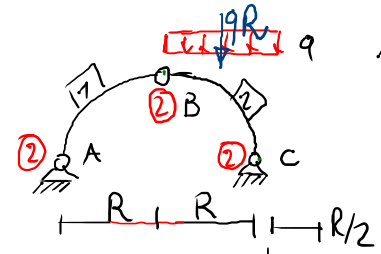


18/05/23

1) CALCOLO REAZ. VINCOLI ESTERNE (4 INCOGNITE)

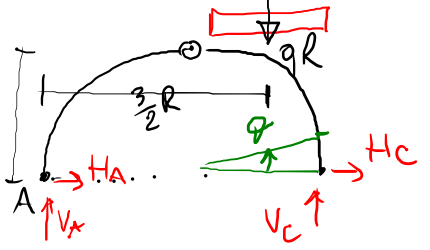


$$V_C = +qR \frac{3}{4}$$

$$V_A = qR - V_C = \frac{1}{4}qR$$

$$H_A = \frac{1}{4}qR$$

$$H_C = -H_A = -\frac{1}{4}qR$$



→ : $H_A + H_C = 0$

+ : $V_A - qR + V_C = 0$

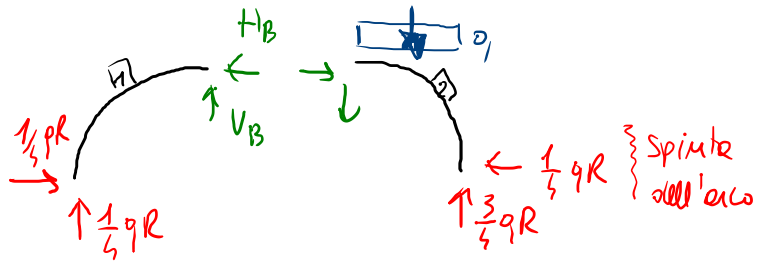
⊙⁺ : $-qR \cdot \frac{3}{2}R + V_C \cdot 2R = 0$

⊙⁺ : $-V_A R + H_A R = 0$

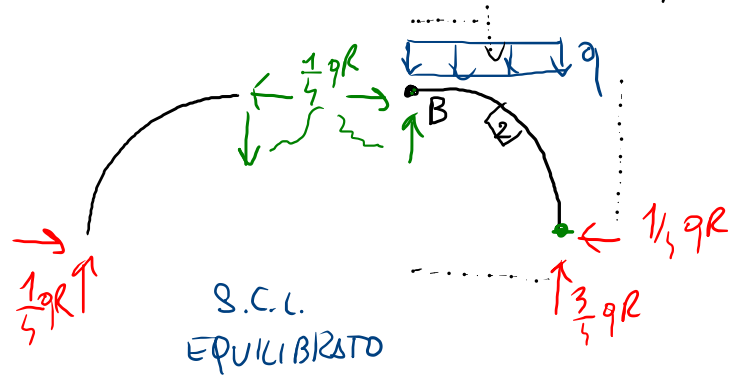
3 EQ. EQUIL. GLOBALE (F.C.S.)

EQ. AUSILIARIE

2) " " " INTERNE (V_B, H_B)



$$\left\{ \begin{array}{l} \rightarrow \uparrow \square : +\frac{1}{4}qR - H_B = 0 \\ \uparrow \square : \frac{1}{4}qR + V_B = 0 \end{array} \right. \quad \begin{array}{l} H_B = \frac{1}{4}qR \\ V_B = -\frac{1}{4}qR \end{array}$$



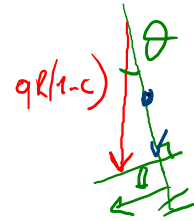
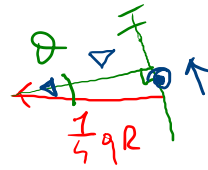
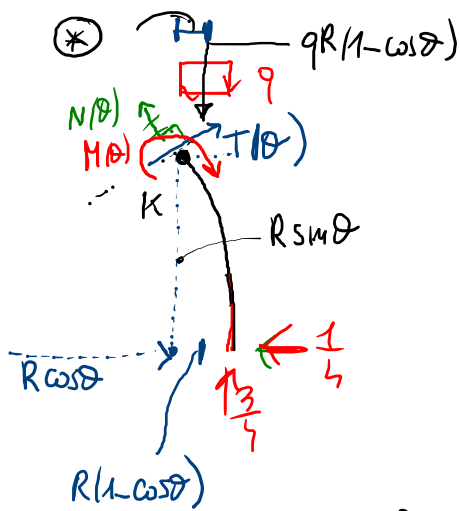
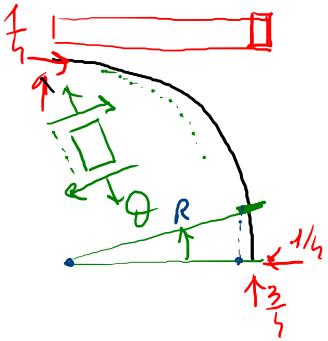
EQUIL. ORIZZ \square OK

" VERT \square OK

" MOMENTO B \square :

$$\left(\square \right)^+ : -qR \cdot \frac{R}{2} + \frac{3}{4}qR \cdot R - \frac{1}{4}qR \cdot R = 0 \quad \text{OK}$$

3) CALCOLO COS



$$c = \cos \theta$$

$$s = \sin \theta$$

OK

$$N(0) = -\frac{3}{4} qR ; N\left(\frac{\pi}{2}\right) = -\frac{1}{4} qR$$

$$\boxed{N(\theta)} : \uparrow + : +N(\theta) - qR(1-c)c + \frac{1}{4} qR s + \frac{3}{4} qR c = 0 ; N(\theta) = qR(1-c)c - \frac{1}{4} qR s - \frac{3}{4} qR c$$

$$\boxed{T(\theta)} : \rightarrow + : +T(\theta) - qR(1-c)s - \frac{1}{4} qR c + \frac{3}{4} qR s = 0 ; T(\theta) = qR(1-c)s + \frac{1}{4} qR c - \frac{3}{4} qR s$$

OK

$$T(0) = +\frac{1}{4} qR ; T\left(\frac{\pi}{2}\right) = qR - \frac{3}{4} qR = +\frac{1}{4} qR$$

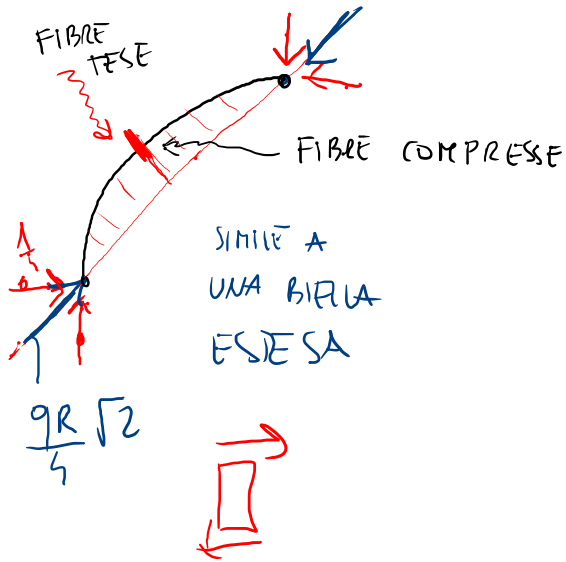
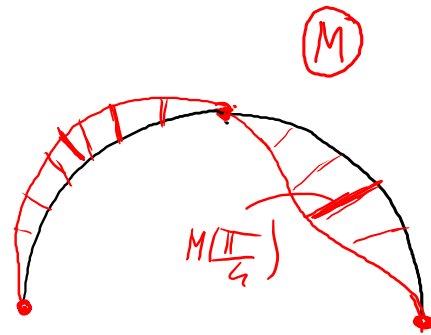
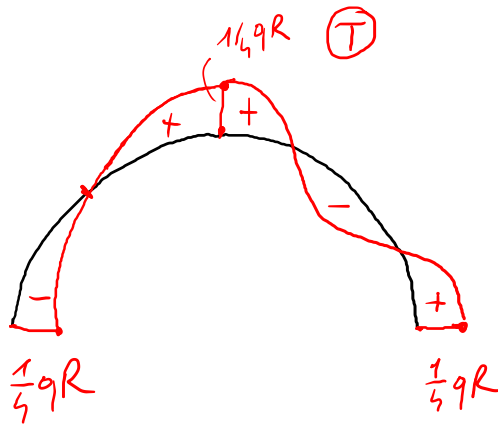
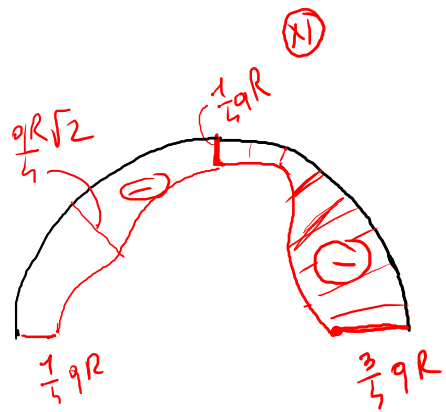
OK

$$\rightarrow M(0) = 0$$

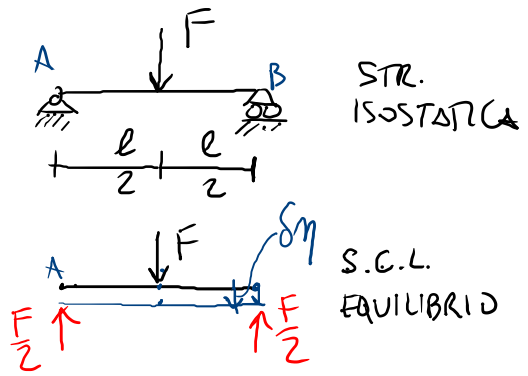
$$\boxed{M(\theta)} : \curvearrowright + : -M(\theta) - qR(1-c) \frac{R(1-c)}{2} - \frac{1}{4} qR \cdot R s +$$

$$+ \frac{3}{4} qR \cdot R(1-c) = 0 ; M(\theta) = -\frac{qR^2}{2} (1-c)^2 - \frac{1}{4} qR^2 s + \frac{3}{4} qR^2 (1-c) \rightarrow M\left(\frac{\pi}{2}\right) = -\frac{qR^2}{2} - \frac{1}{4} qR^2 + \frac{3}{4} qR^2 = 0$$

OK



CENNI ALL'APPLICAZIONE DEL PRINCIPIO DEI LAVORI VIRTUALI (P.L.V.) AL CALCOLO DELLE REAZIONI VINCOLARI NELLE STR. ISOSTATICHE



$\delta \eta$: SPOST. VIRTUALE (TRASLAZIONE DELLA TRAVE) VINGOLI DELLO SCHEMA ASSENTI

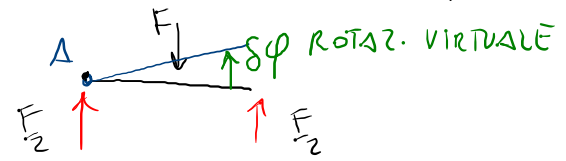
IN GENERALE UNO SPOSTAMENTO VIRTUALE È UNA ROTOTRASLAZIONE INFINITESIMA COMPATIBILE CON I VINGOLI DEL SISTEMA.

LAVORO: $\underline{F} \cdot \underline{ds} = L$

$\delta L =$ LAVORO VIRTUALE, Ossia LAVORO CHE FORZE EFFETTIVE COMPIONO PER GLI SPOST. VIRTUALE

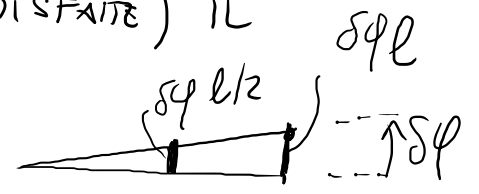
$$\delta L = -\frac{F}{2} \delta \eta + F \delta \eta - \frac{F}{2} \delta \eta = 0$$

PER UNA STRUTTURA EQUILIBRATA (PER CUI LE E.C.S. SONO SODDISFATTE) IL LAVORO VIRTUALE PER LE FORZE È NULLO.

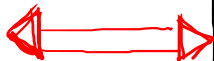


A È FERMO

$$\delta L = \frac{F}{2} \cdot 0 - F \overbrace{\delta \phi \cdot \frac{l}{2}} + \frac{F}{2} \overbrace{\delta \phi \cdot l} = 0$$

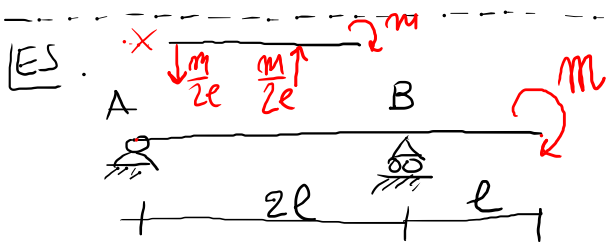


EQUILIBRIO
STRUTTURA



VALE IL PLV
 $\delta L = 0$

DAL PUNTO DI VISTA PRATICO SI PUO' USARE IL P.L.V. ($\delta L = 0$) PER CALCOLARE REAZIONI VINCOLARI INCOGNITE (IN ALTERNATIVA ALLE E.C.S.)



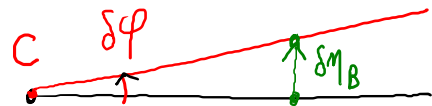
V_B CON IL P.L.V.?

1) ELIMINO IL VINCOLO DUALE A V_B
E METTO IN EVIDENZA L'INCOGNITA



2) LA STR. ORA E' LABILE, ASSEGNO QUINDI UNA ROT. TRSL. COMPATIBILE CON I VINCOLI RIMASTI

$$\delta m_B = \delta \varphi \cdot 2l$$



$$\delta L = \underbrace{+V_B \cdot \delta \varphi \cdot 2l}_{F \cdot L} - \underbrace{m \cdot \delta \varphi}_{F \cdot L} = 0$$

EQ. PER
L'INCOGNITA V_B

SI ELIMINANO
SEMPRE I TERMINI $\delta \dots$

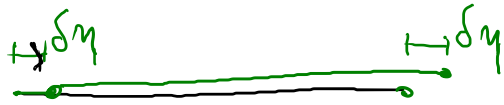
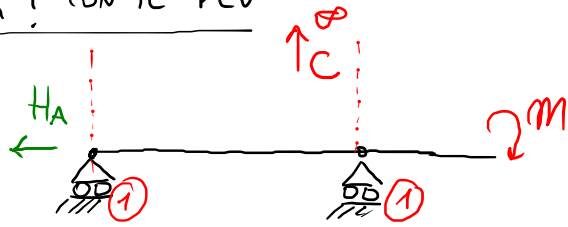
$$V_B \cdot 2l \delta \varphi - m \delta \varphi = 0$$

3) IMPONGO CHE IL LAVORO VIRTUALE δL SIA NULLO

4) RISOLVO E OTTENGONO L'INCOGNITA $\delta L = 0 \Rightarrow V_B$

$$V_B = \frac{m}{2l}$$

H_A ? CON IL PLV



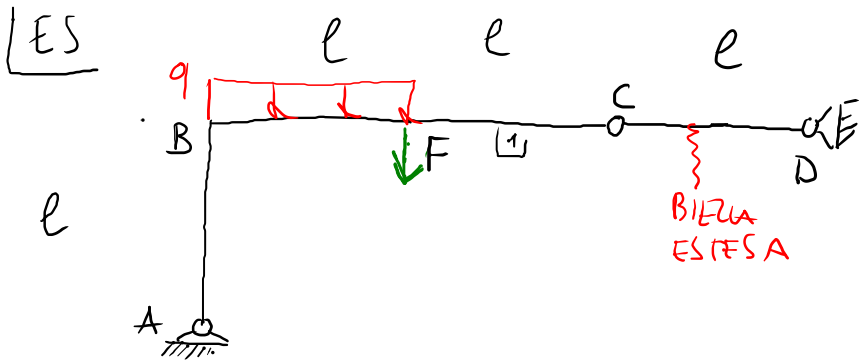
TRASLAZIONE $\delta\eta$
(ROTAZIONE NULLA)

$$\delta L = -H_A \delta\eta + M \phi = 0 \Rightarrow H_A \delta\eta = 0$$

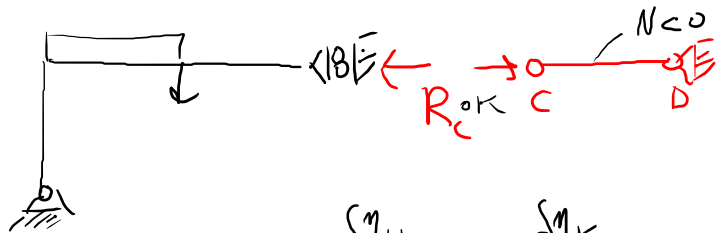
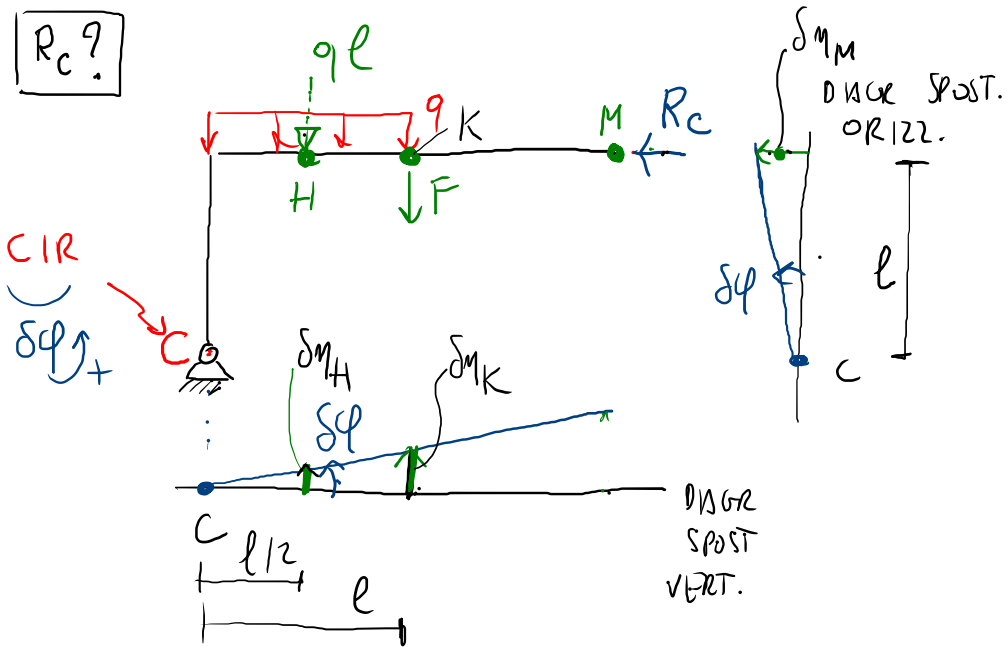
$H_A = 0$

$H_A = 0$

$\delta\eta = 0$ NON PUO' ESSERE = 0



$R_c?$



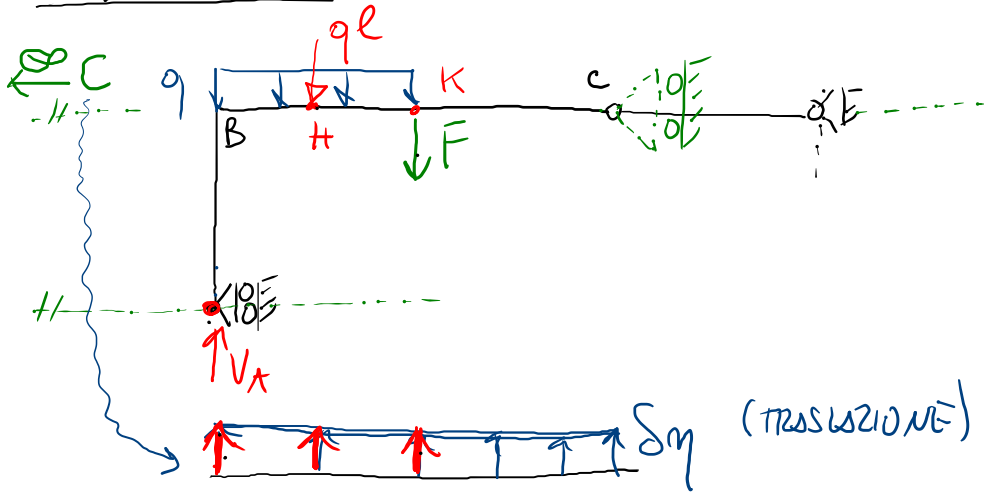
$$SL = \left[-q \cdot \overbrace{\delta q_H}^{S_{qH}} \cdot \frac{e}{2} - F \cdot \overbrace{\delta q_K}^{S_{qK}} + R_c \cdot \overbrace{\delta q_M}^{S_{qM}} = 0 \right]$$

R_c

$$-q \frac{e^2}{2} - F e + R_c e = 0 \quad ; \quad R_c = \frac{q e}{2} + F$$

(BIELLA COMPRESSA)

V_A con il PLV

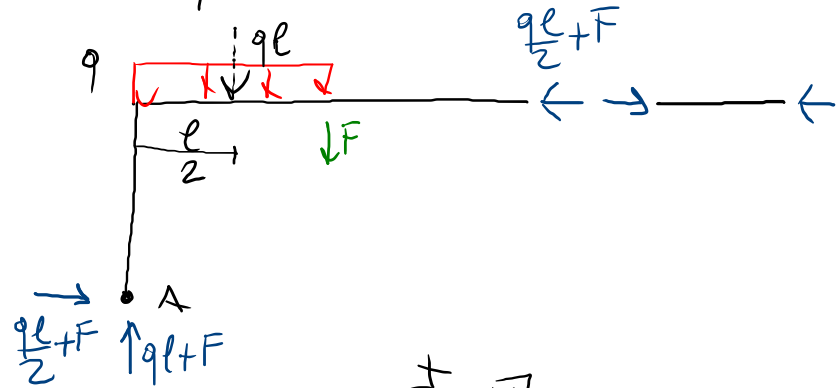


$$\delta L = \left[+V_A \delta \eta - q l \delta \eta - F \delta \eta = 0 \right]$$

$\uparrow V_A$

$$V_A - q l - F = 0 ; \quad V_A = q l + F$$

Posso poi calcolare H_A e ottenere alla fine questo S.C.-L. EQUILIBRATO.



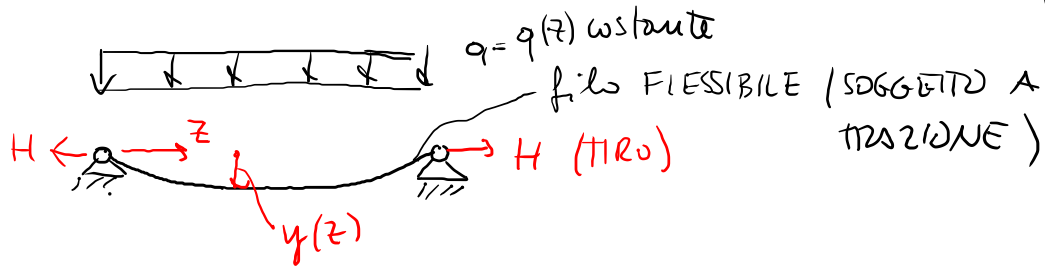
VERIFICHIAMO CHE $\sum M_A = 0$

$$\sum M_A^+ : -q l \cdot \frac{l}{2} - F l + (q \frac{l}{2} + F) \cdot l = 0$$

(SI)

(OK)

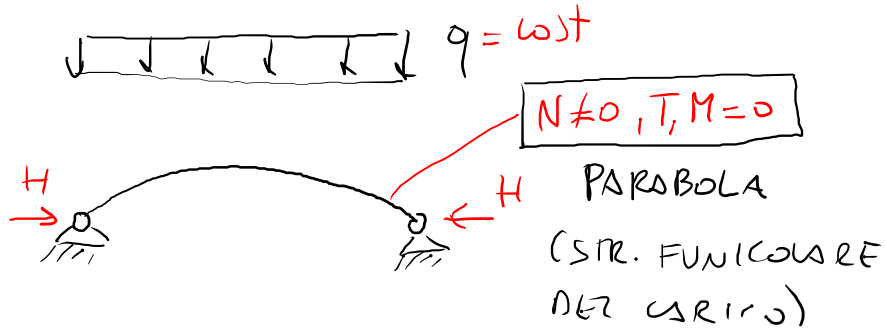
CENNI ALLE STRUTTURE FUNICOLARI DEL CARICO



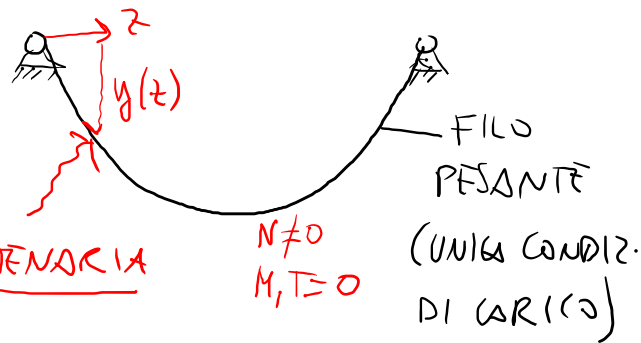
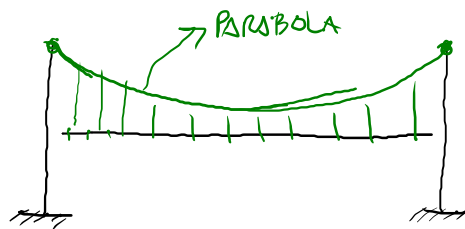
$$y''(z) = \frac{q(z)}{H}; \quad y''(z) = \frac{q}{H} \text{ se } q(z) \text{ costante}$$

costante

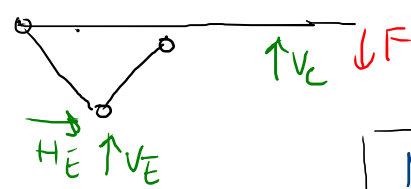
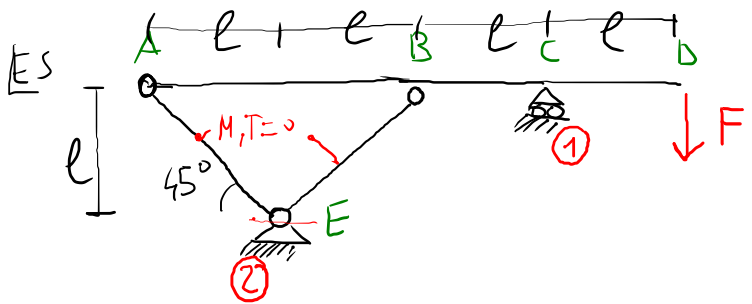
$\rightarrow y(z)$ PARABOLA



PESUPRIOTRASCUR.



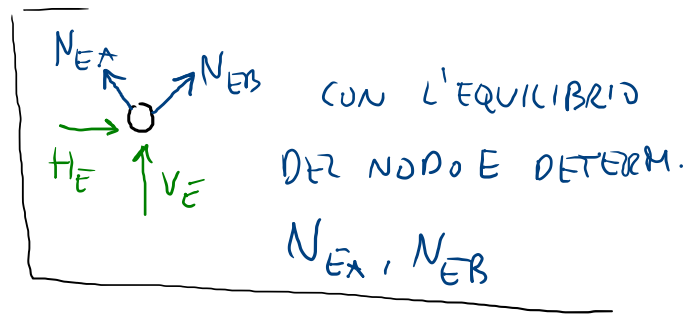
$$y(z) = \frac{H}{\gamma} \cosh\left(\frac{\gamma}{H} z - c_1\right) + c_2$$



V_C, V_E, H_E NOTE PER EQUILIBRIO ESTERNO

$$H_E = 0$$

$$V_C = -\frac{3}{2}F \quad V_E = -\frac{F}{2}$$



$$v_e = 3 (2+1)$$

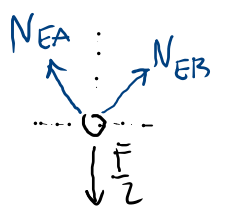
RISOLVO L'EQUILIBRIO ESTERNO E DETERMINO LE 3 INCOGNITE V_C, H_E, V_E

$$\rightarrow: H_E = 0$$

$$\uparrow: +V_E + V_C - F = 0$$

$$\curvearrow E^+: V_C 2l - F 3l = 0$$

EQUILIBRIO NODO E

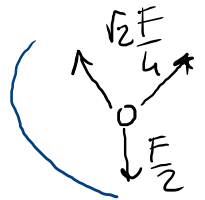
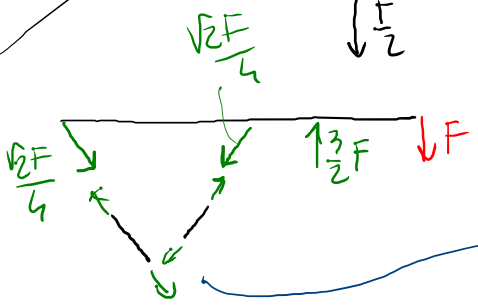
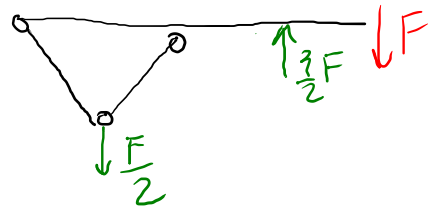


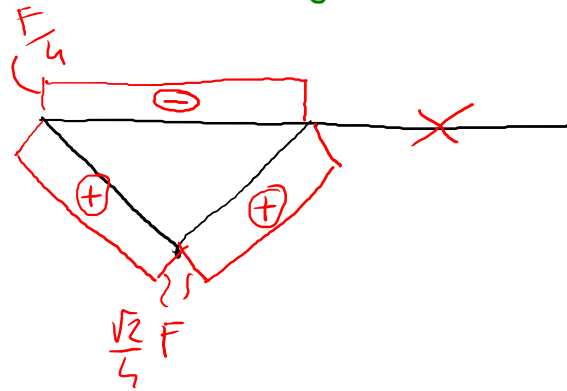
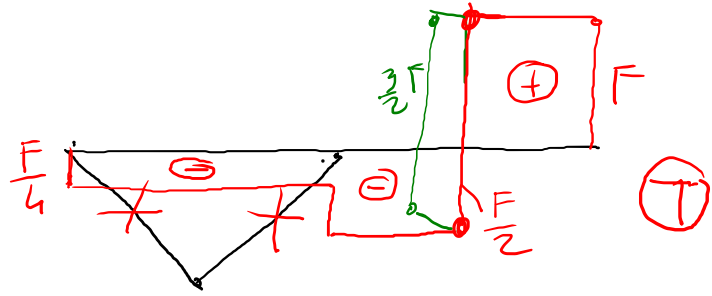
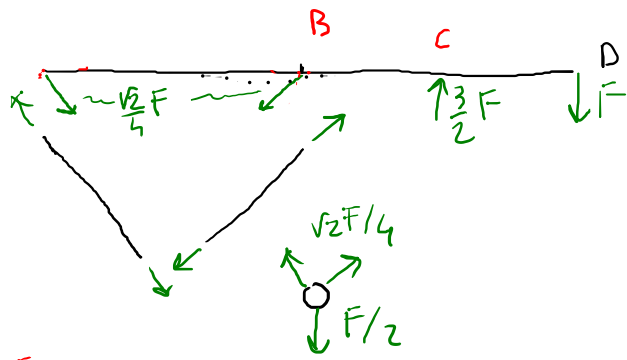
$$\rightarrow: -N_{EA} \frac{1}{\sqrt{2}} + N_{EB} \frac{1}{\sqrt{2}} = 0 \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} N_{EA} = N_{EB}$$

$$\uparrow: +N_{EA} \frac{1}{\sqrt{2}} + N_{EB} \frac{1}{\sqrt{2}} - \frac{F}{2} = 0 \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \frac{2N_{EA}}{\sqrt{2}} = \frac{F}{2}$$

$$N_{EA} = \frac{\sqrt{2}}{4} F = N_{EB}$$

EA, EB: TIRANTI



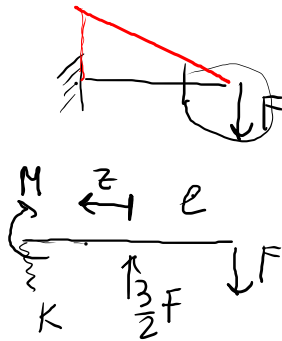


BIETIE
M=0

$$+\uparrow \sum \mathcal{K}: -M + \frac{3}{2}Fz - F(l+z) = 0$$

$$M = -Fl + \frac{F}{2}z \rightarrow M(0) = -Fl$$

$$\rightarrow M(l) = -\frac{Fl}{2}$$

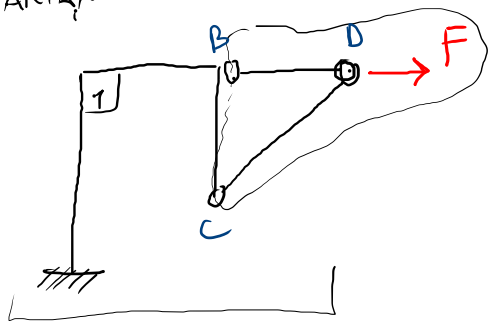


(V)

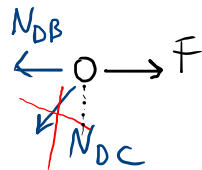
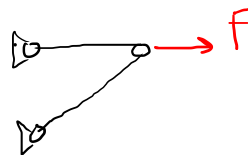
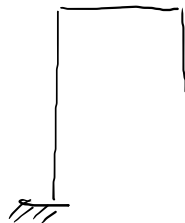
(T)

(M)

VARIANTE



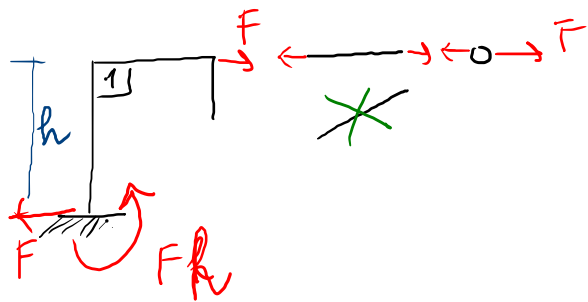
STRUTTURA GERARCHICA

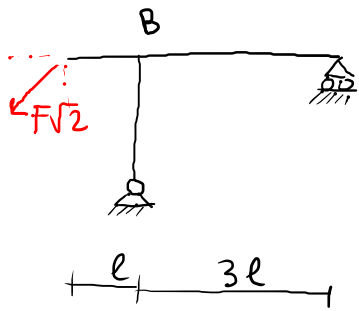


N_{DC} È NULLA PERCHÈ L'EQUAZ DI EQUIL. VERTICALE DEL NODO È:

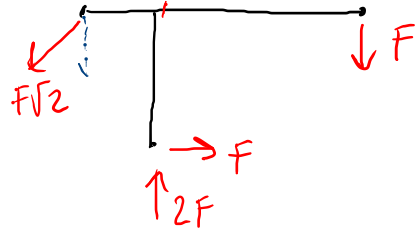
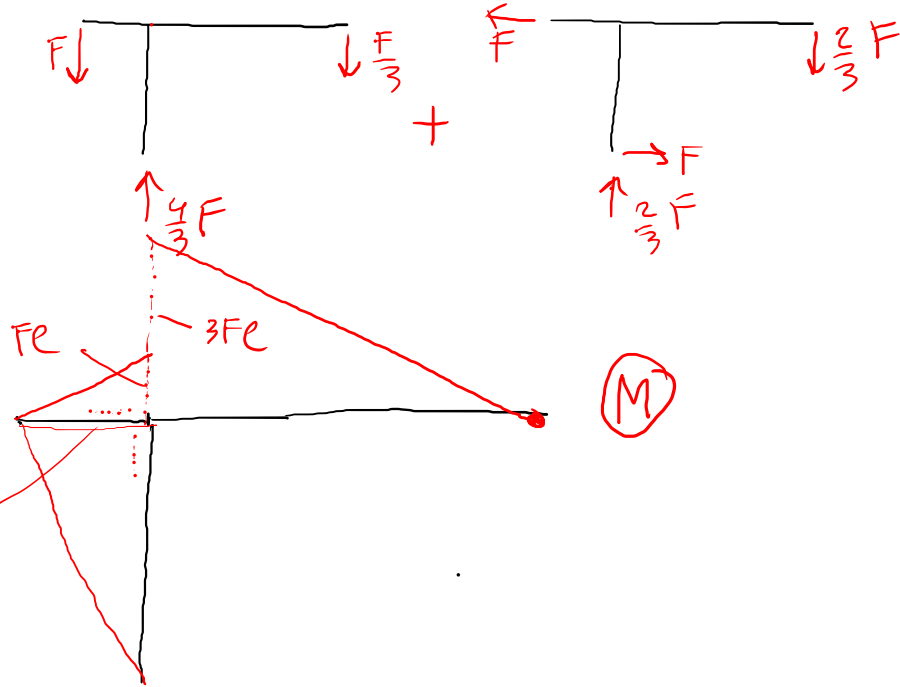
$$+\uparrow: -\frac{N_{DC}}{\sqrt{2}} = 0 \Rightarrow \boxed{N_{DC} = 0}$$

$$+\downarrow: -N_{DB} - \frac{N_{DC}}{\sqrt{2}} + F = 0 \Rightarrow N_{DB} = F$$





$2l$



EQUIL. DEI MOMENTI
NEL NODO B

VERIFICATO

