$\tau_3 = 1$ $\quad \eta = 1$

$\tau_4 = 0,4774$

$C_H \omega_B = (C_A \omega_B + C_B \omega_B) \rightarrow$ ~~$C_A \omega_B = C_B \omega_B = C_H/2$~~

$C_3 = C_1 = C_0$ $\quad C_A/\tau_1 = C_2 = C_3$

$\Big\} \frac{(C_0 + C_3)}{\tau_4} = C_4 \rightarrow \left(\frac{C_A}{\tau_1} + C_B\right)/\tau_4 = C_4 = \frac{C_H}{\tau_4}\left(\frac{1}{2\tau_1} + \frac{1}{2}\right) = C_4$

$C_3 \omega_3 + C_0 \omega_0 = C_4 \omega_4$

$\omega_4 = \Omega \tau_4 \quad \Omega = \frac{\omega_0 + \omega_3}{2} \rightarrow \omega_4 = \tau_4 \frac{\omega_0 + \omega_3}{2}$

$C_3 \omega_3 + C_0 \omega_0 = \frac{C_A}{\tau_1} C_4 \tau_4 \frac{\omega_0}{2} + C_4 \frac{\omega_3 \tau_4}{2}$

$C_3 \omega_3 + C_0 \omega_0 = (C_3 + C_0)\frac{\tau_4}{\tau_4}\frac{\omega_3}{2} + (C_3 + C_0)\frac{\tau_4}{\tau_4} \cdot \frac{\omega_0}{2}$

$C_H = C_A + C_B$ $\quad$ perché $r_A = r_B$ per Hp $\rightarrow$

$\frac{C_A}{C_2} = \tau_1 \rightarrow C_2 = C_A/\tau_1 = C_3$ ✓

~~Tu condizioni ideali~~ Tu condizioni di regime le coppie agenti sul rotismo (C_0, C_3) sono uguali $C_0 = C_3 = C_D$

$C_B = C_1 = C_0$

~~$C_4 = (C_0 + C_3)/\tau_4$~~ ~~$\frac{C_0 + C_3}{C_4} = \tau_4 \rightarrow \left(\frac{C_A}{\tau_1} + C_B\right)\frac{1}{\tau_4} = C_4$~~

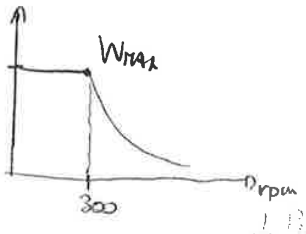
$C_D = C_0 = C_3$

~~$C_0 = C_3$~~ $+ \tau_1 C_0 = C_A \Rightarrow C_H = (1 + \tau_1) C_0 \rightarrow C_0 = C_H/(1 + \tau_1)$

$C_B = C_B$

$\frac{C_D}{C_1} = \frac{2C_A}{C_4} = \frac{C_A}{\tau_4} \rightarrow \frac{2C_D}{\tau_4} = C_4 \rightarrow \frac{2C_H}{\tau_4(1 + \tau_1)} = 287,57 Nm$

$C_4' = 120\% C_4 = 339,1 Nm \rightarrow C_4' = \frac{2\left(C_A \frac{\tau_A}{\tau_B} + C_1\right)}{\tau_4(1 + \tau_1)}$



$W_{max} = C_0 \omega_0 = 1.2\ kW \rightarrow C_0 = 38,216\ Nm$

$\omega_0 = \omega_H \rightarrow$

$\frac{V_s}{C_a} = \frac{V_s}{\omega_A} \cdot \frac{\omega_A}{C_a} = \frac{P}{2\pi} \cdot \frac{1}{C_a}$ $\quad \frac{V_s}{\omega_A} = \frac{P}{2\pi}$

$\eta_v = 0,6 = \frac{P V_s}{C_m \omega_A} = \frac{P V_s}{C_A \omega_A} = \frac{P P \omega_A}{C_A \omega_A 2\pi} = 0,6$

$\Rightarrow |P| = 206451,64\ N$

Se $P = P_{max}/2$ $\quad V_s = \frac{W \eta}{P} = 0,007\ m/s$

$\omega = \frac{2r}{z} \rightarrow r_1 = 0,2425\ m$

$r_2 = 0,0425\ m$

$r_4 = 0,24\ m$

$r_3 = 0,045\ m$

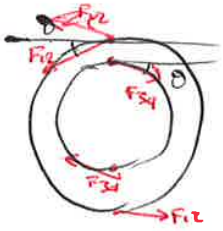
$F_{34} = \frac{C_4}{2 r_4 \cos\delta} = 2144,27\ N$

$\tau_{14} = \frac{z_1}{z_4} = 0,089 = \frac{C_{41}}{C_1} \rightarrow C_1 = 553,35\ Nm$

$F_{34} = \frac{C_{41}}{2 r_{41} \cos\delta} = 1214,11\ N$

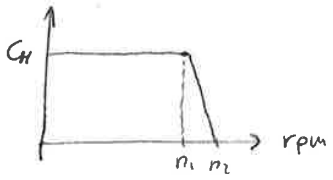
$F_{12} = \frac{C_1}{r_1} \cdot \cos\delta = 2144,2\ N$

$F_{12} =$



$F_{34} r_3 \cos\delta = F_{12} r_2 \cos\delta \rightarrow F_{12} = 1285,53\ N$

5.101

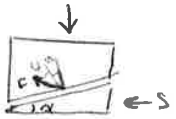


$P_v = 0{,}005\,kW$
$d = 0{,}055\,m$
$\theta = 14{,}5°$
$f = 0{,}11$
$z_2 = 61$
$z_1 = 19$
$\eta_R = 0{,}97$
$\eta_1 = 0{,}98$
$n_1 = 2400\,rpm$
$n_2 = ~~2800~~ 3000\,rpm$
$m = 2000\,kg$
$V = 0{,}025\,m/s$ } $n_{pm} = 2800\,rpm$

$\tau_R = ?$
$C_M = ?$
W_{MAX}

$\omega_M = V \cdot \frac{2\pi}{P_v} = 31{,}4\ rad/s$

$\alpha = ~~\frac{P_v}{\pi d}~~$ $\alpha = \arctg \frac{P_v}{\pi d} = 1.657°$ $\varphi = \arctg \frac{f}{\cos\theta} = ~~6.277°~~ 6.432$



$Q = mg$

$C_V = ~~Q r \tg(\alpha+\varphi')~~ = ~~76{,}11\,Nm~~ ~~7{,}426\,Nm~~ 77{,}33\,Nm$

$W = \omega_M C_V = 2421{,}97\,W$

$C_M = C_V + C_R$

$\tau = \frac{z_1}{z_2} = 0{,}311$ $C_2\omega_2 = \eta_1 C_1 \omega_1 \rightarrow C_2 \frac{I}{\eta_1} = C_1 \rightarrow C_1 = 24{,}48\,Nm$

$\omega_1 = 99\ rad/s$

$\omega_M = 293{,}06\ rad/s$

$\tau_R = \frac{\omega_1}{\omega_M} = 0{,}337$

$C_1\omega_1 = \eta_R C_M \omega_M \rightarrow C_M = \frac{C_1 \tau_R}{\eta_R} = 8{,}521\,Nm$

$\frac{y-0}{8{,}521-0} = \frac{x-3000}{2800-3000} \rightarrow -200y = 8{,}521x - 25562{,}2$

$\rightarrow x = 2400 \rightarrow y = 25{,}56\,Nm$

$W_{MAX} = 6420{,}45\,W$