Esercitazione6 - Organi di Trasmissione - Ingranaggi

Ingranaggi

↳ Molti tipi ma guarderemo e

Spur e Helical ruoti dentati

Usiamo le ruote dentate per trasmettere potenza.

Spur Gears - Ruote dentate denti dritti

La coppia di ruote si conserva la potenza e è a causa del momento torcente

$$P = C_1 \omega_1 = C_2 \omega_2$$

numero di denti

Rapporto di Trasmissione $\rho = \frac{\omega_2}{\omega_1} = \frac{z_1}{z_2}$

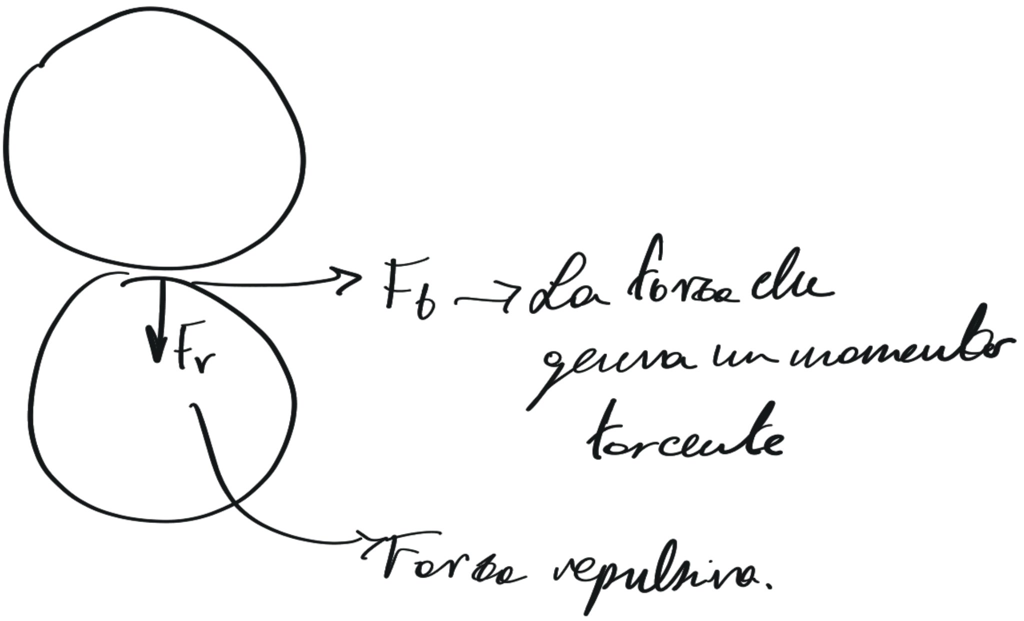
Guardando le ruote dentate usiamo il diametro primitivo, dal centro al mezzo del dente

Il punto di contatto è dove i due diametri si incontro e al punto la velocità tangenziale è uguale

$$\rho = \frac{\omega_2}{\omega_1} = \frac{d_{p1}}{d_{p2}}$$

L'angolo di pressione tra le ruote dentate è 20°

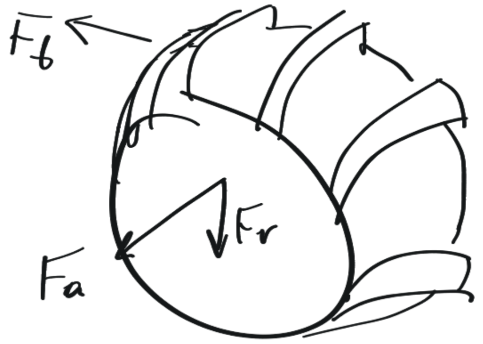
Due ruote dentate devono ruotare in direzione opposta



Helical Gears - Elicoidali

Denti inclinati di angolo d'elica.

Dato l'angolo si genera un altra forza



Generano F_a forza assiale che genera momento flettante

$F_t \rightarrow$ momento torcente

$F_a \rightarrow$ momento flettente

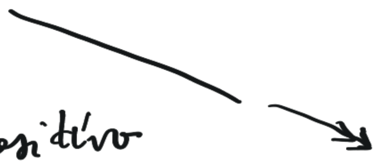
$F_r \rightarrow$ no momento

I calcoli del rapporto è uguale

Forze in 3D

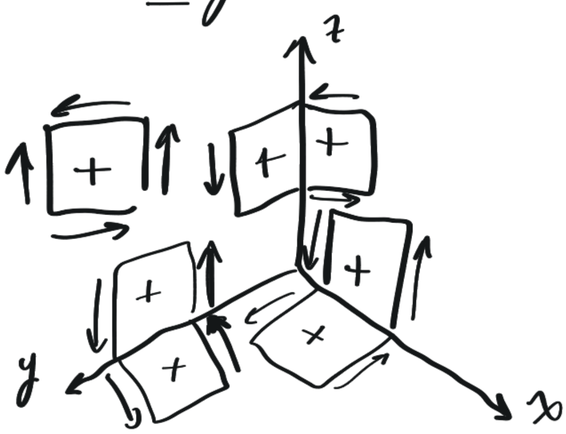
Flettente positivo uscente

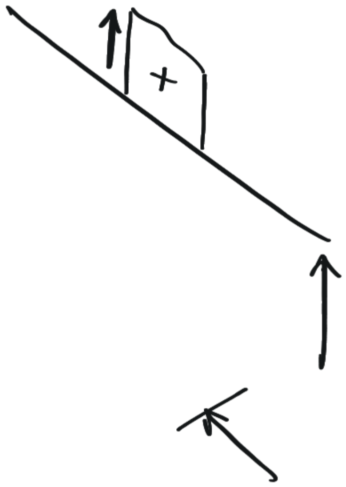
Momento torcente



Positivo uscente

Taglio $\rightarrow$ lo stesso (-)/(+) per orario/antiorario, ma lo guardiamo sul piano

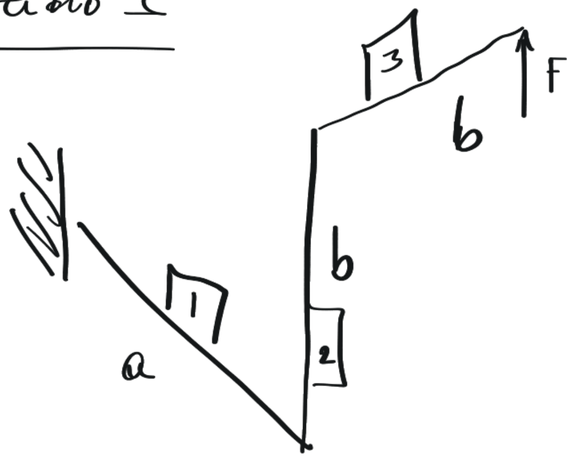




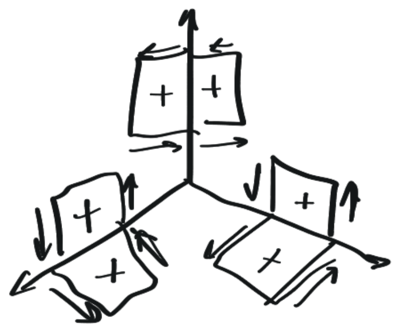
Consideriamo il piano y-z

$T = -F$

Esercizio 1

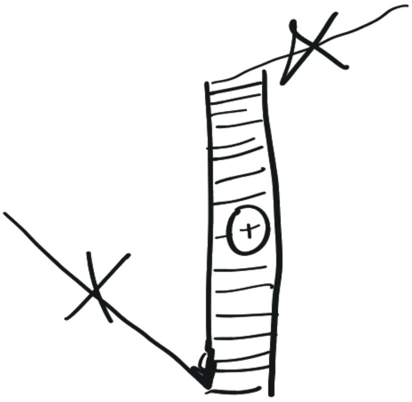


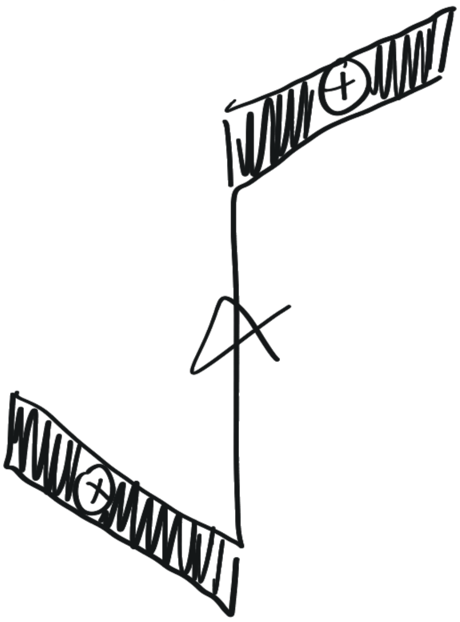
Convenzione del taglio



N

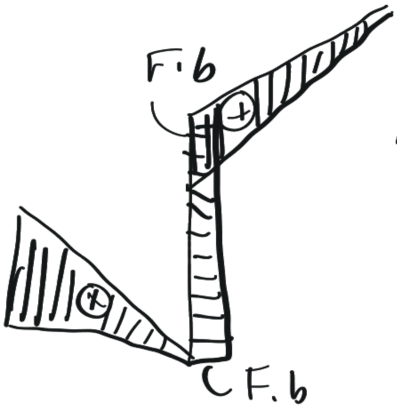
T



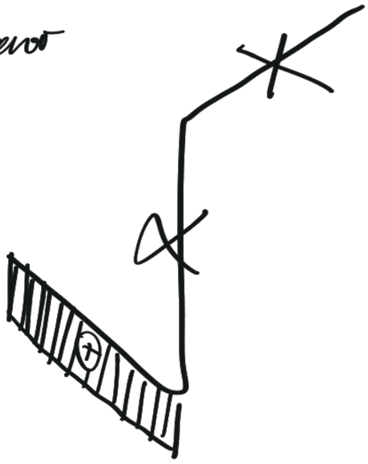


Mf

Mt

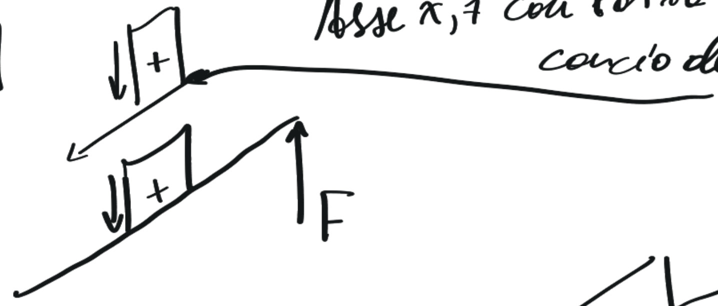


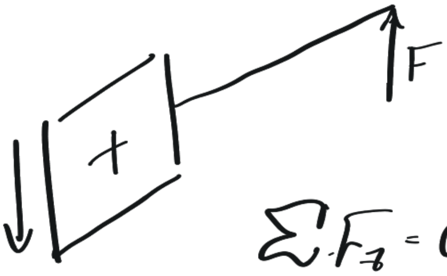
M_f e M_t agiscono sullo stesso piano



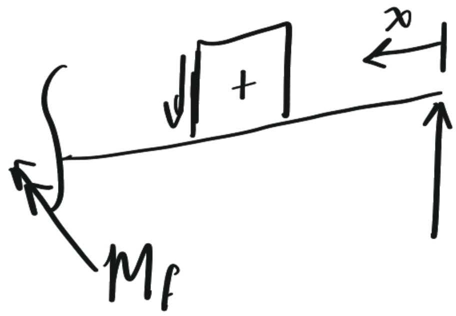
$\boxed{3}$

Asse x, z con forze in direzione z, cambio dei segni



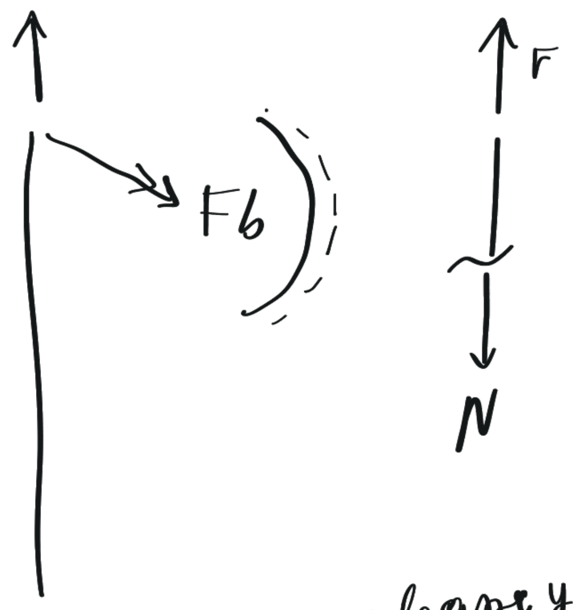


$$\sum F_z = 0 = F - T \Rightarrow F = T$$



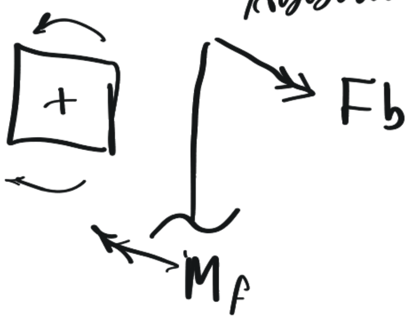
$$\sum M = 0 = F \cdot x - M_f \Rightarrow M_f = Fx$$

2



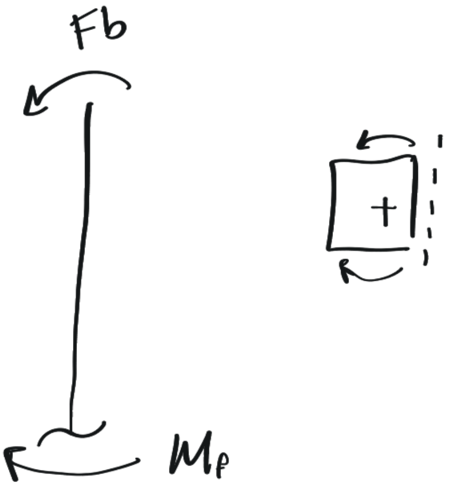
$$\sum F_y = 0 = -N + F \Rightarrow N = F$$

Abbiamo per lo asse y come normale e un concio per determinare il segno



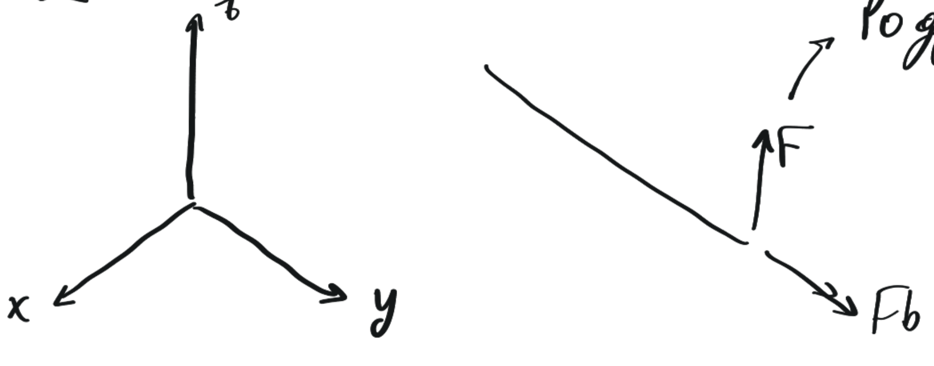
Concio dei segni allineato con l'asta e la forza

$$\sum M_f = 0 = Fb - M_f \Rightarrow M_f = Fb$$

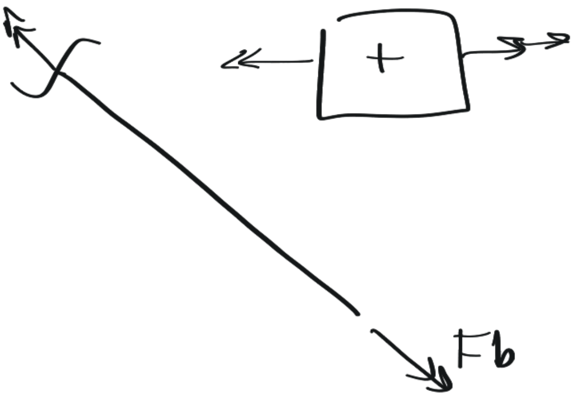


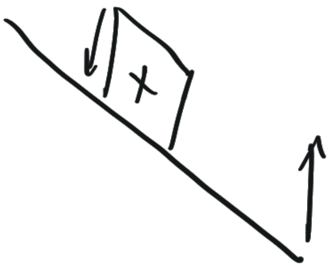
$Fb - M_f = 0$

1

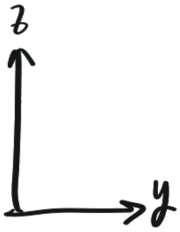


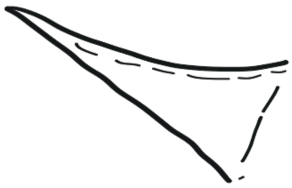
Poggia su asse y e ha freccia come asse z





$$\sum F = 0 = F - T$$
$$\Rightarrow T = F$$



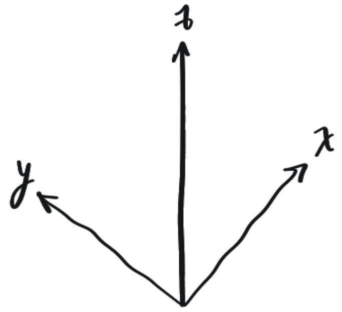


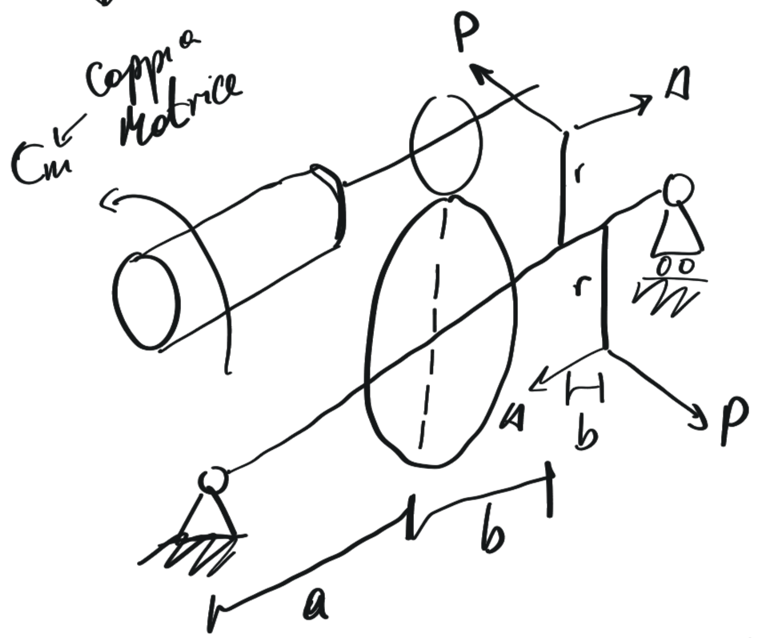
$$M_f = Fx$$

Prendendo il concio

Prendiamo il concio sull'asse che segue l'asse e ha treccie nella stessa direzione della forza.

Calettato – ruota dentata sull'albero, ruota coll'albero





$\omega = 157 \, \frac{rad}{s} = \frac{2\pi n}{60}$ (rpm)

$W = 45 \, kW$

$z_1 = 21$

$z_2 = 60$

$m = 8mm = \frac{dp}{z}$

$a = 200 \, mm$

$b = 400 \, mm$

$r = 150 \, mm$

$d = 40 mm$

$A = 0{,}7P$

Coppia Condotta

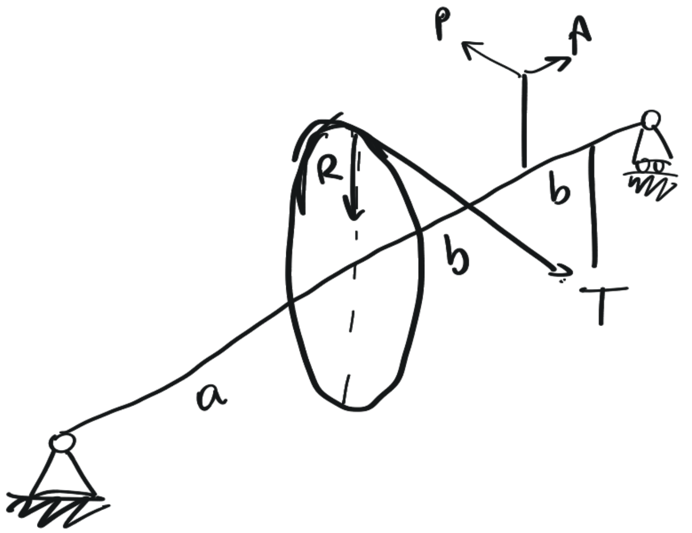
$W = C_m \omega_m = C_c \omega_c$

$\tau = \frac{z_1}{z_2}$ ← # di denti ruota Motrice $= \frac{\omega_c}{\omega_m}$

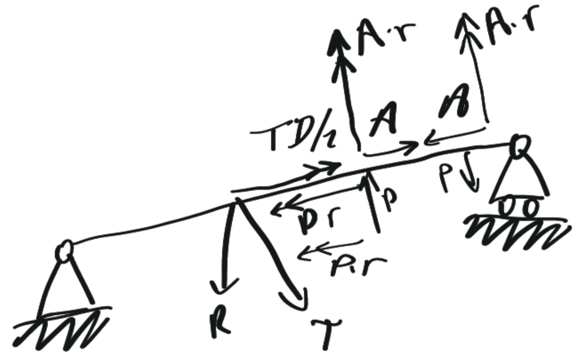
di denti ruota Condotta

Rapporto di Trasmissione

$C_c = C_m \cdot \underbrace{\frac{\omega_m}{\omega_c}}_{\frac{1}{\tau}} = C_m \frac{z_2}{z_1} = 817 \, Nm$



Dato che abbiamo un pezzo rotante abbiamo forze ferme e forze rotanti
Facendo i calcoli dobbiamo separare le forze fisse e le forze rotanti



$T \cdot \frac{D_c}{2} = C_c$ Perchè C_c è il momento torcente portato dall'altra ruota dentata

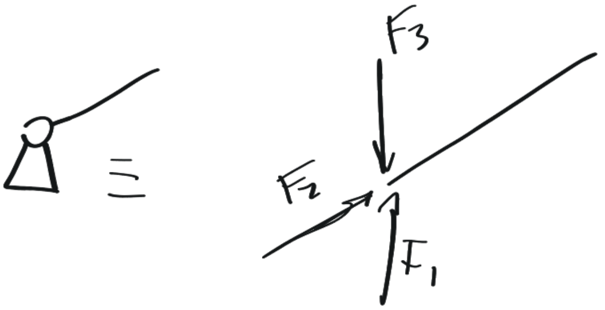
$m = \frac{D_c}{z_2}$ Diametro di C

$\Rightarrow D_c = m z_2 = 480\,mm$

$T \cdot \frac{D_c}{2} = C_c \Rightarrow T = \frac{2 C_c}{D_c} = 3404\,N$

$R = T \tan\alpha = 1239\,N$

20° angolo di pressione da prima



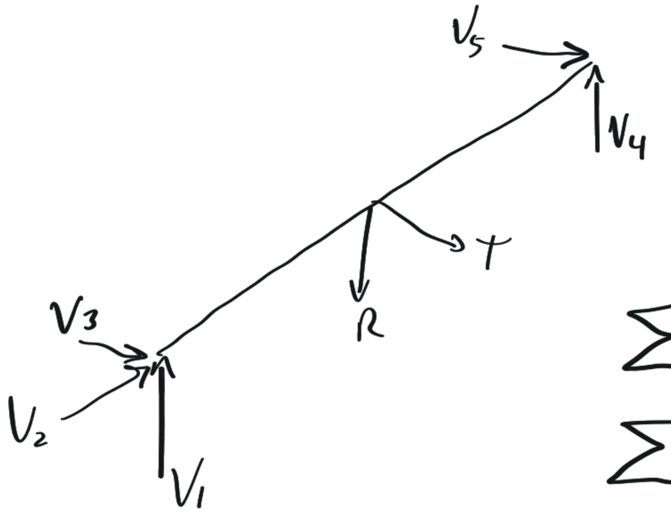
Nessuno di questi genera momento torcente

Vale per il carrello. $\Rightarrow$ Tutti momenti torcenti devono esser in equilibrio

$$\Rightarrow \sum M_x = 0 = C_c - P_r - P_r$$

$$\Rightarrow P = \frac{C_c}{2r} = 2724\,N$$

$$A = 0{,}7P = 1907\,N$$



Carrello non crea vincolo assiale

$$\sum F_z = 0 = V_1 - R + V_4$$

$$\sum F_x = 0 = V_2 = 0$$

$$\sum F_y = 0 = V_3 + P + V_5$$

Dobbiamo calcolare momenti flettenti

$$\sum M_8^c = V_3(2a+2b) + T(a+2b)$$

Carrello orientato per 8

$$\Rightarrow V_3 = -T\frac{(a+2b)}{(2a+2b)}$$

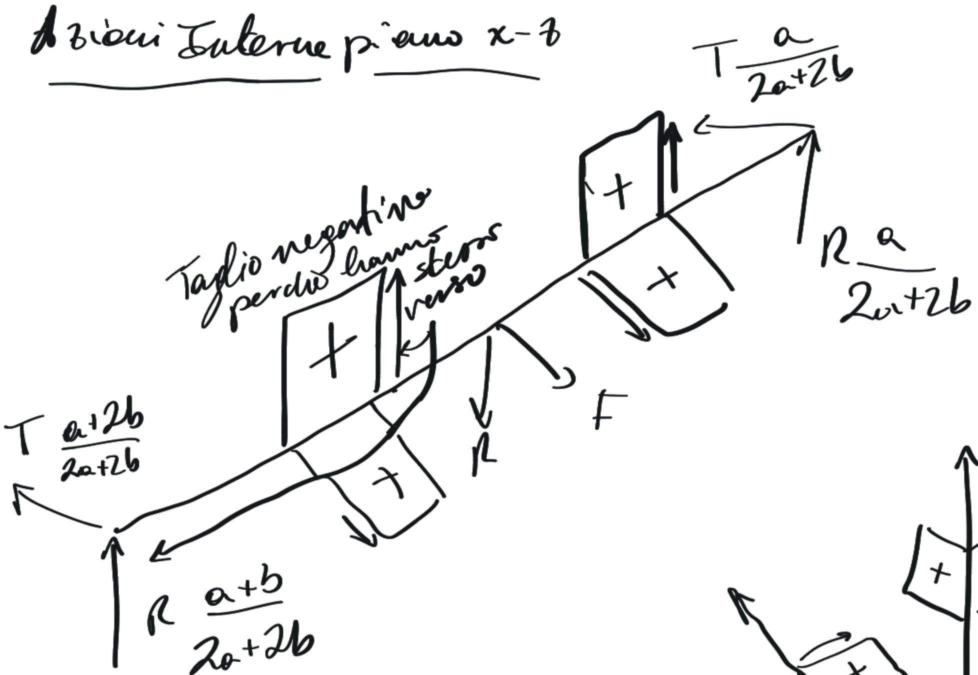
$$\Rightarrow V_5 = \frac{T(a+2b)}{2a+2b} - T = -\frac{Ta}{2a+2b}$$

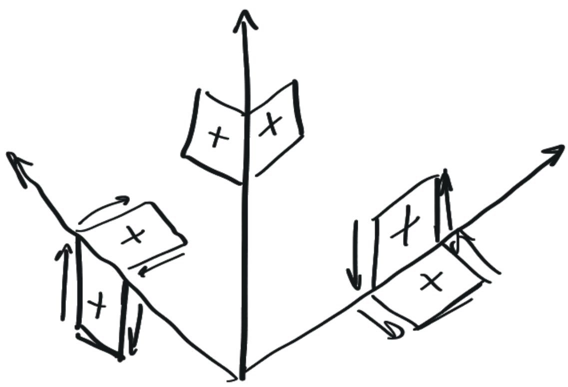
$$\sum M_y = 0 = -V_1(2a+2b) + R(a+2b)$$

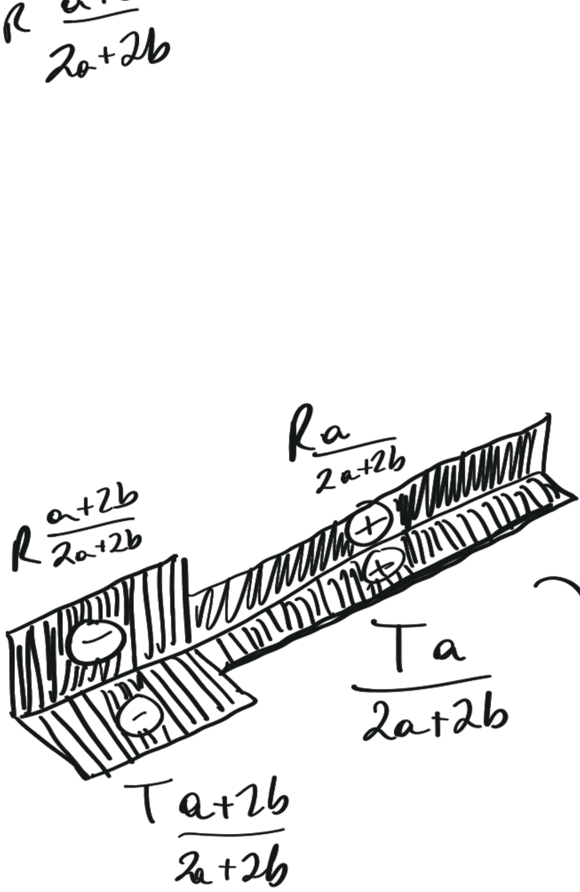
$$\Rightarrow V_1 = \frac{R(a+2b)}{2a+2b}$$

$$\Rightarrow V_4 = R - \frac{R(a+2b)}{2a+2b} = \frac{-Ra}{2a+2b}$$

<u>Azioni Interne piano x-z</u>







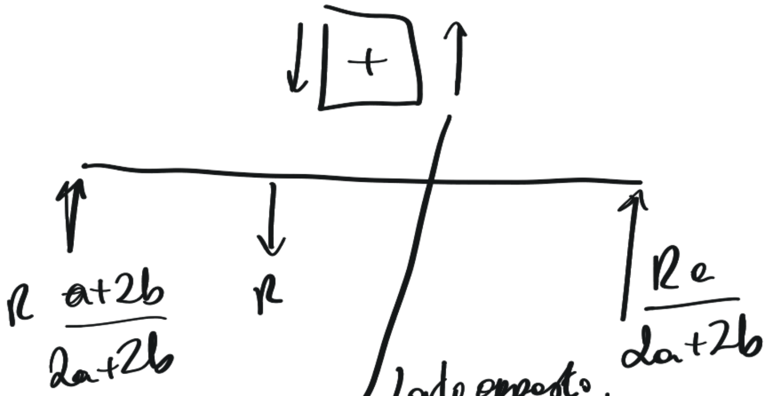
$$\sum F_z = 0 = T - R + \frac{R(a+2b)}{2a+2b}$$

2° taglio

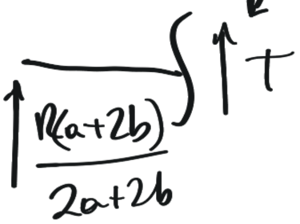
Va fino alla fine perché se guardiamo rispetto a carello troviamo che il valore rimane uguale, più unica forza è quella che cambia il taglio

Visualizzazione 2D

Piano x-z

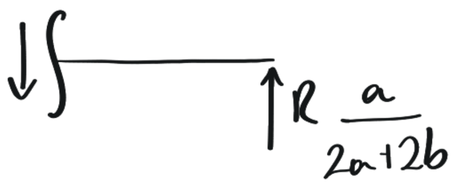


Lato opposto, ma stesso senso quindi negativo



$$\sum F = 0 = T + R\frac{a+2b}{2a+2b}$$

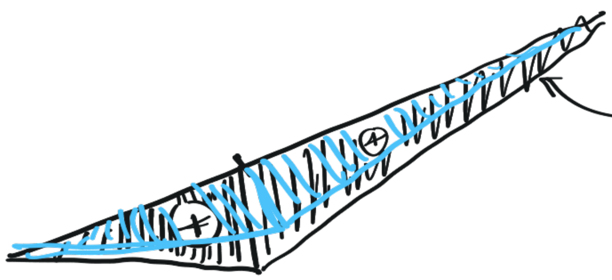
$$\Rightarrow T = -R\frac{a+2b}{2a+2b}$$



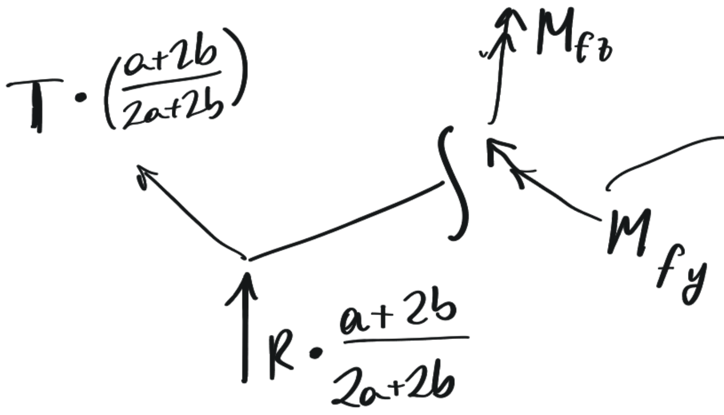
$$T = \frac{Ra}{2a+2b}$$

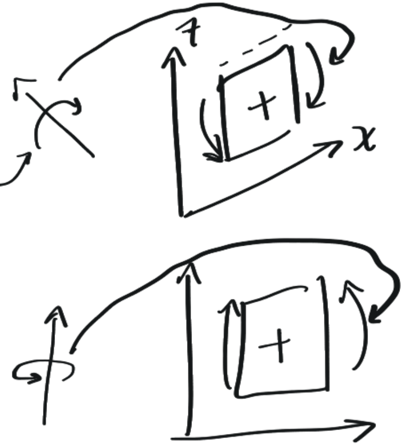
Inizieremo ad usare 3D di più quindi è meglio se ci abi

M_f in 3D $\Rightarrow$



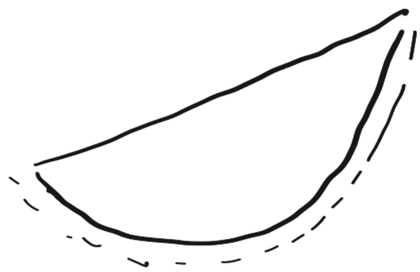
Corretto consente convenzione, quindi M deve esser 0 lì.

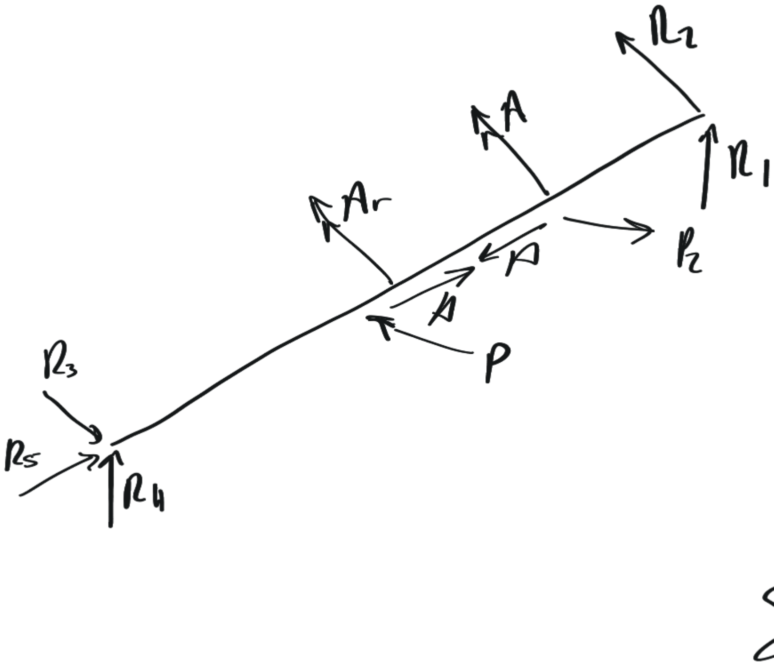




$$\sum M_y = 0 = M_{fy} + R\frac{a+2b}{2a+2b}x \Rightarrow M_y = -R\frac{a+2b}{2a+2b}x$$

$$\sum M_z = 0 = M_{fz} - T\frac{a+2b}{2a+2b}x \Rightarrow M_{fz} = T\frac{a+2b}{2a+2b}x$$





$$\sum F_x = 0 = R_3 + \cancel{A - A} = 0$$

$$\sum F_y = 0 = R_5 \cancel{- P + P} - R_2$$

$$R_5 = R_2$$

$$\sum F_z = 0 = R_4 + R_1$$

$$\sum M_y = 0 = 2A_r + R_4(2a+2b)$$

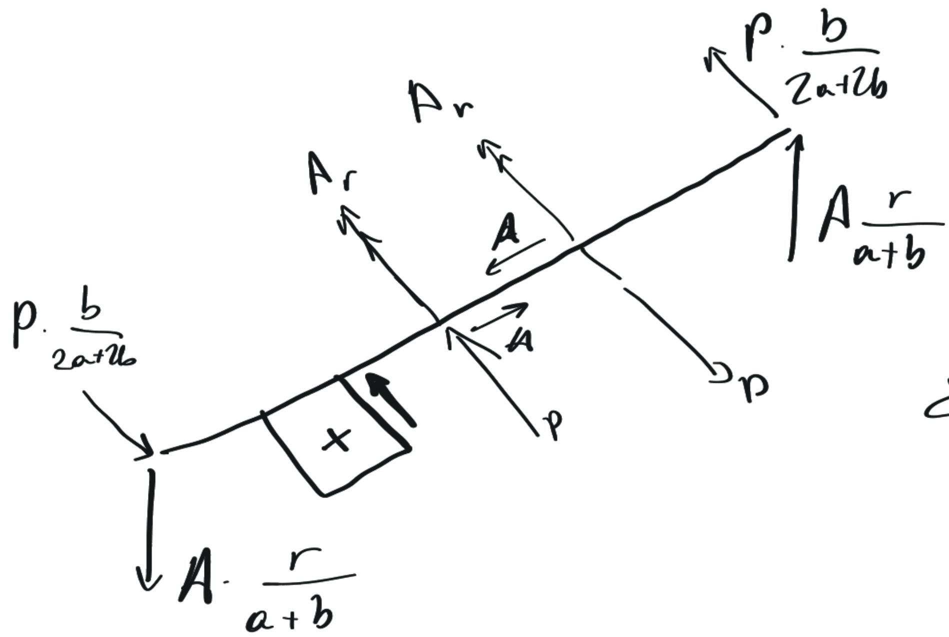
$$\Rightarrow R_4 = A\frac{r}{a+b}$$

$$R_1 = A\frac{r}{a+b}$$

$$\sum M_2 = 0 = R_5 (2a+2b) - P(b-a) + Pa$$

$$\Rightarrow R_5 = P \frac{b}{2a+2b}$$

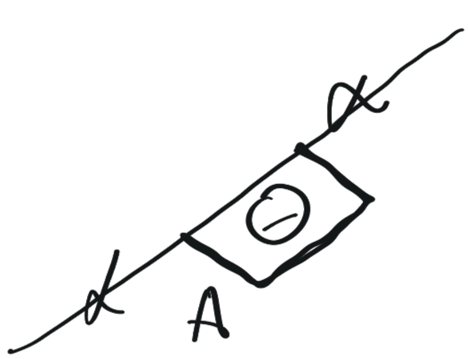
$$\Rightarrow R_2 = R_5 = \frac{b}{2a+2b}$$



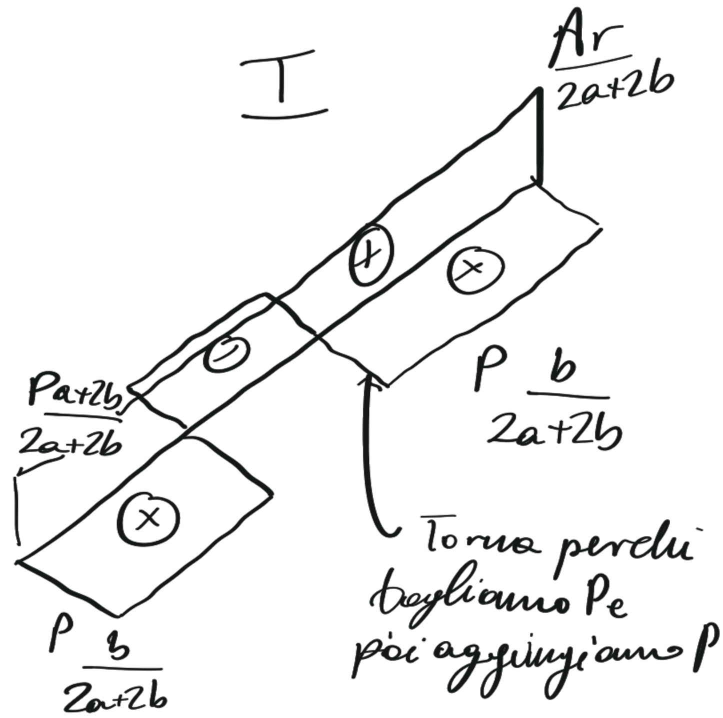
$$\sum F = 0 = \frac{Pb}{2a+2b} - P - T$$

$$\Rightarrow T = -P \frac{2a+b}{2a+2b}$$

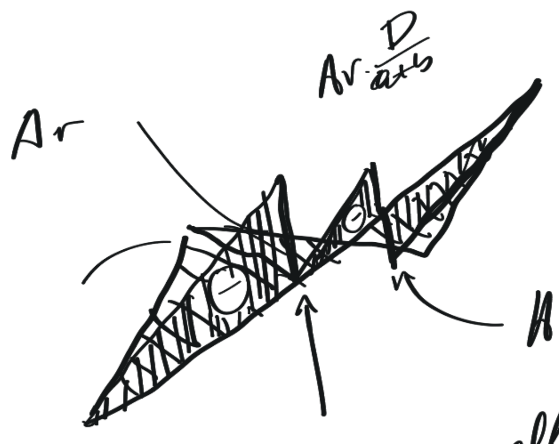
N



T

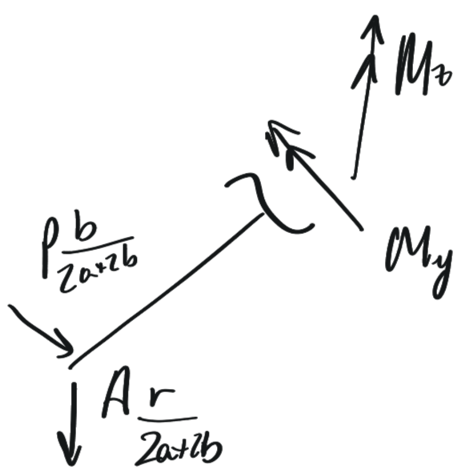


$\underline{M_f}$



Aumenta e viene cancellato di nuovo da Ar

Viene cancellato dalla paletta

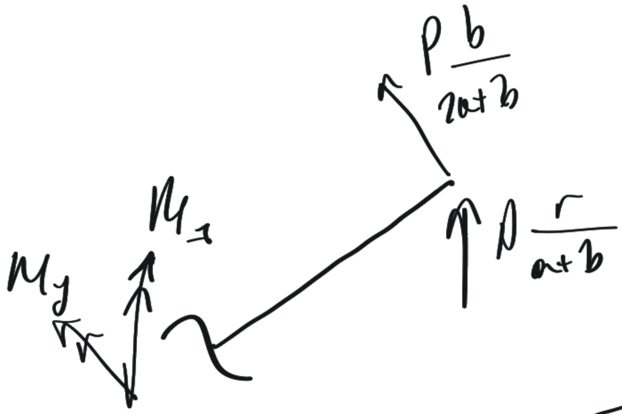


$$\sum M_y = 0 = A\cdot\frac{r}{2a+2b}x - M_y$$

$$\Rightarrow M_y = \frac{Ar}{2a+2b}x$$

$$\sum M_z = 0 = M_z + P\frac{b}{2a+2b}x$$

$$\Rightarrow M_z = -P\frac{b}{2a+2b}x$$

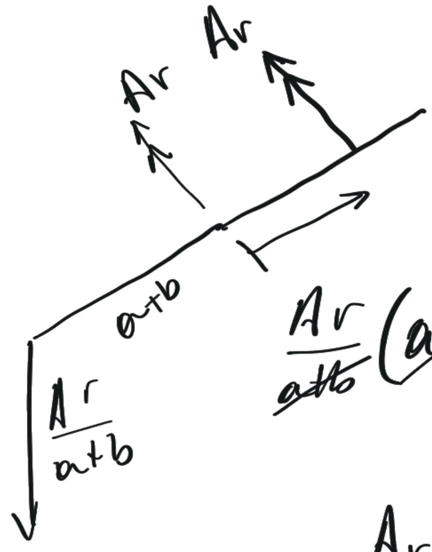


$$\sum M_y = 0 = -A\frac{r}{a+b}x + M_y \Rightarrow$$

$$\Rightarrow M_y = A\cdot\frac{r}{a+b}$$

$$\sum M_z = 0 = M_z + P\frac{b}{a+2b}x \Rightarrow \cancel{M_z} =$$

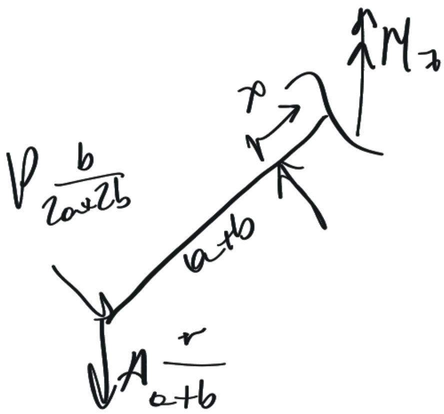
$$\Rightarrow M_z = -P\frac{bx}{2a+2b}$$



$x = b$

$$\frac{Ar}{\cancel{a+b}}\frac{(\cancel{a+b}+x)}{a+b} - Ar$$

$$Ar\frac{b}{a+b} - Ar = -Ar\frac{a}{a+b}$$



$$\sum M_z = 0 = M_z + P\frac{b}{2a+2b}(a+b+x) = Px$$

$$M_z = Px - \frac{Pbx}{2a+2b} - \frac{Pb(a+b)}{2a+2b} =$$

$$= \frac{Px(2a+b)}{2a+2b} - \frac{Pb(a+b)}{2a+2b}$$

$$= \frac{Pb(2a+b)}{2a+2b} - \frac{Pb(a+b)}{2a+2b}$$