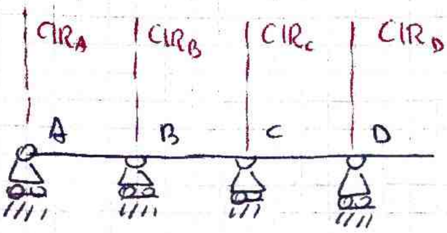


$Gdl = 3$

$\sum Gdv = 1+1+1+1 = 4$

$\exists$ unico CIR all' ∞ → labile

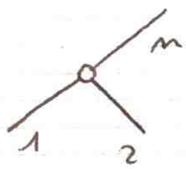
(punto improprio del fascio di rette)

Fino ad ora abbiamo visto corpi vincolati a terra, in particolare i singoli corpi vincolati a terra

→ Passiamo ora ad analizzare m corpi rigidi

- Vincoli interni: limitano il moto relativo dei singoli punti dei corpi rigidi

Cerniera Interna



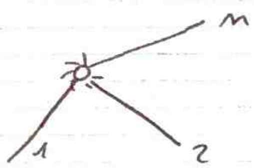
$Gdv: 2(m-1)$

$Gdl = 3 \cdot m$

$Gdl_{residui} = m + 2$

$Gdv = 3m - (m+2) = 2(m-1)$

Cerniera a terra



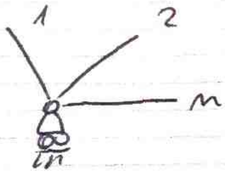
$Gdv: 2m$

$Gdl = 3 \cdot m$

$Gdl_{resid} = m$

$Gdv = 3m - m = 2m$

Carrello a terra

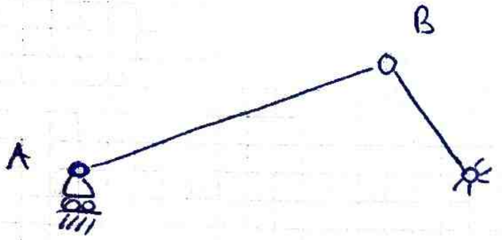


$Gdv: 2m - 1$

$Gdl = 3m$

$Gdl_{residui} = m + 1$

$Gdv = 3m - (m+1) = 2m - 1$



$Gdl = 3 \cdot n = 3 \cdot 2 = 6$

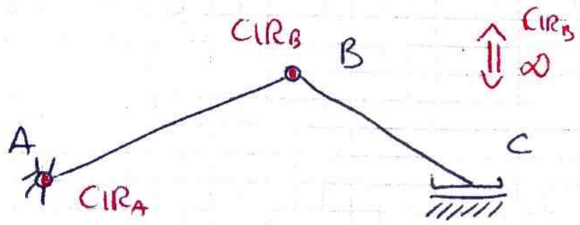
$\sum Gdv = V_A + V_B + V_C =$

$= 1 + 2(2-1) + 2 =$

$= 5$

Sistema biella - manovella

Sistema 1 volta ipostatico



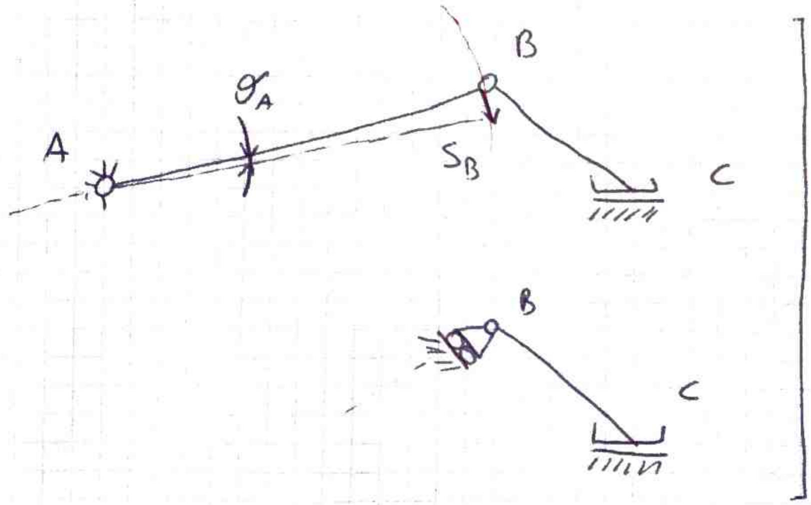
$Gdl = 2 \cdot n = 6$

$\sum Gdv = 2 + 2(n-1) + 2 =$

$= 2 + 2 + 2 = 6$

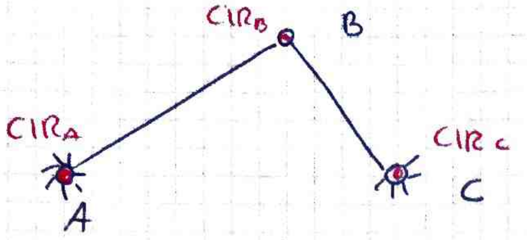
$\nexists$ unico CIR $\rightarrow$ Sistema isostatico

Questo sistema ci permette di introdurre il concetto di equivalenza cinematica:



Sistemi cinematicamente equivalenti

Arco a tre cerniere

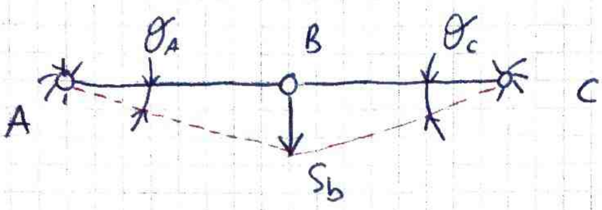


$GdL = 3m = 6$

$\Sigma GdV = 2 + 2(m-1) + 2 = 6$

isostatica

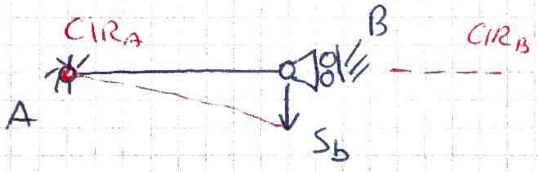
Caso notevole di arco a tre cerniere



Arco a tre cerniere degenere:
$\Rightarrow$ Labile

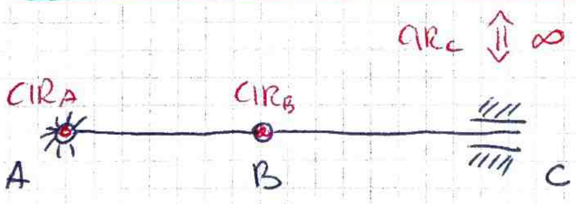
l'arco a tre cerniere allineate è labile

Per capire meglio
facciamo l'equivalenza cinematica:



$\exists$ unico CIR

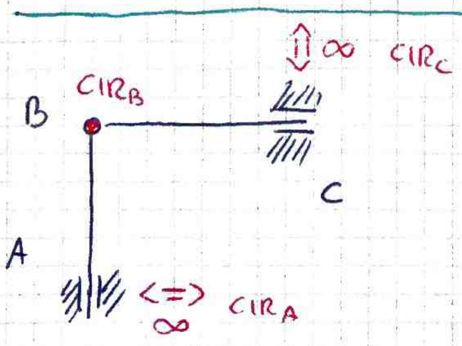
$\rightarrow$ struttura labile



$GdL = 6$

$\Sigma GdV = 2 + 2 + 2 = 6$

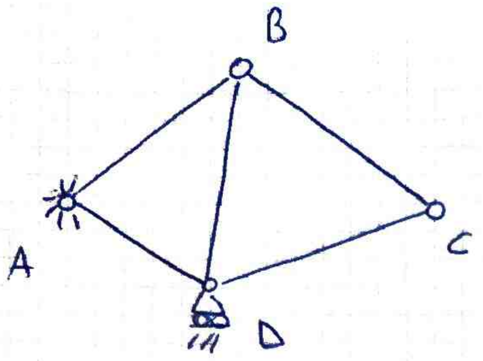
$\nexists$ unico CIR isostatica



$GdL = 2m = 6$

$\Sigma GdV = 2 + 2 + 2 = 6$

$\nexists$ unico CIR isostatica



5 corpi rigidi:

$Gdl = 5n = 15$

Vincolo A

$V_A = 2 \cdot n = 4$

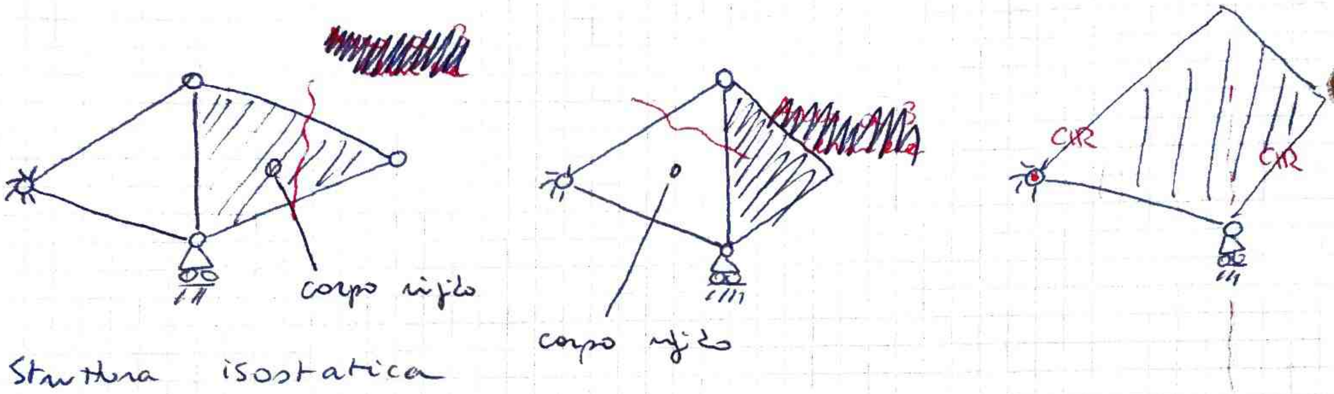
$V_B = 2(n-1) = 4$

$V_C = 2$

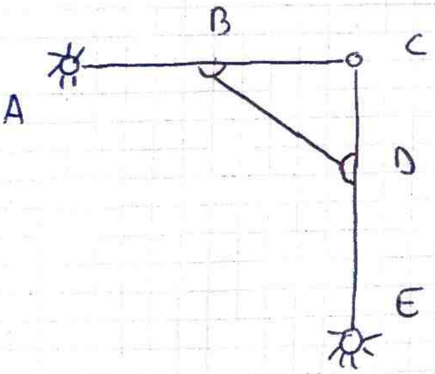
$V_D = 2n - 1 = 5$

$\Sigma GdV = 15$

Analisi delle sotto-strutture:



Struttura isostatica



$Gdl = 3 \cdot 3 = 9$

$V_A = 2$

$V_B = 2(n-1) = 2$

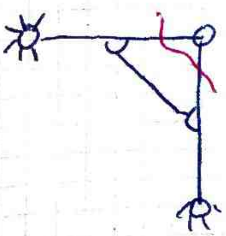
$V_C = 2$

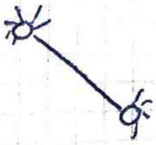
$V_D = 2$

$V_E = 2$

$\Sigma GdV = 10$

Arco A-C-E ben vincolato a terra → Arco a 3 cerniere non allineate



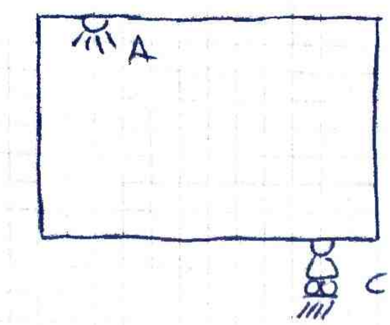


$Gdl = 3$

$\Sigma GdV = 2 + 2 = 4$

Struttura 1 volta iperstatica

Anello chiuso



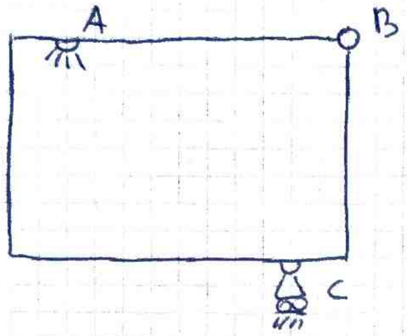
$gdl = 3$

$\Sigma gdv = 2_A + 1_C = 3$

↳ Isostatica a terra

↳ 3 volte iperstatica internamente

↑



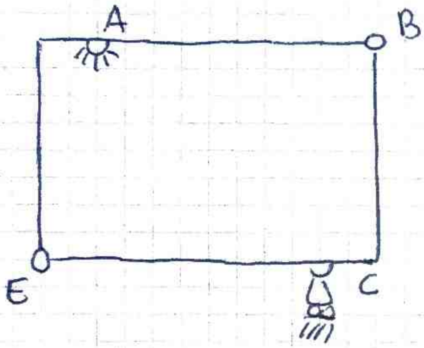
$gdl = 3$

$\Sigma Gdv = 2_A + 2_B + 1_C = 5$

↳ Isostatica a terra

↳ 2 volte iperstatica internamente

↑



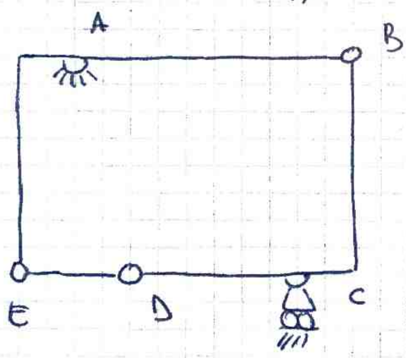
$gdl = 2 \cdot 3 = 6$

$\Sigma gdv = 2_A + 2_B + 1_C + 2_E = 7$

↳ Isostatica a terra

↳ 1 volta iperstatica all'interno

↑



$gdl = 3 \cdot 3 = 9$

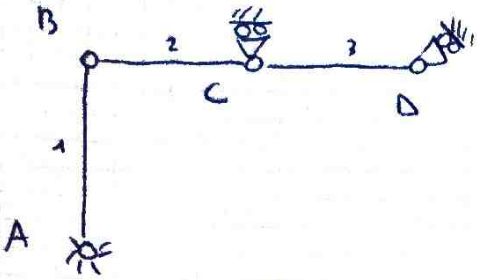
$\Sigma Gdv = 2_A + 2_B + 1_C + 2_D + 2_E = 9$

struttura isostatica

↳ Ben vincolata a terra

↳ Isostatica all'interno

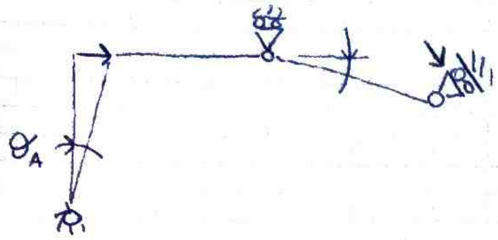
Per capire questo esercizio partire da qua ⤴

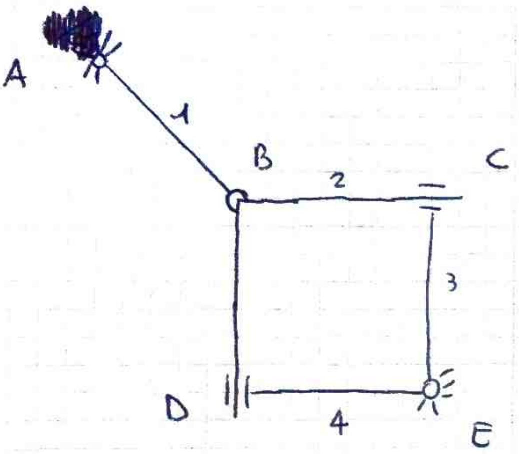


$GdL = 3 \cdot n = 9$

$\sum Gdv = 2_A + 2_B + 3_C + 1_D = 8$

Ipostatica



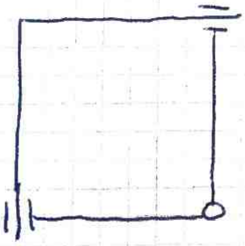


$GdL = 3 \cdot n = 12$

$\sum Gdv = 2_A + 2_B + 2_C + 2_D + 4_E =$

$= 12$

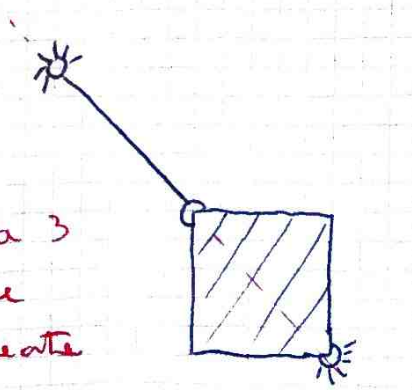
La sotto-struttura B-C-D-E è un anello chiuso isostatico



→ Anello chiuso isostatico

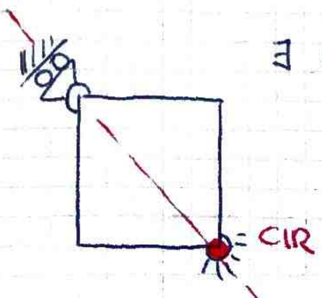
Quindi:

Arco a 3 cerniere allineate



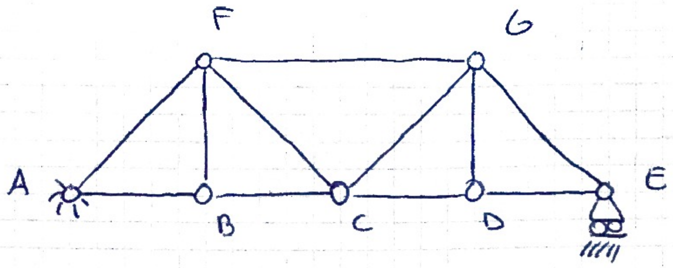
Cinematicamente

≡



∃ unico CIR

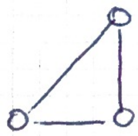
Struttura labile



$$GdL = 3m = 3 \cdot 11 = 33$$

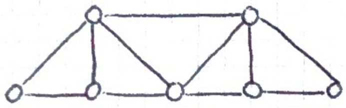
$$\sum GdV = (2m)_A + (2(m-1))_B + (2(m-1))_C + (2(m-1))_D +$$
$$+ (2m-1)_E + (2(m-1))_F + (2(m-1))_G =$$
$$= 4 + 4 + 6 + 4 + 3 + 6 + 6 = 33$$

Tutte le sotto-strutture di questo tipo:



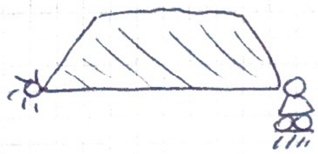
Sono anelli chiusi isostatici

Quindi la struttura

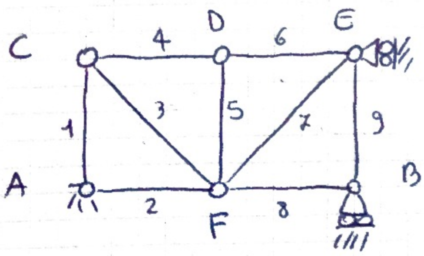


è isostatica internamente

A livello di equivalenza cinematica tale struttura può essere sostituita e "messa a terra" nel modo seguente:



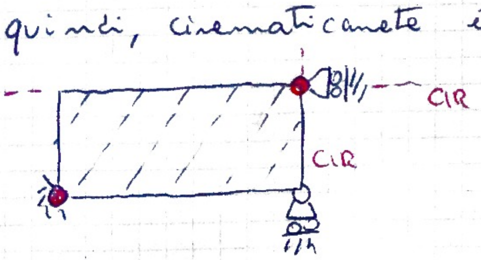
struttura isostatica



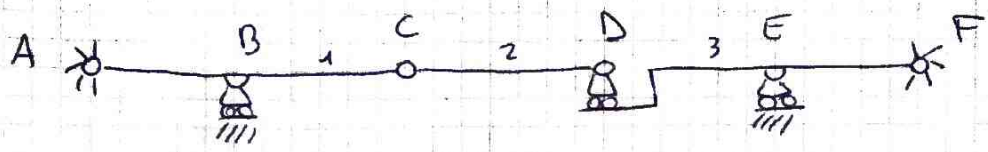
$$GdL = 3m = 3 \cdot 9 = 27$$

$$\sum GdV = (2m)_A + (2(m-1))_F + (2m-1)_B +$$
$$+ (2(m-1))_C + (2(m-1))_D + (2m-1)_E =$$
$$= 4 + 8 + 3 + 4 + 4 + 5 = 28$$

La struttura è formata da 4 anelli chiusi isostatici, quindi, cinematicamente è assimilabile a:



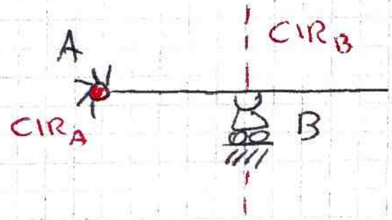
Struttura 1 volta iperstatica a terra



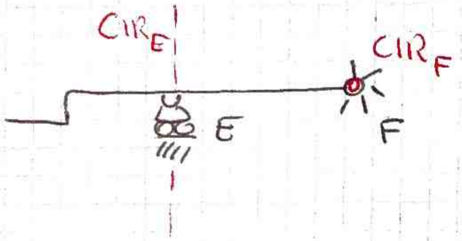
$\sum Gdv = 2_A + 1_B + 2_C + 1_D + 1_E + 2_F = 9$

$Gdl = 3 \cdot n = 9$

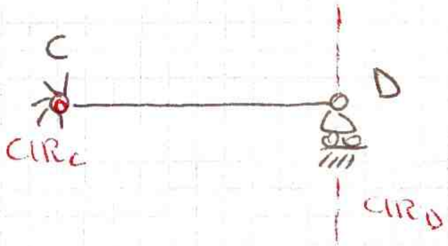
Asta 1 è isostatica



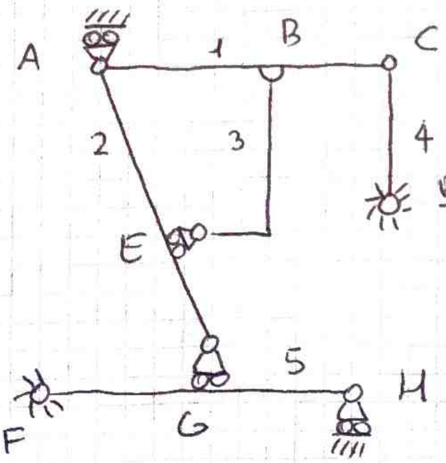
Asta 3 è isostatica



Le 3 aste iniziali sono quindi, cinematicamente, equivalenti a



Struttura isostatica

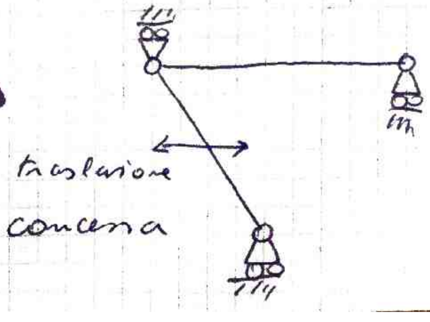


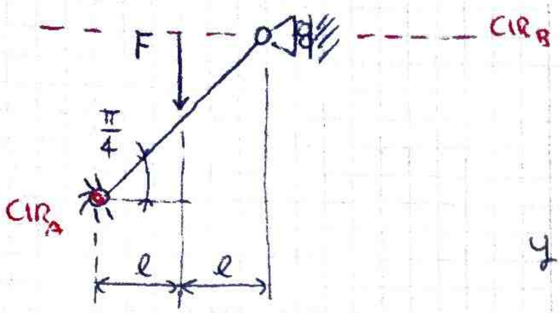
$Gdl = 3 \cdot n = 15$

$\sum Gdv = 3_A + 2_B + 2_C + 2_D + 1_E + 2_F + 1_G + 1_H = 14$

- Asta $\overline{FH}$ è isostatica
- Asta $\overline{CD}$ sostituita con un carrello
- Asta $\overline{EB}$ non genera alcun vincolo relativo tra asta 1 e 2

Struttura ipostatica

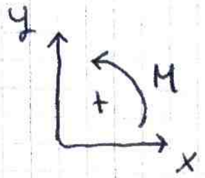


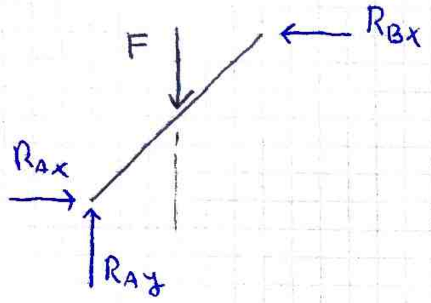


$GdL = 3$

$\Sigma GdV = 2_A + 1_B = 3$

$\nexists$ CIR isostatica





$\Sigma F_x = 0 \qquad R_{Ax} - R_{Bx} = 0 \qquad R_{Ax} = R_{Bx} = \frac{1}{2}F$

$\Sigma F_y = 0 \qquad R_{Ay} - F = 0 \qquad R_{Ay} = F$

$\Sigma M_A = 0 \qquad -Fl + R_{Bx}\,2l = 0 \qquad R_{Bx}\,2\cancel{l} = F\cancel{l} \qquad R_{Bx} = \frac{1}{2}F$

Devo essere furbo scegliendo A invece di B (1 incognita al posto di due)