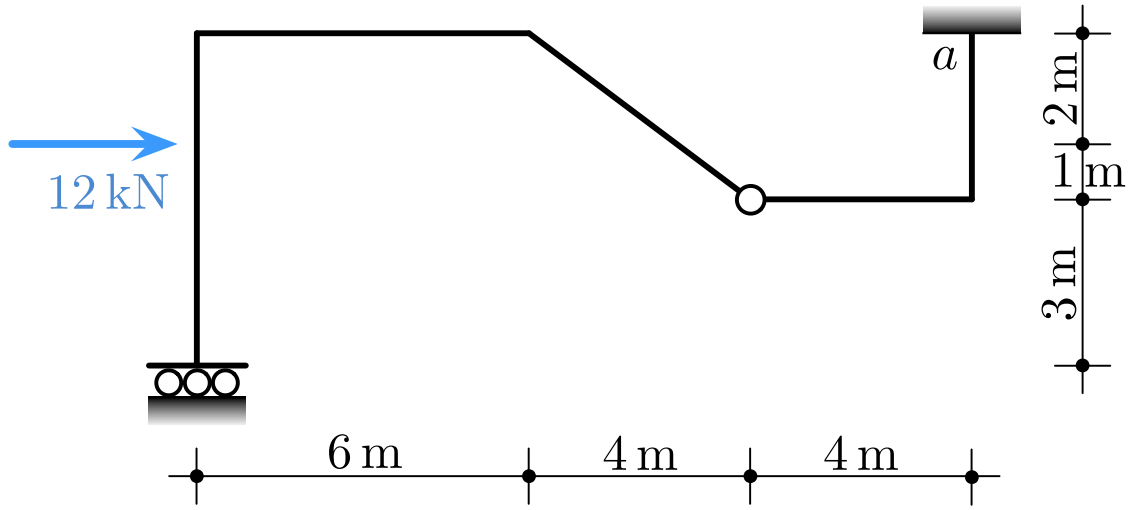
FONDAMENTI DI MECCANICA DELLE STRUTTURE

(docente: G. FORMICA)

PROVA DI VERIFICA – 17 gennaio 2018

STUDENTE: traccia **C**



Parte 2

Del sistema iperstatico rappresentato in figura, composto di elementi in acciaio caratterizzati da un momento ultimo $\boldsymbol{M}_{\mathrm{u}} = \mathbf{500\,kN\,m}$, si stimi il carico di collasso secondo i teoremi dell'analisi limite. Scelta come incognita X la **reazione a momento dell'incastro** in a, si consegnino

2.1. i risultati ottenuti all'interno dell'approccio statico:

- i diagrammi di $(N_0,\, T_0,\, M_0)$ e $(N_X,\, T_X,\, M_X)$ distribuiti sullo schema isostatico,
- il valore del fattore di amplificazione del carico λ_s e
- il relativo diagramma $M = M_0 + M_X$ *staticamente ammissibile* ($\left|M\right| \leq M_{\mathrm{u}}$);

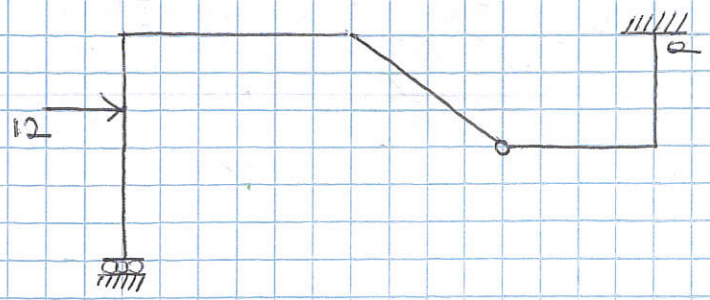
2.2. i risultati ottenuti all'interno dell'approccio cinematico:

- il (grafico del) meccanismo di collasso *cinematicamente ammissibile*,
- il relativo valore del fattore di amplificazione del carico λ_p.

AMEDEO AMATILLI
17.01.2018
A.A 2017/2018

TRACCIA C

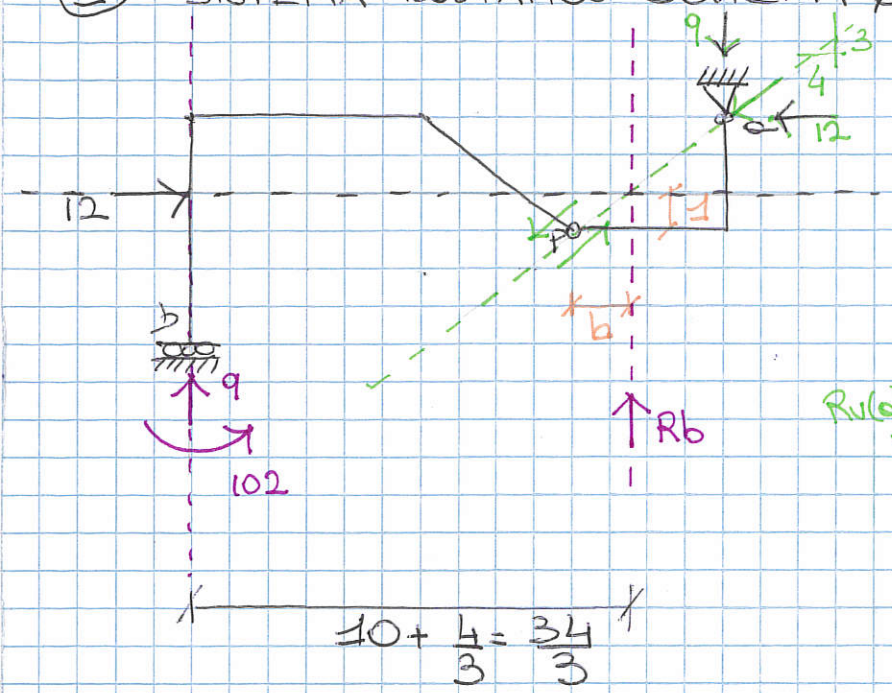
12/30



SISTEMA ~~STRUTTURA~~ IPERSTATICO

SISTEMA ISOSTATICO

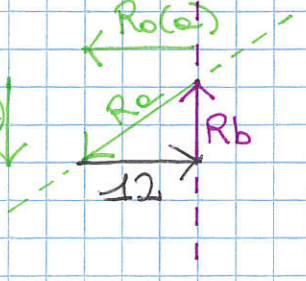
(1) ~~SISTEMA ISOSTATICO~~ SCHEMA Ø



- EQL. DX CASO Ø - 2F

$R_0(a) = R_0(b)$
$R_V(a) = R_V(b)$

- EQL. SX / GLO CASO 3 - 3F no //



$R_0(a) = 12$

$\rightarrow \frac{R_0(a)}{R_V(a)} = \frac{4}{3}$

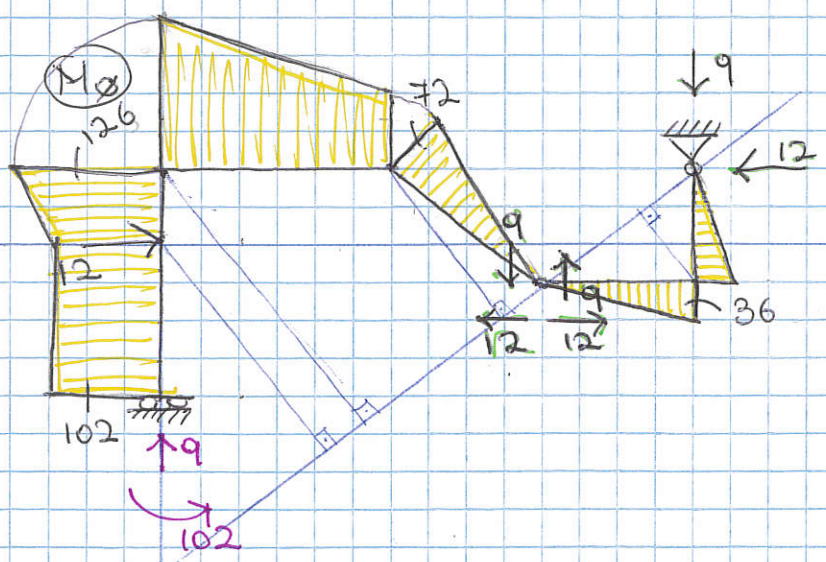
$\rightarrow R_V(a) = 9 = Rb$

EQV. 2

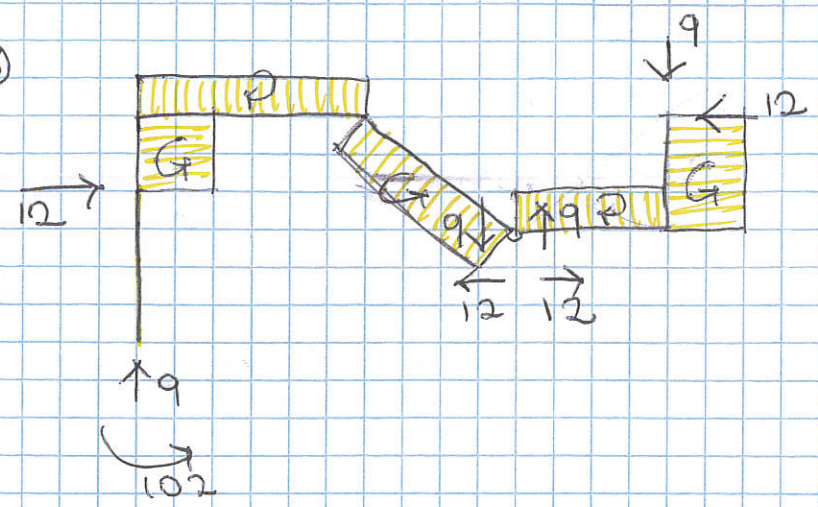
$\frac{b}{1} = \frac{4}{3}$

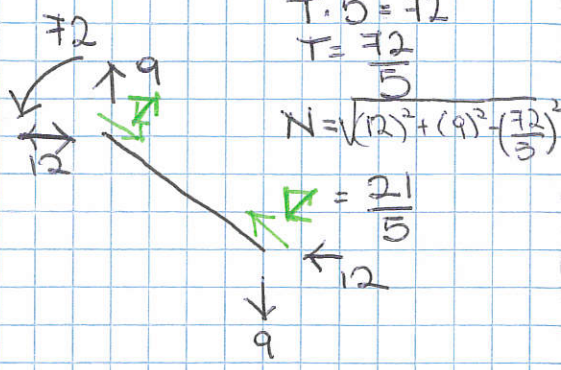
$Rb = 9$

$Mb = 9 \cdot \frac{34}{3} = 102$



(T∅)





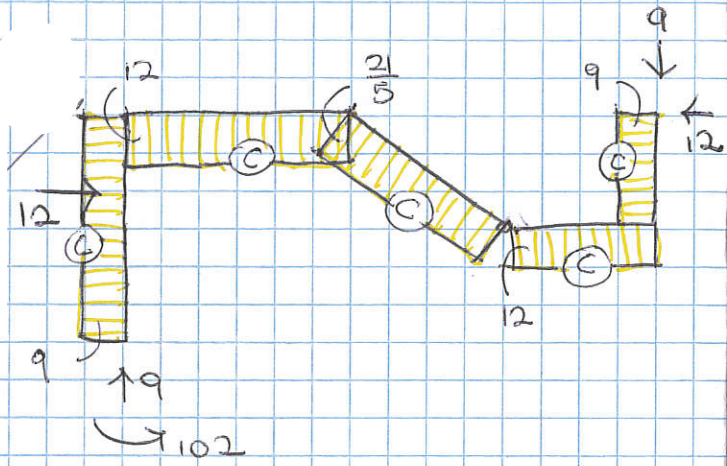
$T \cdot 5 = 12$

$T = \frac{12}{5}$

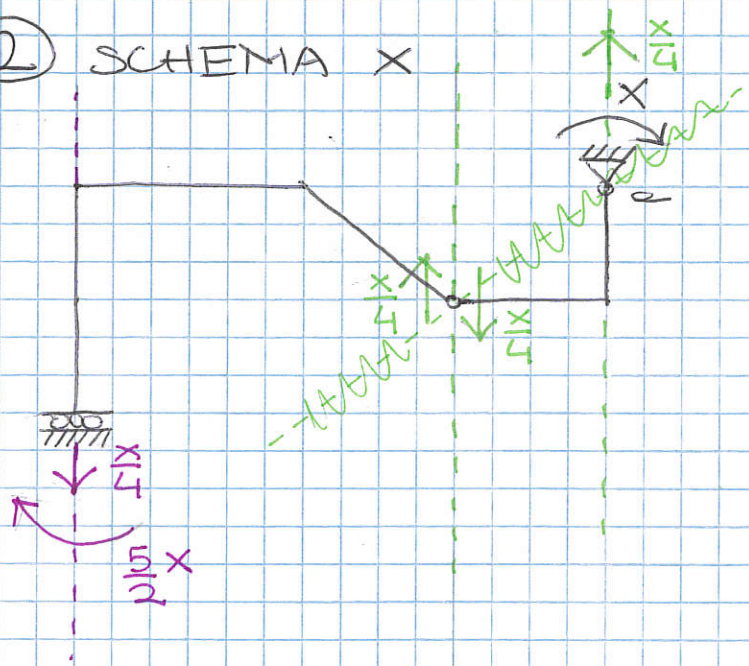
$N = \sqrt{(12)^2 + (9)^2 + (\frac{12}{5})^2}$

$= \frac{21}{5}$

(N∅)



(2) SCHEMA X



EQl. DX CASO 1 - 2F + 1M

$R_V \cdot 4 = X$

$R_V = \frac{X}{4}$

EQl. SX ~~1000~~ CASO 1

$R_V \cdot 10 = M_b$

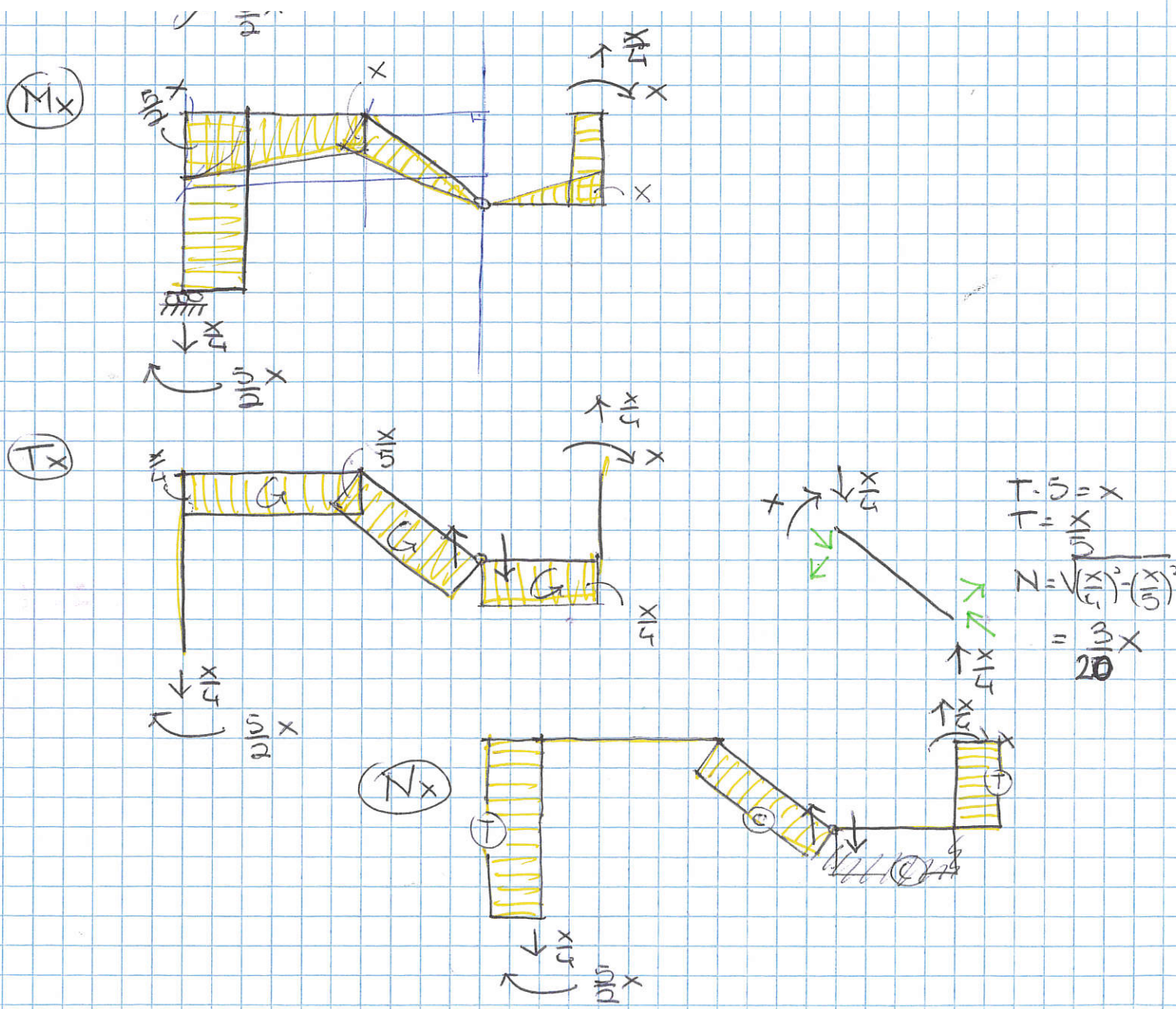
$\frac{X}{4} \cdot 10 = \frac{5}{2} X = M_b$

EQl. GLO CASO 1

$R_V \cdot 14 = M_b + X$

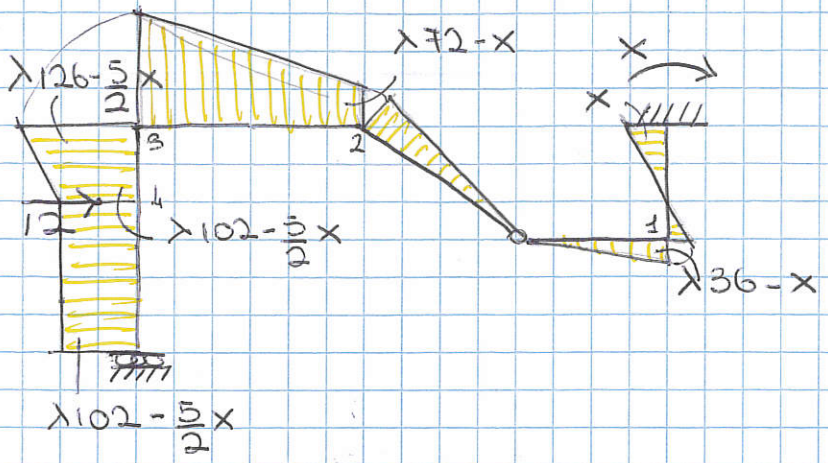
$\frac{X}{4} \cdot 14 = \frac{5}{2} X + X$

$\frac{7}{2} X = \frac{7}{2} X$


Mx
Tx
Nx
T·5 = x
T = x/5
N = √((x/4)² + (x/5)²)
= 3/20 x

③ λ_S $M\emptyset + Mx$

$M_u = 500\ kNm$



M_0	$x \leq M_u$
M_1	$\lambda 36 - x \leq M_u$
M_2	$\lambda 72 - x \leq M_u$
M_3	$\lambda 126 - \frac{5}{2}x \leq M_u$
M_4	$\lambda 102 - \frac{5}{2}x \leq M_u$

$x = M_u \longrightarrow$

$M_1 \rightarrow \lambda_S = \frac{250}{9} \cong 27,8$

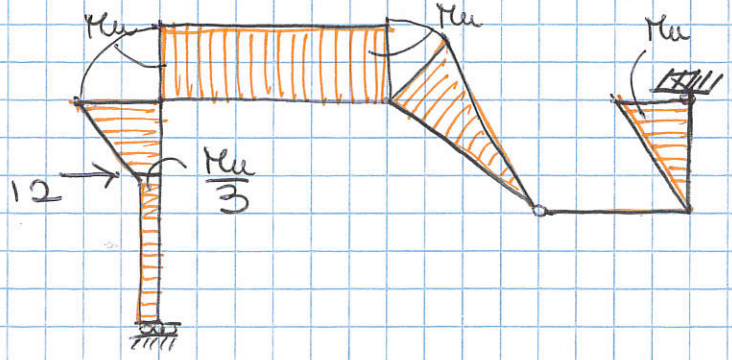
$M_2 \rightarrow \lambda_S = \frac{125}{9} \cong 13,9$

$M_3 \rightarrow \lambda_S = \frac{3500}{252} = \frac{125}{9} \cong 13,9$

$M_4 \rightarrow \lambda_S = \frac{3500}{204} = \frac{875}{51} \cong 17,15$

$$\boxed{\lambda_S = 13,9}$$

④ APPROCCIO STATICO (Moment ammissibile) $\lambda_S = 13,9$



$x = M_u = M_0 = M_2 = M_3$

$M_1 = \frac{125}{9}36 - 500 = \emptyset$

$M_4 = \frac{125}{9}102 - \frac{5}{2}\overset{250}{\cancel{500}} = \frac{M_u}{3}$

⑤ APPROCCIO CINEMATICO

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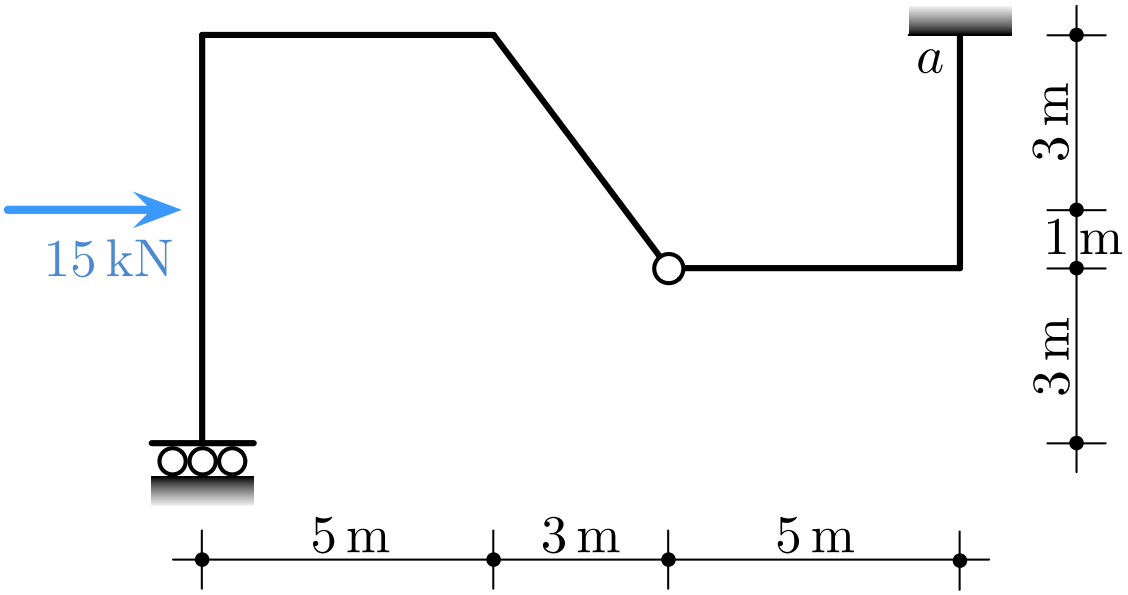

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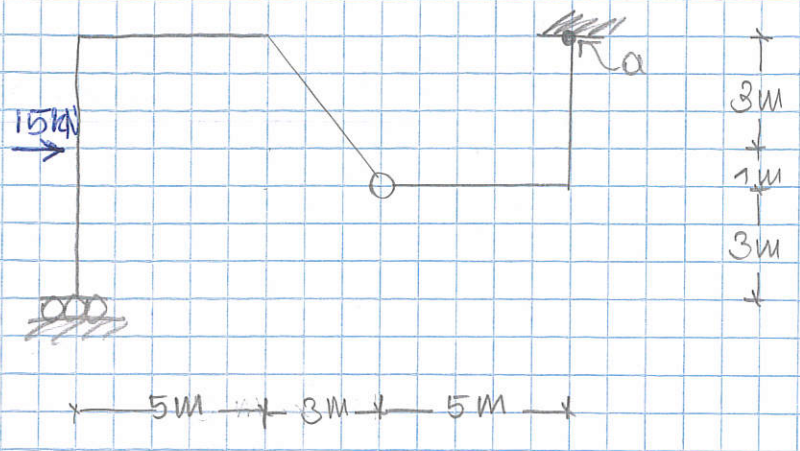
Veronica Cesaroni

17/01/2018

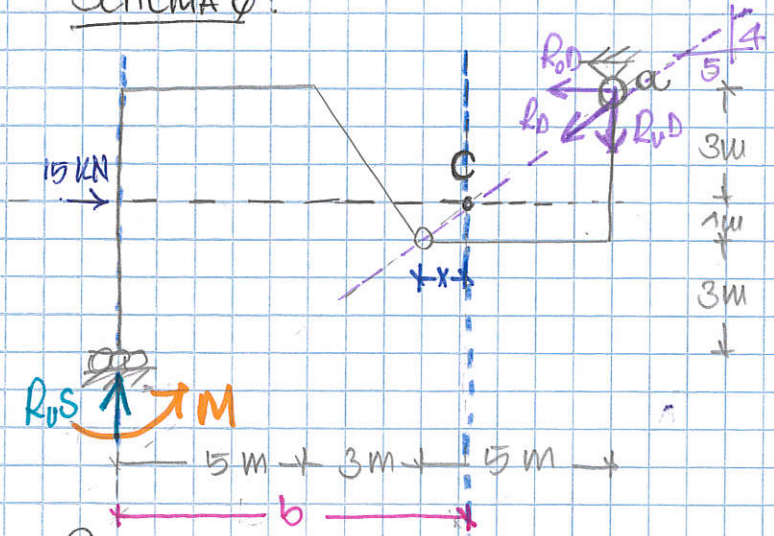
TRACCIA E

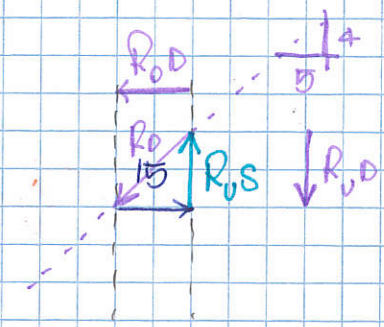
02/30



→ APPROCCIO STATICO:

SCHEMA Ø:





$R_{oD} = 15$; $R_{vD} = R_{vS}$

$R_{oD} : R_{vD} = 5 : 4$

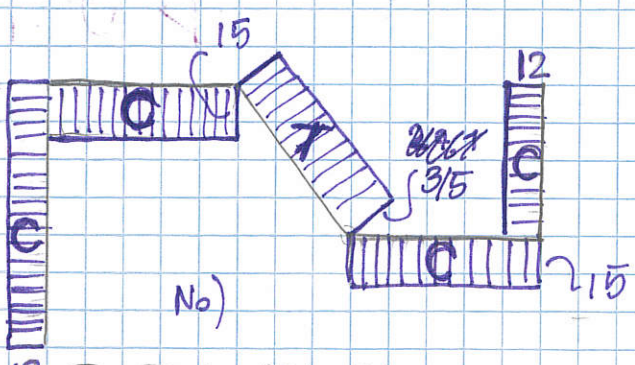
$\Rightarrow R_{oD} = \frac{5}{4} R_{vD}$

$R_{oD} = \frac{5}{4} R_{vD} = 15 \Rightarrow \frac{5}{4} R_{vD} = 15 \Rightarrow R_{vD} = \frac{15 \cdot 4}{5_1} = 12$

$\boxed{R_{vD} = 12}$ $\boxed{R_{vS} = 12}$ $\boxed{R_{oD} = 15}$

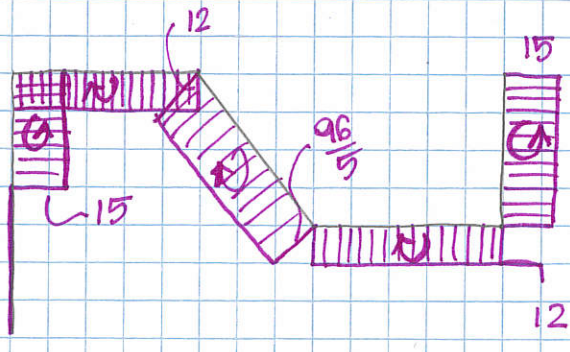
b $\Rightarrow$ $5 : 4 = x : 1 \Rightarrow x = \frac{5}{4}$ $\Rightarrow b = 8 + x = 8 + \frac{5}{4} = \frac{32+5}{4} = \frac{37}{4}$

$M_{\circlearrowleft} = 12 \cdot \frac{37}{4_1} = 111$ $\boxed{M_{\circlearrowleft} = 111}$



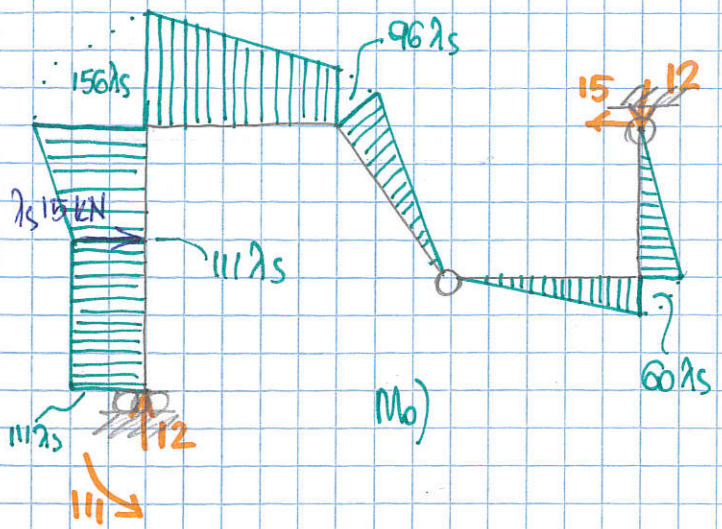
$12 \cdot 3 + 15 \cdot 4 = M_{\circlearrowleft} = 96$

$T_5 = 96 \Rightarrow T = \frac{96}{5}$

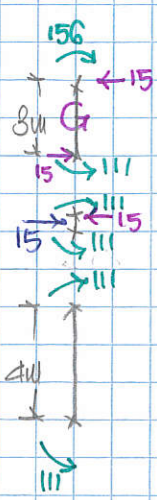


To)

$N = \sqrt{12^2 + 15^2 - \left(\frac{96}{5}\right)^2} = \frac{3}{5}$

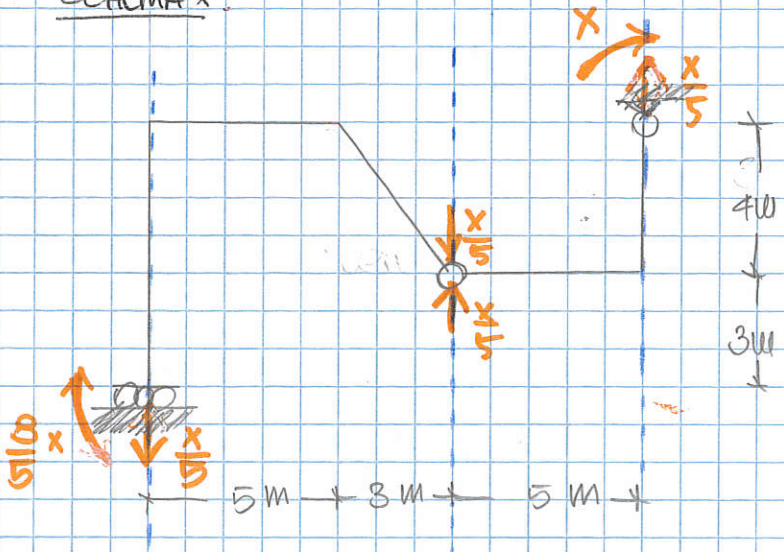


M_0)



$\underset{\curvearrowright}{M} = \underset{\curvearrowright}{15} \cdot 3 + 111 = 45 + 111 = \underset{\curvearrowright}{156}$

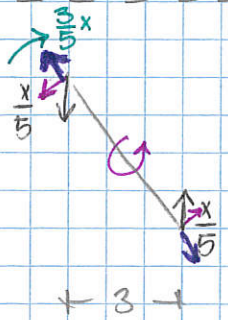
SCHEMA X:



EQL. ADX: $\underset{\curvearrowright}{X} = \underset{\curvearrowright}{R} \cdot 5 \Rightarrow R = \frac{X}{5}$

EQL. ASX: $\underset{\curvearrowright}{\frac{X}{5}} \cdot 8 = \underset{\curvearrowright}{M} \Rightarrow \underset{\curvearrowright}{M} = \frac{8}{5}X$

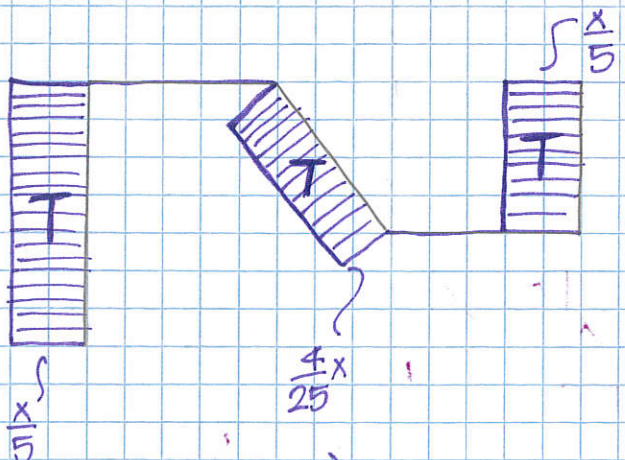
$= R$



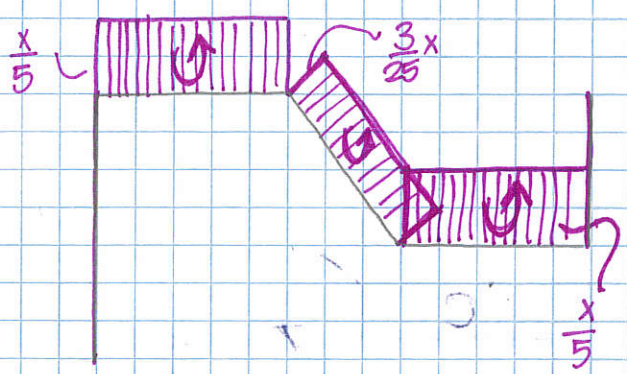
$\underset{\curvearrowright}{\frac{X}{5}} \cdot 3 = \underset{\curvearrowright}{M} \Rightarrow M = \frac{3}{5}X$

$\underset{\curvearrowright}{T5} = \underset{\curvearrowright}{\frac{3}{5}X} \Rightarrow T = \frac{3}{25}X$

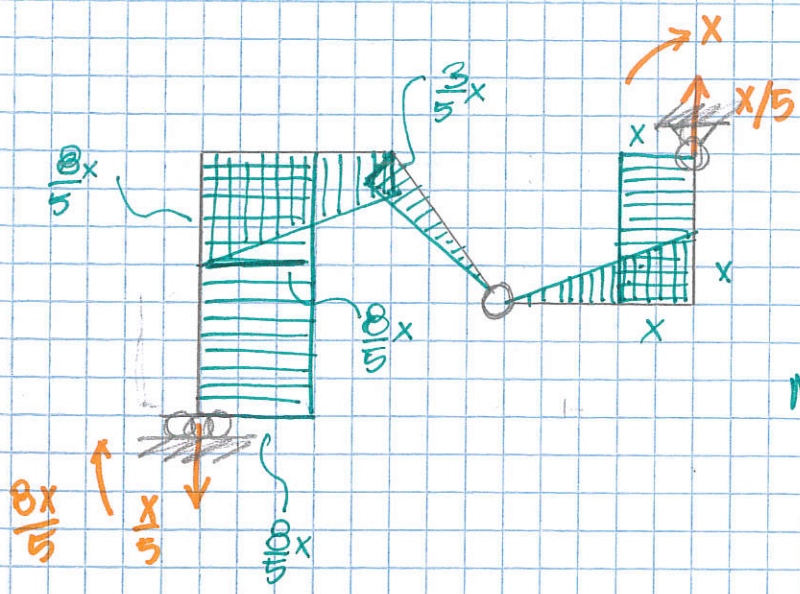
$N = X\sqrt{\left(\frac{1}{5}\right)^2 - \left(\frac{3}{25}\right)^2} = \frac{4}{25}X$



N_X)

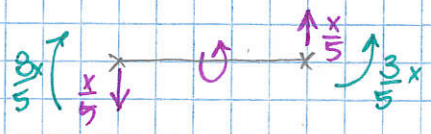


T_X)

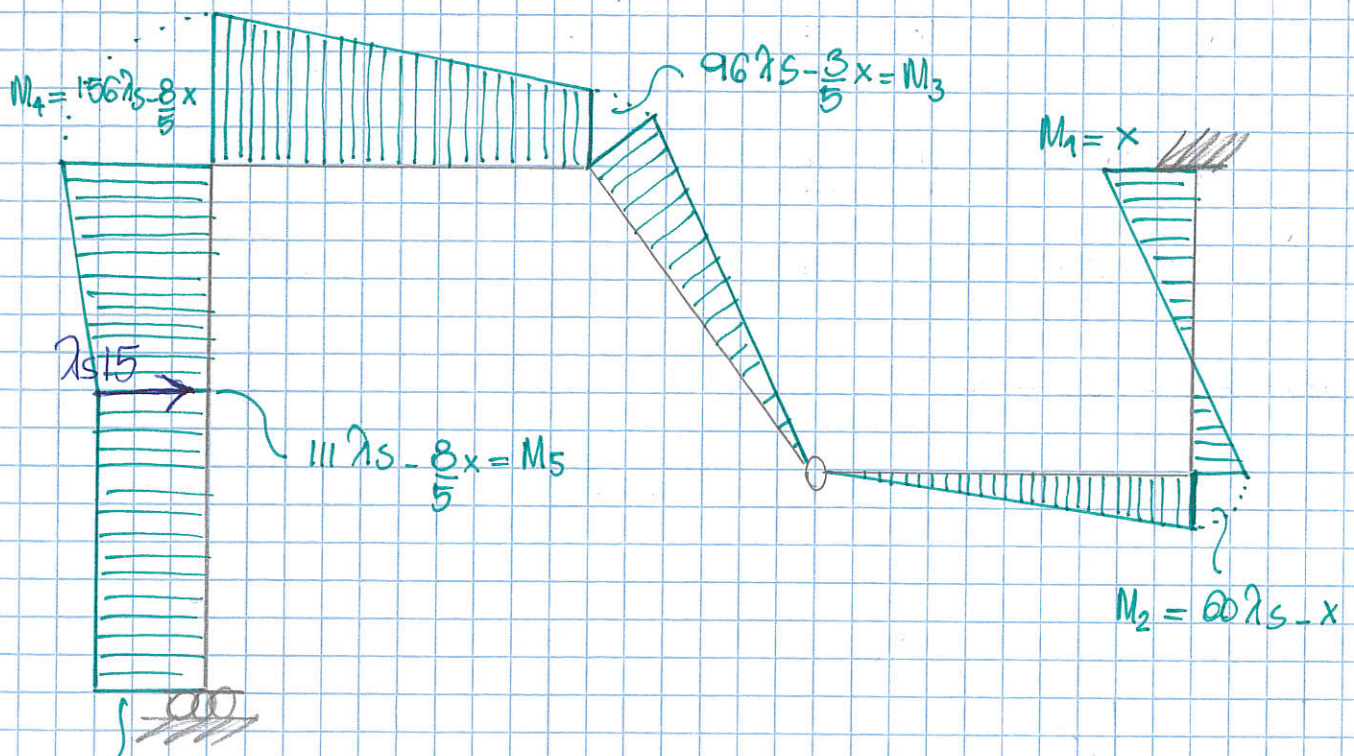


M_x)

$M_{\circlearrowleft} = \frac{8}{5}x - \frac{x}{5}\cdot 5 = \frac{3}{5}x$



$M = M_0 + M_x$



$M_u = 500\ kN\cdot m$

$$\begin{cases} M_1 = x \le M_u \\ M_2 = 60\lambda s - x \le M_u \\ M_3 = 96\lambda s - \frac{3}{5}x \le M_u \\ M_4 = 156\lambda s - \frac{8}{5}x \le M_u \\ M_6 = M_5 = 111\lambda s - \frac{8}{5}x \le M_u \end{cases}$$

1° TENTATIVO : $\underline{x = Mu = 500\ kN\cdot m}$

$M_1 = 60\lambda s - Mu \le Mu \rightarrow 60\lambda s \le 2Mu \Rightarrow \lambda s \le \frac{2Mu}{60} \simeq 16.66$

$M_3 = 96\lambda s - \frac{3}{5}Mu \le Mu \rightarrow 96\lambda s \le \frac{8}{5}Mu \Rightarrow \lambda s \le \frac{8Mu}{5\cdot 96} \simeq 8.33$

$M_4 = 156\lambda s - \frac{8}{5}Mu \le Mu \rightarrow 156\lambda s \le \frac{13}{5}Mu \Rightarrow \lambda s \le \frac{13\cdot Mu}{5\cdot 156} \simeq 8.33$

VALORE λs DA PRENDERE IN CONSIDERAZIONE

$M_5 = 111\lambda s - \frac{8}{5}Mu \le Mu \rightarrow 111\lambda s \le \frac{13}{5}Mu \Rightarrow \lambda s \le \frac{13\cdot Mu}{5\cdot 111} \simeq 11.71$

Vengono due valori uguali perché semplificando il λs relativo a M_3 sarebbe:

$$\lambda s = \frac{\cancel{8}^{1}Mu}{5\cdot \cancel{96}^{12}} = \frac{Mu}{5\cdot 12}$$

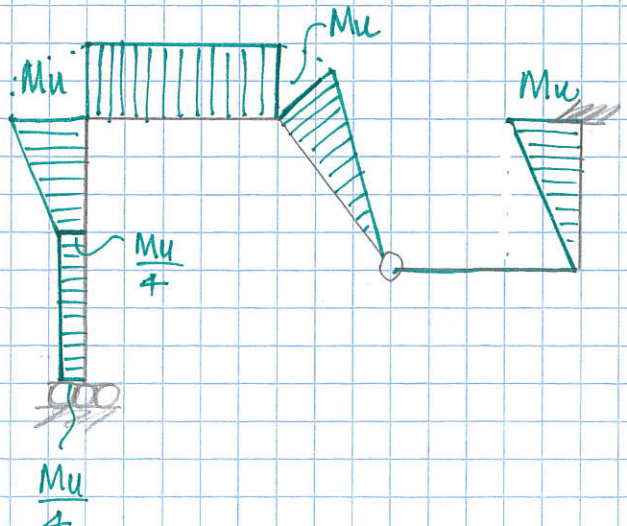
e il λs relativo a M_4 è: $\lambda s = \frac{\cancel{13}^{1}Mu}{5\cdot \cancel{156}^{12}} = \frac{Mu}{5\cdot 12}$

Quindi per la verifica si ha $\underline{M_3 = M_4 = Mu = 500\ kN\cdot m}$.

VERIFICA PER QUATTRO MOMENTI CON $\lambda s = \frac{Mu}{5\cdot 12} = \frac{\overset{25}{\cancel{500}}}{\underset{3}{\cancel{600}}} = \frac{25}{3}$; $x = Mu = 500$

$M_2 = \overset{20}{\cancel{60}}\cdot\frac{25}{\cancel{3}1} - 500 = 500 - 500 = 0$

$M_6 = M_5 = 111\cdot\frac{25}{3} - \frac{8}{\cancel{5}1}\cdot\overset{100}{\cancel{500}} = \frac{2275}{3} - 800 = \frac{2275 - (3\cdot 800)}{3} = \frac{375}{3} = 125 = \frac{Mu}{4}$



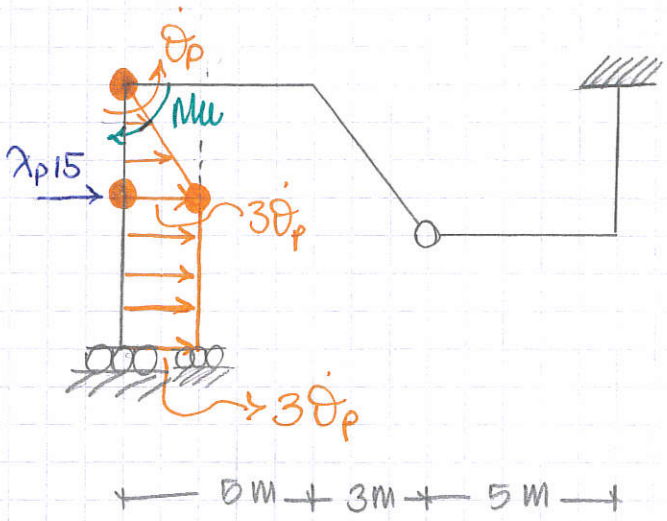
$\lambda s = \frac{500}{60} \simeq 8.33$

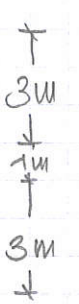
Veronica Cesaroni

17/01/2018

TRACCIA E

→ APPROCCIO CINEMATICO:

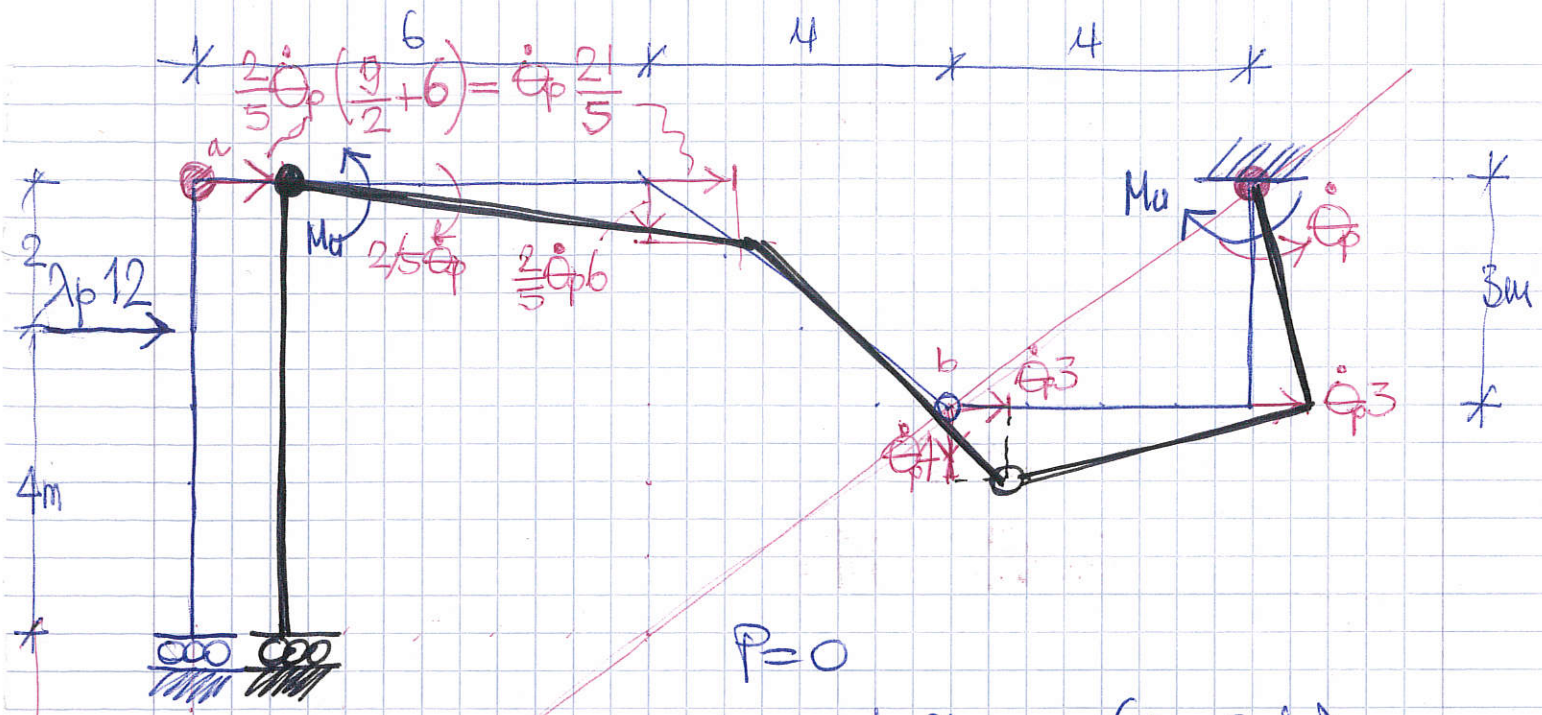




$$\Phi = 15\lambda_p \dot{\vartheta}_p 3 - Mu\left(\dot{\vartheta}_p + \dot{\vartheta}_p\right) = 0$$

$$15\lambda_p \dot{\vartheta}_p 3 - Mu\, 2\dot{\vartheta}_p = 0 \Rightarrow \quad \lambda_p = \frac{Mu\,2}{15\cdot 3} = \frac{500\cdot 2}{15\cdot 3} \simeq 22.22$$

$$\lambda_s \leq \lambda_c \leq \lambda_p \Rightarrow \quad 8.33 \leq \lambda_c \leq 22.22$$



$P = 0$

$$\lambda_p 12 \dot{\theta}_p \frac{21}{5} - M_u\left(\dot{\theta}_p + \frac{2}{5}\dot{\theta}_p\right) = 0$$

$$\rightarrow \lambda_p = \frac{M_u \cdot 7/5}{12 \times 21/5} = \frac{500}{36} = \frac{125}{9} \simeq 13.9$$

$\frac{6}{4}3 = \frac{9}{2}$

$\frac{\dot{\theta}_p 4}{10} = \frac{2}{5}\dot{\theta}_p$ (rotazione corpo tra a-b)

$$\lambda_s = \lambda_p = \boxed{13.9 = \lambda_c}$$