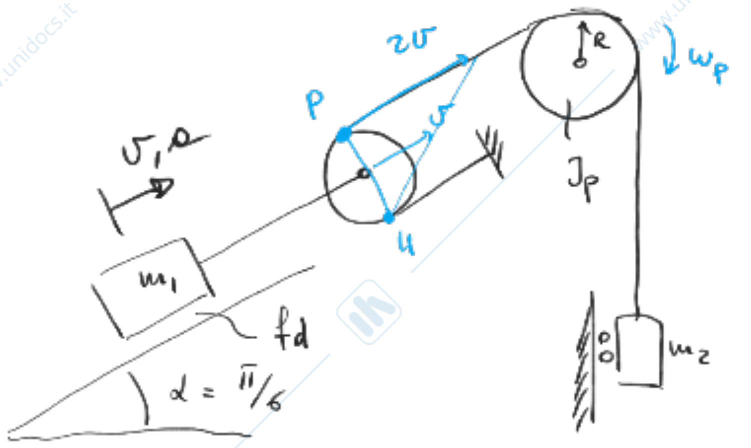
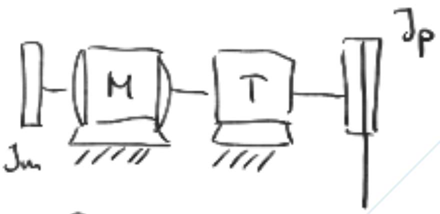
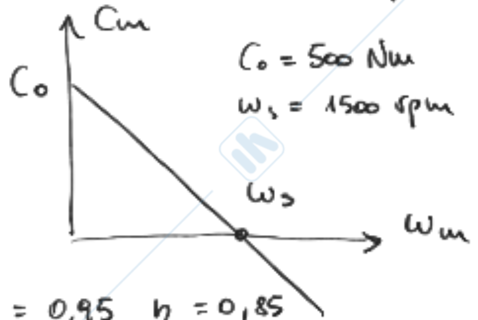
Ese15 mtu







$C_0 = 500\ Nm$

$\omega_s = 1500\ rpm$

$m_1 = 1000\ kg$ $\quad f_d = 0{,}1$ $\quad \tau = 1/5$ $\quad \eta_d = 0{,}95$ $\quad \eta_R = 0{,}85$

$m_2 = 100\ kg$ $\quad R = 0{,}4\ m$ $\quad J_p = 0{,}1\ kg\,m^2$ $\quad J_m = 0{,}5\ kg\,m^2$

CINEMATICA $\quad \omega_p = 2v/R \quad v_2 = 2v \quad \dot\omega_p = \dfrac{2a}{R} \quad a_2 = 2a$

$$\omega_p = \tau\,\omega_m \qquad \omega_m = \frac{2v}{R\tau} \qquad \dot\omega_m = \frac{2a}{R\tau}$$

1) v REGIME m_1 ↑

$$W_m + W_u + W_p = \frac{dE_c}{dt}$$

$$E_c = E_{cu} + E_{cm} = \underbrace{\left(\frac{1}{2}m_1 v_1^2 + \frac{1}{2}m_2 v_2^2 + \frac{1}{2}J_p\omega_p^2\right)}^{E_{cu}} + \frac{1}{2}J_m\omega_m^2$$

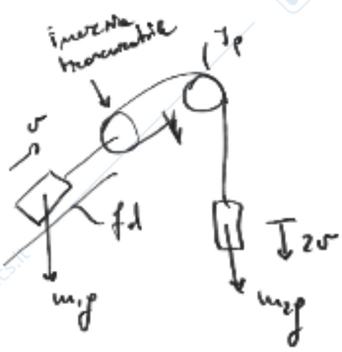
$$\frac{dE_c}{dt} = \left(m_1 + 4m_2 + \frac{4J_p}{R^2}\right)va + \left(J_m\frac{4}{R^2\tau^2}\right)va$$

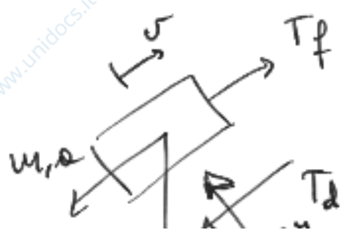
$$\frac{dE_c}{dt} = \left(m_u^* + m_m^*\right)va = \left(1402{,}5 + 312{,}5\right)va$$

[kg]

$$W_m = C_m\omega_m = C_m(\omega_m)\cdot\omega_m$$

$$W_u = -m_1 g \sin\alpha\, v + 2m_2 g v + - T_d v$$





$T_d = f_d N$

$\Sigma F_\perp = 0 \qquad N = m_1 g\cos\alpha$

$m_1 g$ $\quad N$ $\qquad T_d = f_d\, m_1 g \cos\alpha$

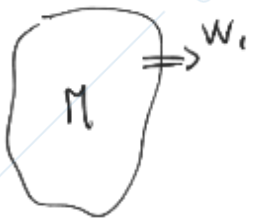
$$W_u = -m_1 g \sin\alpha\, v + 2 m_2 g v - f_d m_1 g \cos\alpha\, v$$
$$= -\left(m_1(\sin\alpha + f_d\cos\alpha) - 2m_2\right) g v$$
$$= -F_u v = -3792{,}6 \cdot v < 0$$
$$[N]$$

W_p ?

$$W_u - W_2 = \frac{dE_{cu}}{dt}$$
$$W_2 = W_u - \frac{dE_{cu}}{dt} = -F_u v - m_u^* v a$$

$v \uparrow$ REGIME $(a=0)$ $\rightarrow$ $W_2 = -F_u v < 0$
$\rightarrow$ DIRETTO

$$W_p = W_{p_d} = -(1-\eta_d)\, W_1$$



$$W_m - W_1 = \frac{dE_{cm}}{dt}$$
$$W_1 = C_m \omega_m - J_m \omega_m \dot{\omega}_m$$

DIRETTO $\quad W_p = -(1-\eta_D)\, W_1$
RETROGRADO $\quad W_p = -(1-\eta_R)\, W_2$

1) $v \uparrow$ REGIME $\rightarrow$ DIRETTO $\quad W_p = -(1-\eta_D)\, W_1$

$$C_m\omega_m - F_u v - (1-\eta_D)(C_m\omega_m - J_m\omega_m\dot{\omega}_m) = (m_u^* + m_m^*)\, v a$$

A regime $a = 0$

$$C_m\cancel{\omega_m} - F_u v - (\cancel{1}-\eta_D)\, C_m \omega_m = 0$$

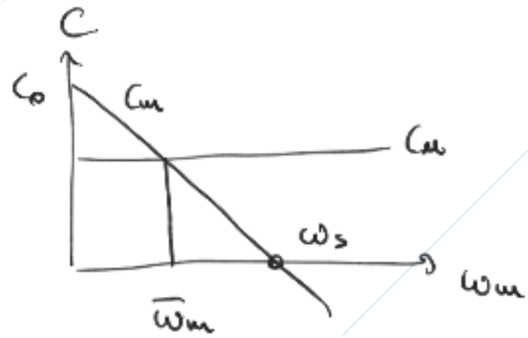
$$\eta_D \frac{2v}{R\tau} C_m - F_u v = 0 \qquad \frac{\eta_D\, 2}{R\tau} C_m = F_u \text{ all'utilizzatore}$$

$$\overline{C_m} = \frac{R\tau F_u}{2\eta} = \frac{0{,}4 \cdot 1/5}{} \quad F_u = 160 \text{ Nm}$$

$< \eta_D \qquad \simeq 0{,}95$

$\uparrow$

C_u ridotta all'albero motore



$$\rightarrow \quad C_m = C_0 \left(1 - \frac{\omega_m}{\omega_s}\right)$$

$$C_0 = 500 \text{ Nm} \qquad \omega_s = 1500 \text{ rpm} = \frac{1500}{60} 2\pi = 157 \text{ rad/s}$$

$$\overline{\omega_m} = \frac{\omega_s}{C_0}\left(C_0 - \overline{C_m}\right) = 106{,}8 \text{ rad/s} \simeq 1020 \text{ rpm}$$

$$\overline{v} = \frac{\tau R}{2} \overline{\omega_m} = 4{,}27 \text{ m/s}$$

$$\overline{W_m} = \overline{C_m} \cdot \overline{\omega_m} = 17\,088 \text{ W} \qquad \eta_D = \frac{-\overline{W_u}}{\overline{W_m}} = 0{,}95$$

$$\overline{W_u} = -F_u \overline{v} = -16\,202 \text{ W}$$

2) $v > 0$ (in salita), spengo motore ($C_m = 0$)

$\rightarrow a < 0$ DIRETTO o RETROGRADO ?

U $\Rightarrow W_2$

$$W_2 = W_u - \frac{dE_{cu}}{dt}$$

$$= \underbrace{-F_u v}_{<0} \underbrace{- m_u^* v \overset{<0}{a}}_{>0} \quad \overset{?}{\gtrless} 0$$

M $\Rightarrow W_1$

$$W_1 = W_m - \frac{dE_{cm}}{dt}$$

$$W_1 = \underset{\substack{\uparrow \\ 0}}{\cancel{C_m}} \omega_m - J_m \omega_m \dot{\omega}_m > 0 \rightarrow \text{DIRETTO}$$

$$\overset{0}{\cancel{C_m \omega_m}} - F_u v - (1 - \eta_D)\left(\overset{0}{\cancel{C_m \omega_m}} - J_m \omega_m \dot{\omega}_m\right) = (m_u^* + m_m^*) v a$$

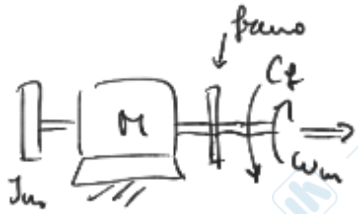
$$- F_u v + J_m \omega_m \dot{\omega}_m - \eta_D J_m \omega_m \dot{\omega}_m = (m_u^* + m_m^*) v a$$

$$- F_u v + \underset{\substack{\uparrow \\ m_m^*}}{\cancel{\frac{J_m h}{R^2 \tau^2}}} v a - \eta_D \underset{\uparrow m_m^*}{\frac{J_m h}{R^2 \tau^2}} v a = (m_u^* + \cancel{m_m^*}) v a$$

$$-F_u v = (m_u^* + \eta_D m_m^*) v a$$

$$a = -\frac{F_u}{m_u^* + \eta_D m_m^*} = -2{,}34 \ m/s^2$$

4) $\boxed{\text{Mot spento} \quad v \text{ salita} \quad C_f? \ \text{t.c.} \ a = -5 \, m/s^2}$



$$W_m = \cancel{C_m}\omega_m - C_f \omega_m$$

$$W_m = -C_f \omega_m$$

$$\bar{C}_f = -C_{f0} \frac{\vec{\omega}_m}{|\vec{\omega}_m|}$$

$$W_m - W_1 = \frac{dE_{cm}}{dt}$$

$$W_1 = W_m - \frac{dE_{cm}}{dt} = \underbrace{-C_f \omega_m}_{<0} \underbrace{- J_m \overset{>0}{\omega_m} \overset{<0}{\dot{\omega}_m}}_{>0}$$

$$W_1 \gtrless 0 \ ?$$

$$W_u - W_2 = \frac{dE_{cu}}{dt}$$

$$W_2 = W_u - \frac{dE_{cu}}{dt} = -F_u v - m_u^* v a$$

$$= -3792{,}6 \cdot v + 7012{,}5 \cdot v$$

$$= 3219{,}9 \cdot v > 0 \rightarrow \text{RETROGRADO}$$

$$W_p = -(1-\eta_R) W_2 = -(1-\eta_R)(-F_u v - m_u^* v a)$$

$$W_m + W_u + W_p = \frac{dE_c}{dt}$$

$$-C_f \omega_m - \cancel{F_u v} - (\cancel{1} - \eta_R)(-F_u v - m_u^* v a) = (\cancel{m_u^*} + m_m^*) v a$$

$$-C_f \omega_m - \eta_R F_u v = (\eta_R m_u^* + m_m^*) v a$$

$$-\frac{2 C_f}{R\tau} - \eta_R F_u = (\eta_R m_u^* + m_m^*) a$$

$$C_f = \frac{R\tau}{2} \left(-\eta_R F_u - (\eta_R m_u^* + m_m^*) a \right)$$

$$= \frac{R\tau}{2}\left(-\eta_R\underbrace{\left(F_u + m_u^* a\right)} - m_u^* a\right)$$

$$= \frac{0{,}4 \; 1/5}{2}\left(+0{,}85 \; 3219{,}9 + 312{,}5 \cdot 5\right)$$

$$= 172 \text{ Nm}$$

4) $E_{\text{dissipata}}$ dal freno? $(v = \bar{v} \rightarrow v = 0)$

$$E_{din} = \int_0^t W_{din} \, dt$$

$$W_{din} = C_f \, \omega_m(t) \qquad \bar{\omega}_m = 106{,}8 \text{ rad/s}$$

$$\bar{v} = 4{,}27 \text{ m/s}$$

$a = -5$ m/s² = costante

$v = \bar{v} + at$ $\qquad$ t^* tempo di arresto $(v = \bar{v} \rightarrow v = 0)$

$v(t = t^*) = 0$ $\qquad$ $0 = \bar{v} + at^*$ $\qquad$ $t^* = -\frac{\bar{v}}{a} = 0{,}854$ s

$$W_{din}(t) = C_f \frac{2}{R\tau} v(t) = C_f \frac{2}{R\tau}\left(\bar{v} + at\right)$$

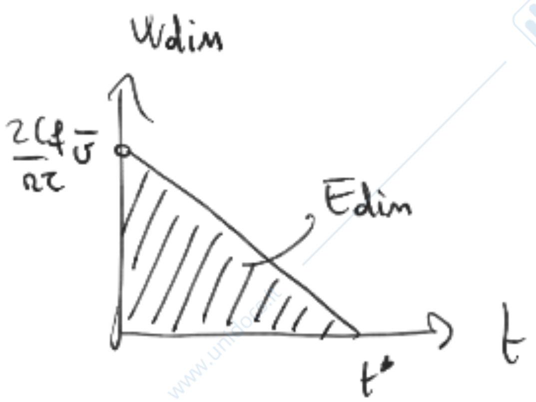
$$E_{din}(t^*) = \int_0^{t^*} W_{din} \, dt = \int_0^{t^*} C_f \frac{2}{R\tau}\left(\bar{v} + at\right) dt =$$

$$= \frac{C_f \, 2}{R\tau}\left(\bar{v}t + \frac{1}{2}at^2\right)_0^{t^*} = \frac{2C_f}{R\tau}\left(\bar{v}t^* + \frac{1}{2}at^{*2}\right)$$

$t^* = -\frac{\bar{v}}{a}$ $\qquad$ $E_{din}(t^*) = \frac{2C_f}{R\tau}\left(-\frac{\bar{v}^2}{a} + \frac{1}{2}\frac{\bar{v}^2}{a}\right)$

$$= -\frac{2C_f}{R\tau}\left(\frac{\bar{v}^2}{2a}\right)$$

$$= 7803 \text{ J}$$



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