*Politecnico di Milano - Corso di Laurea in Architettura (N.O.)*

Campus Mantova

# CORSO DI T. E P. DI COSTRUZIONI E STRUTTURE

A.A. 2003-04

## Seconda esercitazione scritta del 03.06.2004

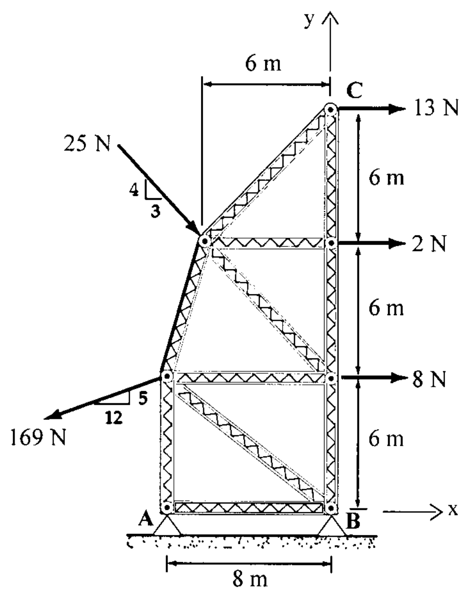
(da riconsegnare entro le 17:30 del 10.06.2004)

*Nota: I risultati numerici (in forma frazionaria o con 3 cifre decimali) vanno riportati su questo stesso foglio, nei riquadri predisposti; i calcoli (in forma ordinata) vanno allegati su fogli in formato A4 bianchi o a quadretti.*

| Allievo:...................................................... Matricola:....... |
|---|

**Esercizio n.1** (6 punti)

Si consideri la struttura data in figura

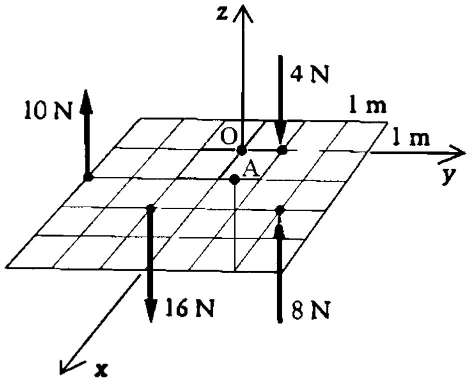



Calcolare la risultante **F** delle 5 forze applicate, il suo modulo $F$ e l'intersezione della retta a cui appartiene il vettore risultante con la retta $x$ passante per AB e la retta $y$ passante per BC.

| |
|---|
| **F** = ..........................................; $F = \|\mathbf{F}\|$ = ...................................; |
| $x_{AB}$ = ...........................................; $y_{BC}$ = ...................................; |

**Esercizio n.2** (6 punti)

Le 4 forze rappresentate in figura hanno linee di azione verticale ed agiscono su una griglia orizzontale di passo unitario.

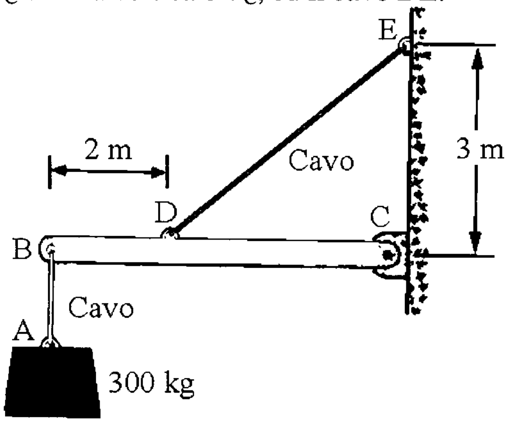



Per tale sistema di forze trovare la singola forza **R** equipollente, il suo punto di applicazione ($x_R$,$y_R$) sulla griglia, il vettore $\mathbf{M}_O$ momento risultante del sistema di forze rispetto all'origine O del sistema di riferimento Oxyz ed il vettore $\mathbf{M}_A$ momento risultante della forza **R** rispetto al punto A = (4,2,2)

| |
|---|
| **R** = ............................................; ($x_R$,$y_R$) = ...................................; |
| $\mathbf{M}_O$ = ..........................................; $\mathbf{M}_A$ = ..................................; |

**Esercizio n.3** (6 punti)

Un blocco di massa pari a 300 kg è sorretto tramite il cavo verticale AB dalla barra orizzontale BC lunga 6m e di peso trascurabile.
La barra BC è collegata alla parete tramite la cerniera in C, che garantisce una reazione orizzontale $H_C$ ed una verticale $V_C$, ed il cavo DE.

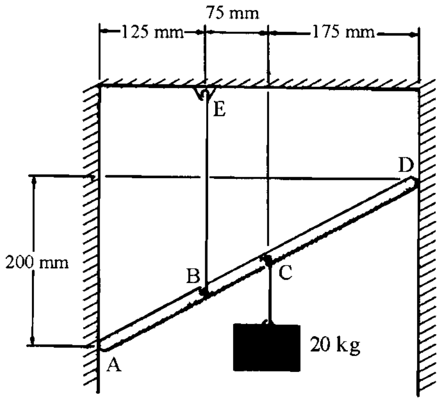



Si chiede di calcolare la tensione del cavo $T_{DE}$ e le reazioni $H_{C,1}$ e $V_{C,1}$.
Si chiede inoltre di calcolare la tensione del cavo $T_{BE}$ e le reazioni $H_{C,2}$ e $V_{C,2}$ nel caso che il cavo diagonale fosse vincolato in E ed in B.

| |
|---|
| $T_{DE}$ = .......................; $H_{C,1}$ = .......................; $V_{C,1}$ = .......................; |
| $T_{BE}$ = .......................; $H_{C,2}$ = .......................; $V_{C,2}$ = .......................; |

**Esercizio n.4** (6 punti)

La barra leggera AD è sospesa per mezzo del cavo BE e sostiene, nel punto C, un blocco di massa $m$ = 20 kg. Le estremità A e D della barra sono in contatto con le pareti verticali in assenza attrito.

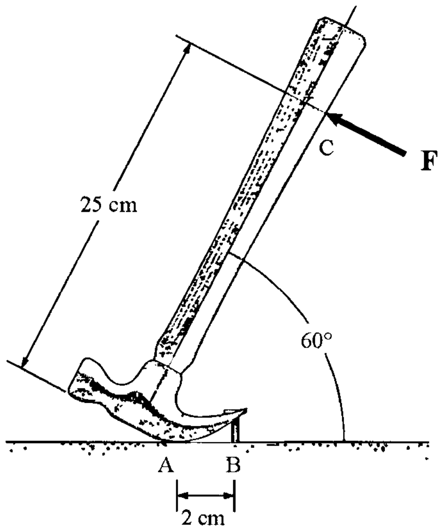



Determinare la tensione $T_{BE}$ nel cavo BE e le reazioni (orizzontali) $H_A$ e $H_D$ all'estremità della barra.

| |
|---|
| $T_{DE}$ = ......................; $H_{C,1}$ = ......................; $V_{C,1}$ = ......................; |

**Esercizio n.5** (6 punti)

Si assuma che la forza esercitata dal martello sulla testa del chiodo sia verticale e che il peso del martello risulti trascurabile.
La forza **F** esercitata sul martello nel punto C ha modulo $F$ = 20 N ed è diretta ortogonalmente al manico del martello stesso.

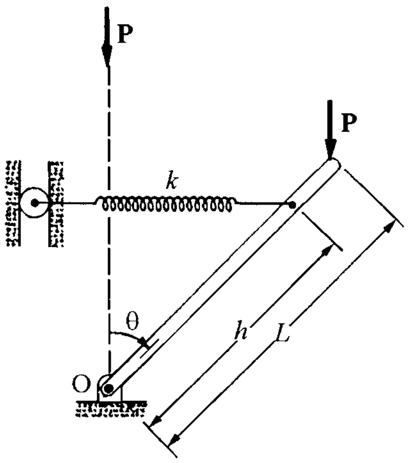



Calcolare la forza $R$ esercitata dal martello sulla testa del chiodo e le reazioni orizzontale, $H_A$, e verticale, $V_A$, nel punto A.

| |
|---|
| $R$ = ........................; $H_A$ = ........................; $V_A$ = ........................; |

**Esercizio n.6** (bonus, 3 punti)

Una barra leggera rigida è fissata al terreno nel punto O tramite una cerniera che fornisce una reazione orizzontale $H_O$ ed una verticale $V_O$.
La molla di costante elastica $k$ è vincolata a rimanere orizzontale ed è nella posizione di riposo quando $\theta = 0$.




Se $P\,L < k\,h^2$ esiste una configurazione di equilibrio per $0 < \theta < \pi/2$.
Trovare l'angolo $\theta \neq 0$ tale per cui viene garantito l'equilibrio e la forza $F_{el}$ nella molla in tale configurazione.
Per $\theta = 0$ è possibile garantire l'equilibrio?

| | | |
|---|---|---|
| $\theta$ = ..........................................; $F_{el}$ = ...................................; | | |
| Equilibrio ($\theta = 0$) | SI | NO |

| | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| TOT | |

# II ESERCITAZIONE SCRITTA DEL 03.06.04

(1)

$\vec{F_1} = +8\vec{i}$ N

$\vec{F_2} = +2\vec{i}$ N

$\vec{F_3} = +13\vec{i}$ N

$\vec{F_4} = 25\cdot\frac{3}{5}\vec{i} - 25\cdot\frac{4}{5}\vec{j} = 15\vec{i} - 20\vec{j}$ N

$\vec{F_5} = -169\cdot\frac{12}{13}\vec{i} - 169\cdot\frac{5}{13}\vec{j} = -156\vec{i} - 65\vec{j}$ N

$P_1 \equiv (0,6)$ m

$P_2 \equiv (0,12)$ m

$P_3 \equiv (0,18)$ m

$P_4 \equiv (-6,12)$ m

$P_5 \equiv (-8,6)$ m

$B \equiv (0,0)$ m

$\vec{R} = \vec{F_1} + \vec{F_2} + \vec{F_3} + \vec{F_4} + \vec{F_5}$

$\vec{R} = (8+2+13+15-156)\vec{i} + (-20-65)\vec{j}$ N

$\vec{R} = -118\vec{i} - 85\vec{j}$ N $\qquad |\vec{R}| = \sqrt{118^2+85^2}$ N $= \sqrt{21149}$

$|\vec{R}| = 145.427$ N

$\vec{M}_{(B)} = (P_1-B)\wedge\vec{F_1} + (P_2-B)\wedge\vec{F_2} + (P_3-B)\wedge\vec{F_3} + (P_4-B)\wedge\vec{F_4} + (P_5-B)\wedge\vec{F_5}$

$\vec{M}_{(B)} = 6\vec{j}\wedge 8\vec{i} + 12\vec{j}\wedge 2\vec{i} + 18\vec{j}\wedge 13\vec{i} + (-6\vec{i}+12\vec{j})\wedge(15\vec{i}-20\vec{j}) +$
$(-8\vec{i}+6\vec{j})\wedge(-156\vec{i}-65\vec{j})$ N.m

$\vec{M}_{(B)} = 48(\vec{j}\wedge\vec{i}) + 24(\vec{j}\wedge\vec{i}) + 234(\vec{j}\wedge\vec{i}) + 120(\vec{i}\wedge\vec{j}) + 180(\vec{j}\wedge\vec{i}) +$
$520(\vec{i}\wedge\vec{j}) - 936(\vec{j}\wedge\vec{i})$ N.m

$\vec{M}_{(B)} = (48+24+234+180-936)(\vec{j}\wedge\vec{i}) + (120+520)\,\vec{i}\wedge\vec{j}$ N.m

Ora, $\vec{j}\wedge\vec{i} = -\vec{k}$ ; $\vec{i}\wedge\vec{j} = +\vec{k}$

$\vec{M}_{(B)} = -450(\vec{j}\wedge\vec{i}) + 640(\vec{i}\wedge\vec{j})$ Nm $= (450+640)(\vec{i}\wedge\vec{j})$ N.m $= 1090\vec{k}$ N.m

$\vec{M}_{(B)} = (P_{AB}-B)\wedge\vec{R}$

dove $P_{AB} \equiv (x_{AB}, 0)$

sicché

$\vec{M}_{(B)} = x_{AB}\,\vec{i}\wedge(-118\vec{i} - 85\vec{j})$ N.m

$\vec{M}_{(B)} = -85\,x_{AB}(\vec{i}\wedge\vec{j})$ N.m $= -85\,x_{AB}\,\vec{k}$ N.m

$\Rightarrow 1090\,\vec{k} = -85\,x_{AB}\,\vec{k} \qquad x_{AB} = -\frac{1090}{85} = -12.824$ m

$$\vec{M}_{(B)} = (\overrightarrow{P_{BC} - B}) \wedge \vec{R}$$

dove $P_{BC} \equiv (0, y_{BC})$

sicché

$$\vec{M}_{(B)} = y_{BC}\, \vec{j} \wedge (-118\vec{i} - 85\vec{j}) \ N \cdot m$$

$$\vec{M}_{(B)} = -118 y_{BC} (\vec{j} \wedge \vec{i}) \ N \cdot m = -118\, y_{BC} (-\vec{k}) \ N \cdot m = 118 y_{BC}\, \vec{k} \ N \cdot m$$

$$\Rightarrow 118\, y_{BC}\, \vec{k} = 1090\, \vec{k} \qquad y_{BC} = \frac{1090}{118} = +9.237 \ m.$$

(2)

$\vec{F}_1 = 10\vec{k} \ N$ $\qquad P_1 \equiv (1, -3, 0) \ m$

$\vec{F}_2 = -16\vec{k} \ N$ $\qquad P_2 \equiv (2, -1, 0) \ m$

$\vec{F}_3 = +8\vec{k} \ N$ $\qquad P_3 \equiv (2, 2, 0) \ m$

$\vec{F}_4 = -4\vec{k} \ N$ $\qquad P_4 \equiv (0, 1, 0) \ m$

$$\vec{M}_{(O)} = (\overrightarrow{P_1 - O}) \wedge \vec{F}_1 + (\overrightarrow{P_2 - O}) \wedge \vec{F}_2 + (\overrightarrow{P_3 - O}) \wedge \vec{F}_3 + (\overrightarrow{P_4 - O}) \wedge \vec{F}_4$$

$$\vec{M}_{(O)} = (\vec{i} - 3\vec{j}) \wedge 10\vec{k} + (2\vec{i} - \vec{j}) \wedge (-16\vec{k}) + (2\vec{i} + 2\vec{j}) \wedge 8\vec{k} + \vec{j} \wedge (-4\vec{k}) \ N \cdot m$$

$$\vec{M}_{(O)} = 10(\vec{i} \wedge \vec{k}) - 30(\vec{j} \wedge \vec{k}) - 32(\vec{i} \wedge \vec{k}) + 16(\vec{j} \wedge \vec{k}) + 16(\vec{i} \wedge \vec{k}) + 16(\vec{j} \wedge \vec{k}) - 4(\vec{j} \wedge \vec{k}) \ N \cdot m$$

$$\vec{M}_{(O)} = (10 - 32 + 16)(\vec{i} \wedge \vec{k}) + (-30 + 16 + 16 - 4)(\vec{j} \wedge \vec{k}) \ N \cdot m$$

e poiché $\vec{i} \wedge \vec{k} = -\vec{j}$; $\vec{j} \wedge \vec{k} = \vec{i}$

$$\vec{M}_{(O)} = (-6)(-\vec{j}) + (-2)\vec{i} = -2\vec{i} + 6\vec{j} \ N \cdot m$$

$$\vec{R} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \vec{F}_4$$

$$\vec{R} = (10 - 16 + 8 - 4)\vec{k} \ N = (18 - 20)\vec{k} \ N = -2\vec{k} \ N$$

$$\vec{M}_{(O)} = (\overrightarrow{P_R - O}) \wedge \vec{R} \qquad \text{dove} \quad P_R \equiv (x_R, y_R, 0)$$

$$\vec{M}_{(O)} = (x_R\vec{i} + y_R\vec{j}) \wedge (-2\vec{k}) \ N \cdot m = -2x_R(\vec{i} \wedge \vec{k}) - 2y_R(\vec{j} \wedge \vec{k}) \ N \cdot m$$

$$\vec{M}_{(O)} = -2x_R(-\vec{j}) - 2y_R\vec{i} \ N \cdot m$$

$$\Rightarrow -2\vec{i} + 6\vec{j} = -2y_R\vec{i} + 2x_R\vec{j} \qquad \begin{cases} -2 = -2y_R & \Rightarrow y_R = 1 \ m \\ 6 = 2x_R & \Rightarrow x_R = 3 \ m \end{cases}$$

$$P_R \equiv (3, 1, 0) \ m$$

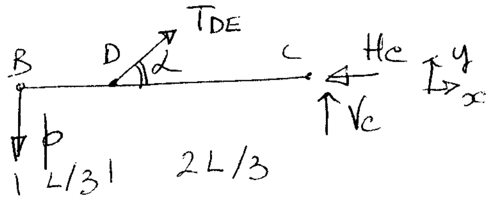
$$\vec{M}_{(A)} = (\overrightarrow{P_R - A}) \wedge \vec{R} \qquad A \equiv (4,2,2)\ m$$

$$\vec{M}_{(A)} = (-\vec{i} - \vec{j} - 2\vec{k}) \wedge (-2\vec{k}) \quad N.m$$

$$\vec{M}_{(A)} = 2(\vec{i} \wedge \vec{k}) + 2(\vec{j} \wedge \vec{k}) \quad N.m$$

$$\vec{M}_{(A)} = 2\vec{i} - 2\vec{j} \quad N.m$$

(3) 1. Diagramma di corpo libero:




$p = 300\ kp \cdot 9{,}81\ m/s^2 = 2943\ N$

$\cos\alpha = \frac{4}{5}; \qquad \sin\alpha = \frac{3}{5}$

$\rightarrow R_x = 0 \quad +T_{DE} \cos\alpha - H_c = 0$

$\uparrow R_y = 0 \quad -p + T_{DE} \sin\alpha + V_c = 0$

$\circlearrowleft M_{z(c)} = 0 \quad pL - T_{DE} \sin\alpha \cdot \frac{2}{3} L = 0$

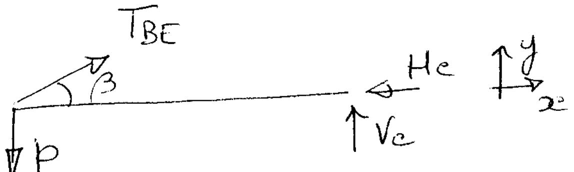
Risolvendo si ottiene:

$$T_{DE} = \frac{3p}{2\sin\alpha} = \frac{3}{2} \cdot \frac{5}{3} p = \frac{5}{2} p = 7357{,}5\ N$$

$$H_c = T_{DE} \cdot \cos\alpha = \frac{5}{2} p \cdot \frac{4}{5} = 2p = 5886{,}0\ N$$

$$V_c = p - T_{DE} \cdot \sin\alpha = p - \frac{5}{2} p \cdot \frac{3}{5} = -\frac{p}{2} = -1471{,}5\ N$$

2 Diagramma di corpo libero




$\cos\beta = \frac{6}{\sqrt{45}} = \frac{2\sqrt{5}}{5}$

$\sin\beta = \frac{3}{\sqrt{45}} = \frac{\sqrt{5}}{5}$

$\rightarrow R_x = 0 \quad T_{BE} \cdot \cos\beta - H_c = 0$

$\uparrow R_y = 0 \quad -p + T_{BE} \sin\beta + V_c = 0$

$\circlearrowleft M_{z(c)} = 0 \quad pL - T_{BE} \sin\beta L = 0$

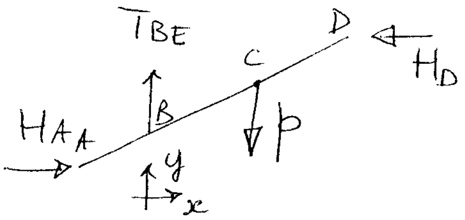
La soluzione è, in questo caso:

$$T_{BE} = \frac{pL}{L\sin\beta} = \frac{5p}{\sqrt{5}} = \sqrt{5}p = 6580{,}748\ N$$

$$H_C = T_{BE} \cdot \cos\beta = \sqrt{5}p \cdot 2\frac{\sqrt{5}}{5} = 2p = 5886.0\ N$$

$$V_C = p - T_{BE} \cdot \sin\beta = p - \sqrt{5}\,p \cdot \frac{\sqrt{5}}{5} = p - p = 0\ N.$$

(4) Diagramma di corpo libero:




$p = 20\ kg \cdot 9.81\ m/s^2 = 196.20 N$

$\rightarrow R_x = 0 \qquad H_A - H_D = 0$

$\uparrow R_y = 0 \qquad T_{BE} - p = 0$

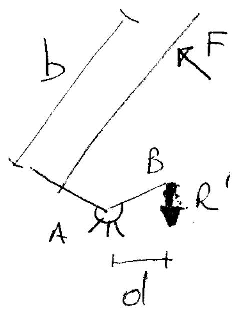
$\circlearrowleft M_{z(A)} = 0 \qquad T_{BE} \cdot 125 - p \cdot 200 + H_D \cdot 200 = 0$

Si ottiene: $T_{BE} = p = 196.20 N$

$H_D = p - T_{BE} \cdot \frac{125}{200} = p\left(1 - \frac{5}{8}\right) = \frac{3}{8}p = 73.575\ N$

$H_A = H_D = 73.575\ N$

(5) Schema statico:



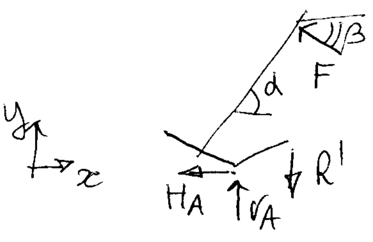

$M_{z(A)} = 0 \quad Fb - R'd = 0$

$R' = F\frac{b}{d} = 20 \cdot \frac{25}{2}\ N \cdot cm$

$R' = 250 N$

NB: R' è la azione che il chiodo esercita sul martello, eguale e opposta a quella che il martello esercita sul chiodo.

Diagramma di corpo libero:




$\beta = \frac{\pi}{2} - \alpha = 30°$

$\rightarrow R_x = 0 \quad -F\cos\beta - H_A = 0$

$\uparrow R_y = 0 \quad V_A - R' + F\sin\beta = 0$

$$H_A = -F\cos 30^\circ = -\frac{\sqrt{3}}{2}F = 17{,}321\ N$$
$$V_A = R' - F\sin 30^\circ = 250 - 10\ N = 240\ N$$

(6)

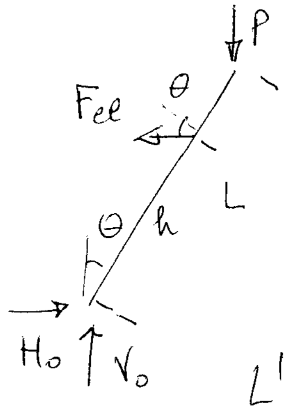



Diagramma di corpo libero

$\rightarrow R_x = 0 \qquad H_0 - F_{el} = 0$

$\uparrow R_y = 0 \qquad V_0 - P = 0$

$\circlearrowleft M_{z(0)} = 0 \qquad F_{el}\cdot\cos\theta\cdot h - P\sin\theta\cdot L = 0$ [•]

L'ultima è eq. puro; le prime 2 determinano le reazioni vincolari $H_0$, $V_0$.

Si ha che $F_{el} = k\cdot\Delta x \qquad \Delta x = h\sin\theta$

$\Rightarrow F_{el} = k\,h\sin\theta$

e per avere equilibrio, in base alla [•] deve risultare:

$$k h^2 \sin\theta\cos\theta - PL\sin\theta = 0$$

Le soluzioni sono esprimibili come:

$$(k h^2\cos\theta - PL)\sin\theta = 0 \quad < \quad \begin{array}{l} \sin\theta = 0 \rightarrow \theta = 0 \text{ o } \theta = \pi \\ \cos\theta = \frac{PL}{kh^2} \rightarrow \theta = \arccos\frac{PL}{kh^2} \end{array}$$

si noti che l'ultima soluzione esiste solo a condizione che

$$\cos\theta = \frac{PL}{kh^2} < 1 \Rightarrow PL < kh^2$$

La prima soluzione esiste qualunque sia P: in questo caso infatti $F_{el} = 0$ e la forza P è allineata con la cerniera o, sicché $M_{z(0)} = 0 \ \forall P$.

*Politecnico di Milano - Corso di Laurea in Architettura (N.O.)*

Campus Mantova

**CORSO DI T. E P. DI COSTRUZIONI E STRUTTURE**

A.A. 2003-04

II Prova in Itinere – 08.07.2004

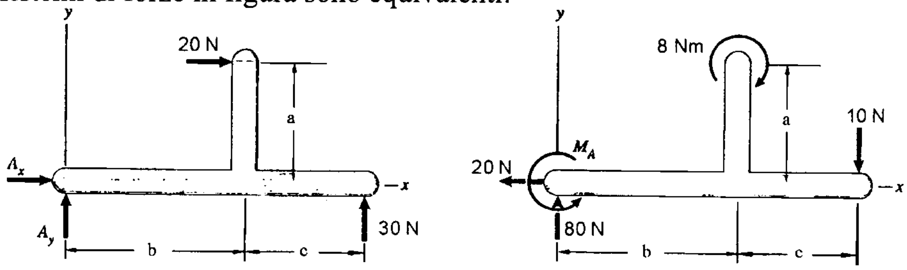
*Nota: I risultati numerici (in forma frazionaria o con 3 cifre decimali) vanno riportati su questo stesso foglio, nei riquadri predisposti.*

| Allievo:...................................................... Matricola:....... |
|---|

FILA 1

**Esercizio n.1** (6 punti)

I due sistemi di forze in figura sono equivalenti:

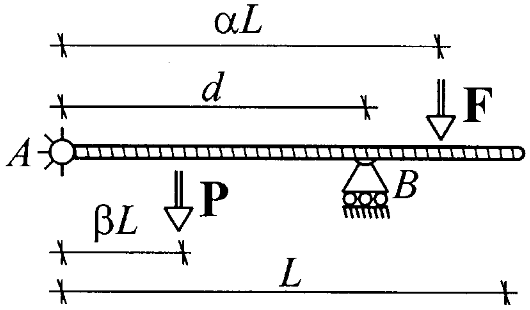



Siano $b$ = 600 mm, $a = c$ = 400 mm.
Determinare le forze $A_x$, $A_y$ e la coppia $M_A$.

| $A_x$ = ........................; $A_y$ = ........................; $M_A$ = ........................ . |
|---|

**Esercizio n.2** (6 punti)

Si consideri l'asta caricata in figura:



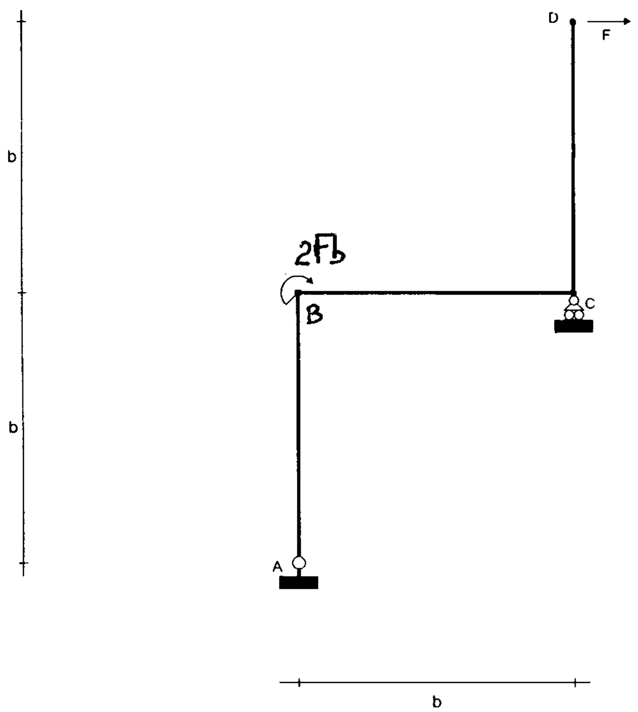

Siano $L$ = 8 m, $\alpha$ = 0,8 e $\beta$ = 0,1. Le due forze valgono $F$ = 10N, $P$ = 40N.
Determinare il valore della distanza $d$ tale per cui la reazione verticale $V_B$ valga 1,2 $P$ e la reazione verticale $V_A$ per tale valore di $d$.

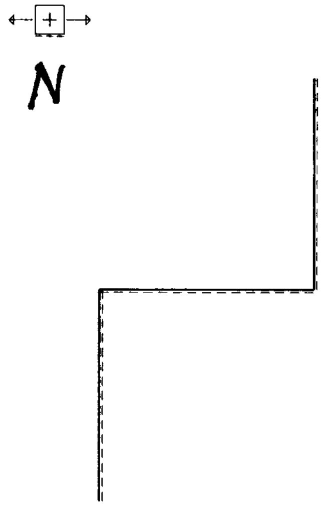
| $d$ = ......................................................; $V_A$ = ......................................................; |
|---|

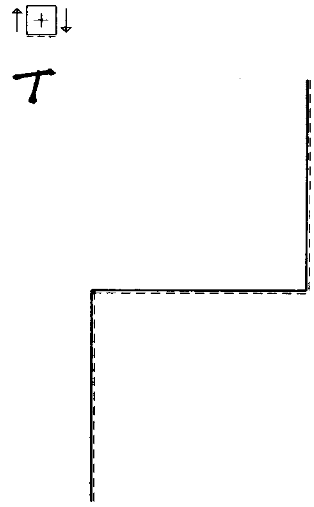
1/1

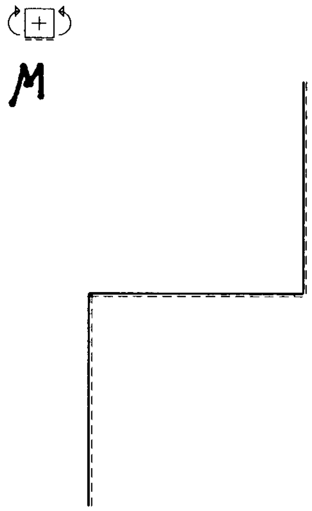
**Esercizio n.3** (9 punti)

Per la struttura in figura, riportare le reazioni vincolari ed i diagrammi delle azioni interne M, N, T.




| $V_A$ = ........................; $H_A$ = ........................; $V_C$ = ........................ . |
|---|

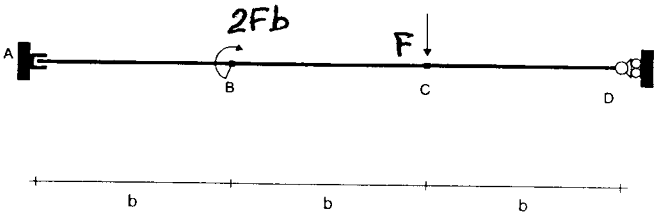
$N_{AB}$ =　　　　$T_{AB}$ =　　　　$M_{AB}$ =

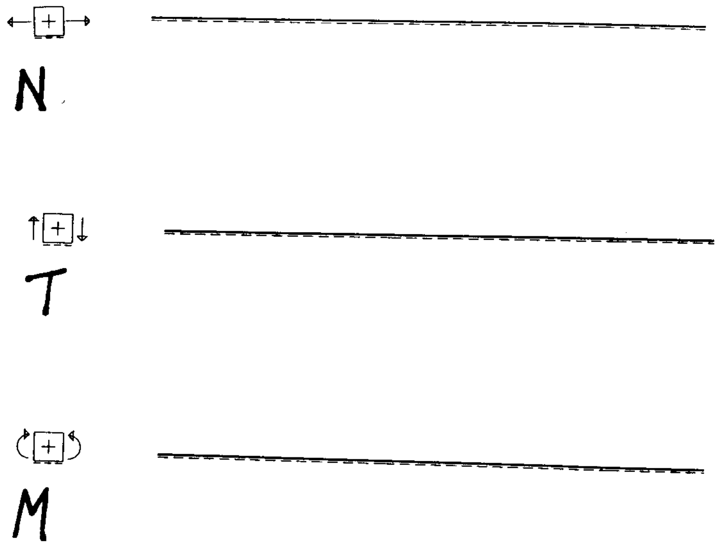
$N_{BC}$ =　　　　$T_{BC}$ =　　　　$M_{BC}$ =

$N_{CD}$ =　　　　$T_{CD}$ =　　　　$M_{CD}$ =

**Esercizio n.4** (9 punti)

Per la struttura in figura, riportare le reazioni vincolari ed i diagrammi delle azioni interne M, N, T.




$N_{AB}$ = $N_{BC}$ = $N_{CD}$ =

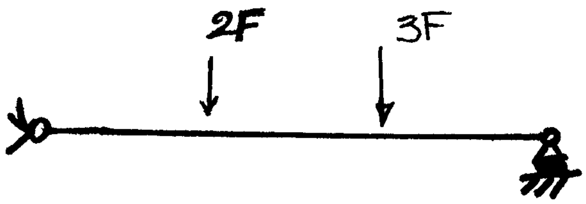
$T_{AB}$ = $T_{BC}$ = $T_{CD}$ =

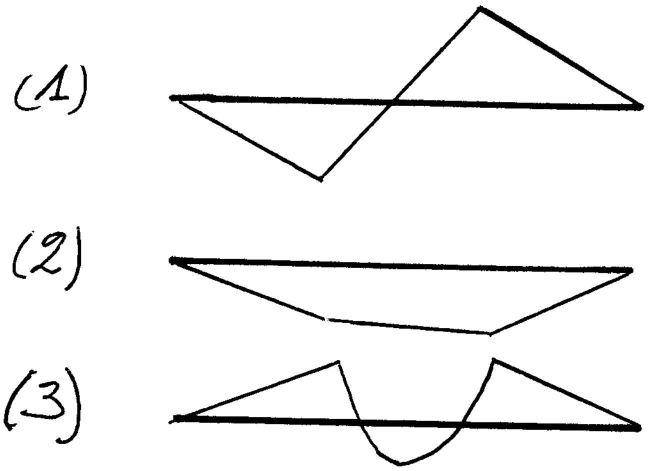
$M_{AB}$ = $M_{BC}$ = $M_{CD}$ =

| $V_A$ = ......................; $M_A$ = ......................; $H_D$ = ...................... . |
|---|

**Esercizio n.5** (3 punti)

Si consideri la struttura data in figura e si indichi qual'è l'esatta distribuzione del momento flettente.

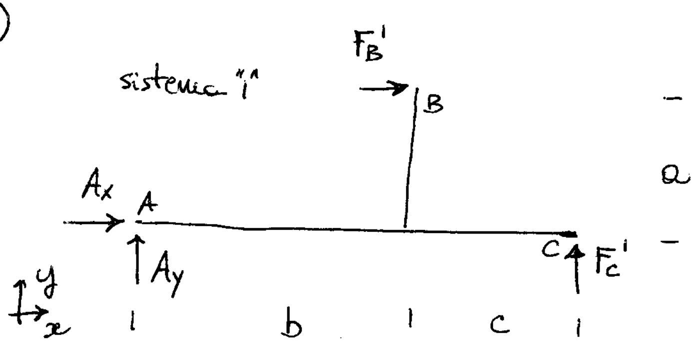


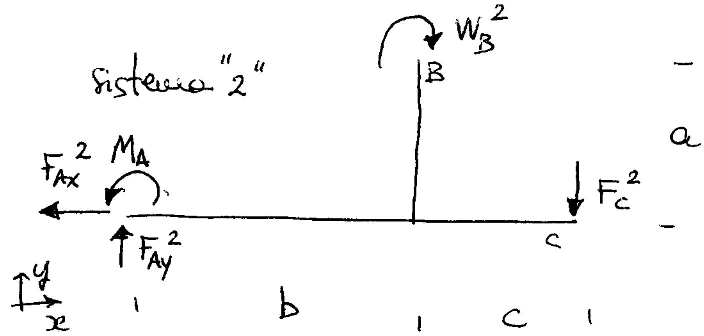




| (1) | (2) | (3) |
|---|---|---|

II SCRITTO IN AULA DEL 08.07.04

(1)




Per equivalenza statica

$$\vec{R}^1 = \vec{R}^2 \qquad [\circ] \qquad \vec{R}^1 = R_x^1 \vec{i} + R_y^1 \vec{j} + R_z^1 \vec{k} \; ; \; \vec{R}^2 = R_x^2 \vec{i} + R_y^2 \vec{j} + R_z^2 \vec{k}$$

$$\vec{M}^1_{(\cdot)} = \vec{M}^2_{(\cdot)} \qquad [\circ\circ] \qquad \vec{M}^1_{(\cdot)} = M^1_{x(\cdot)} \vec{i} + M^1_{y(\cdot)} \vec{j} + M^1_{z(\cdot)} \vec{k} \; ; \; \vec{M}^2_{(\cdot)} = M^2_{x(\cdot)} \vec{i} + M^2_{y(\cdot)} \vec{j} + M^3_{z(\cdot)} \vec{k}$$

Dalla $[\circ]$ segue:

$$R_x^1 = R_x^2$$
$$R_y^1 = R_y^2$$
$$(R_z^1 = R_z^2) \Leftarrow$$ automaticamente soddisfatta perché il sistema di forze è piano.

Dalla $[\circ\circ]$ segue:

$$(M^1_{x(\cdot)} = M^2_{x(\cdot)})$$
$$(M^1_{y(\cdot)} = M^2_{y(\cdot)})$$
} automaticamente soddisfatte perché il sistema di forze è piano.

$$M^1_{z(\cdot)} = M^2_{z(\cdot)}$$

Si ha così:

$$\rightarrow R_x^1 = A_x + F_B^1 = -F_{Ax}^2 = \rightarrow R_x^2$$

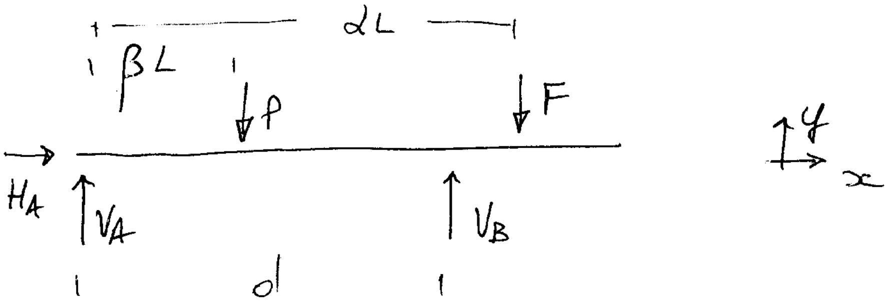
$$\uparrow R_y^1 = A_y + F_C^1 = F_{Ay}^2 - F_C^2 = \uparrow R_y^2$$

$$\circlearrowleft M^1_{z(A)} = (b+c) F_C^1 - a \cdot F_B^1 = M_A - W_B^2 - (b+c) F_C^2 = \circlearrowleft M^2_{z(A)}$$

Risolvendo rispetto alle incognite $A_x, A_y, M_A$ si trova:

$$A_x = - F_{Ax}^2 - F_B^1$$
$$A_y = + F_{Ay}^2 - F_C^1 - F_C^2$$
$$M_A = W_B^2 + (b+c)(F_C^1 + F_C^2) - a F_B^1$$

(2)




Per equilibrio

$\rightarrow R_x = 0 \qquad H_A = 0$

$\uparrow R_y = 0 \qquad V_A + V_B - P - F = 0$

$\circlearrowleft M_{z(A)} = 0 \qquad -P\beta L + V_B \cdot d - F \cdot \alpha L = 0$

Se $F = \gamma P$ si ha:

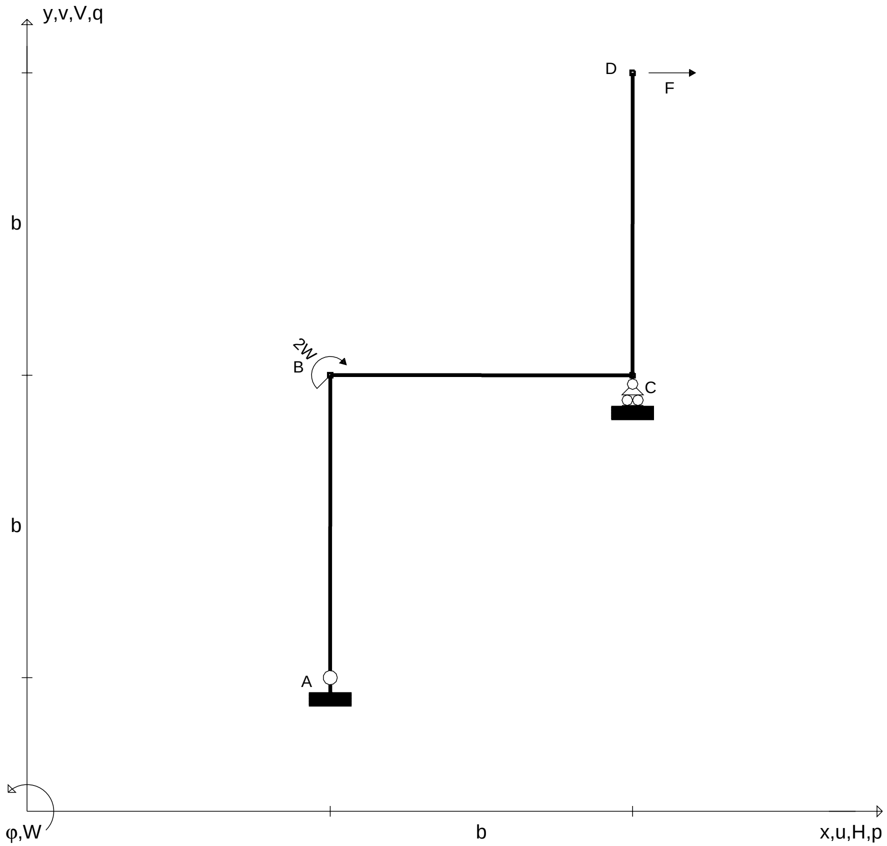
$$V_B = \frac{P\beta L + \gamma P \cdot \alpha L}{d} = P\frac{(\beta + \alpha\gamma)L}{d}$$

ma $V_B = \delta \cdot P \quad \Rightarrow \quad \delta \cdot P = \frac{(\beta + \alpha\gamma)L}{d} P \quad \Rightarrow \quad d = \frac{(\beta + \alpha\gamma)L}{\delta}$

$$V_A = P + F - V_B = P + \gamma P - \delta \cdot P = P(1 + \gamma - \delta)$$

| Esercizio 1 | | Testo 1 | Testo 2 | Testo 3 | Testo 4 | Testo 5 | Testo 6 |
|---|---|---|---|---|---|---|---|
| F_B(1) | [N] | 20 | 60 | 20 | 60 | 20 | 20 |
| F_C(1) | [N] | 30 | 20 | 80 | 20 | 80 | 30 |
| F_Ax(2) | [N] | 20 | 20 | 70 | 20 | 70 | 20 |
| F_Ay(2) | [N] | 80 | 40 | 30 | 40 | 30 | 80 |
| W_B(2) | [N·m] | 8 | 12 | 12 | 12 | 12 | 8 |
| F_C(2) | [N] | 10 | 20 | 50 | 20 | 50 | 10 |
| a | [m] | 0.4 | 0.4 | 0.2 | 0.4 | 0.1 | 0.3 |
| b | [m] | 0.6 | 0.3 | 0.8 | 0.6 | 0.7 | 0.4 |
| c | [m] | 0.4 | 0.4 | 0.2 | 0.1 | 0.4 | 0.2 |
| **A_x** | **[N]** | **-40** | **-80** | **-90** | **-80** | **-90** | **-40** |
| **A_y** | **[N]** | **40** | **0** | **-100** | **0** | **-100** | **40** |
| **M_A** | **[N·m]** | **40** | **16** | **138** | **16** | **153** | **26** |

| Esercizio 2 | | Testo 1 | Testo 2 | Testo 3 | Testo 4 | Testo 5 | Testo 6 |
|---|---|---|---|---|---|---|---|
| L | [m] | 8 | 10 | 6 | 10 | 8 | 6 |
| F | [N] | 10 | 20 | 10 | 10 | 30 | 20 |
| P | [N] | 40 | 30 | 20 | 80 | 20 | 40 |
| F/P = $\gamma$ | [-] | 0.250 | 0.667 | 0.500 | 0.125 | 1.500 | 0.500 |
| $\alpha$ | [-] | 0.8 | 0.9 | 0.9 | 0.8 | 0.8 | 0.9 |
| $\beta$ | [-] | 0.1 | 0.2 | 0.1 | 0.3 | 0.2 | 0.3 |
| V_B/P = $\delta$ | [-] | 1.2 | 1.2 | 0.6 | 1.1 | 2.7 | 1.5 |
| **d** | **[m]** | **2.000** | **6.667** | **5.500** | **3.636** | **4.148** | **3.000** |
| **V_A** | **[N]** | **2** | **14** | **18** | **2** | **-4** | **0** |
| **V_B** | **[N]** | **48** | **36** | **12** | **88** | **54** | **60** |
| **V_A + V_B - F - P** | **[N]** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** |



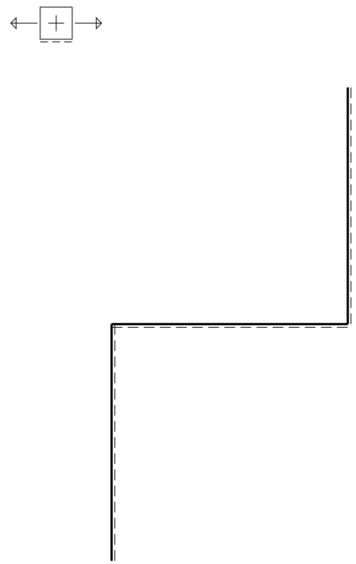

$H_D = F$ $EJ_{AB} = EJ$ $EJ_{CD} = EJ$

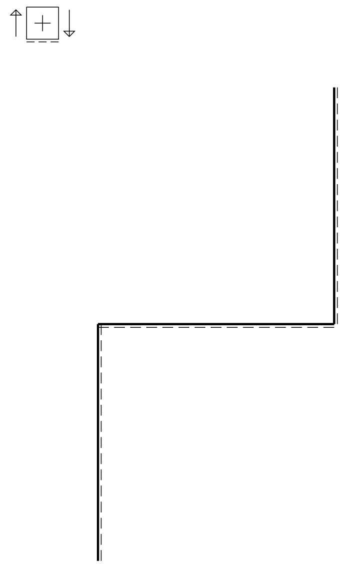
$W_B = -2W = -2Fb$ $EJ_{BC} = EJ$

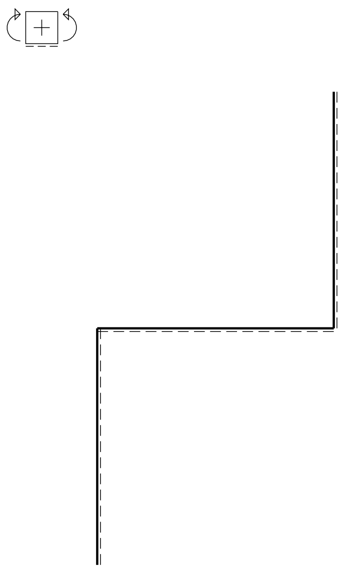
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

MANTENERE I RISULTATI IN FORMA FRAZIONARIA



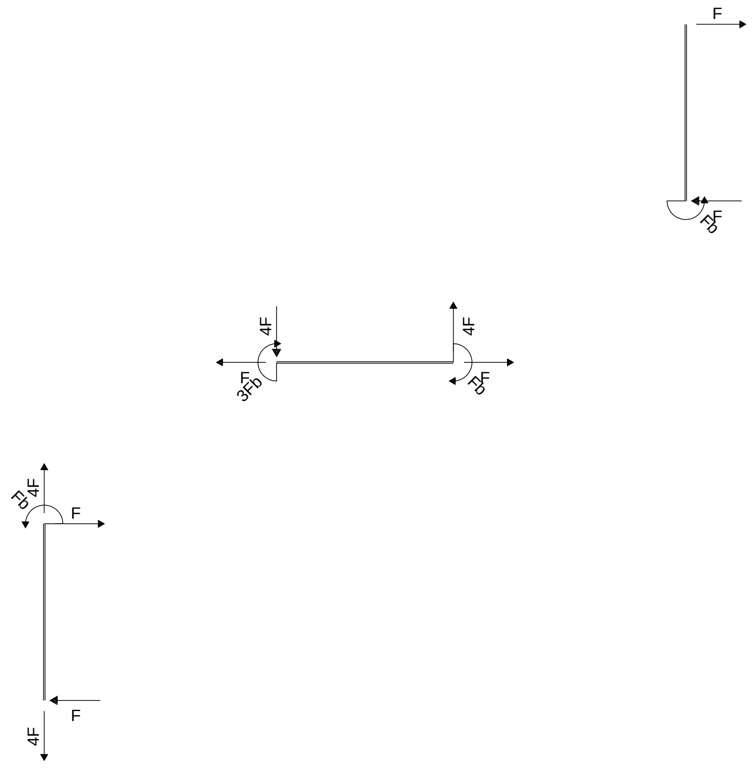






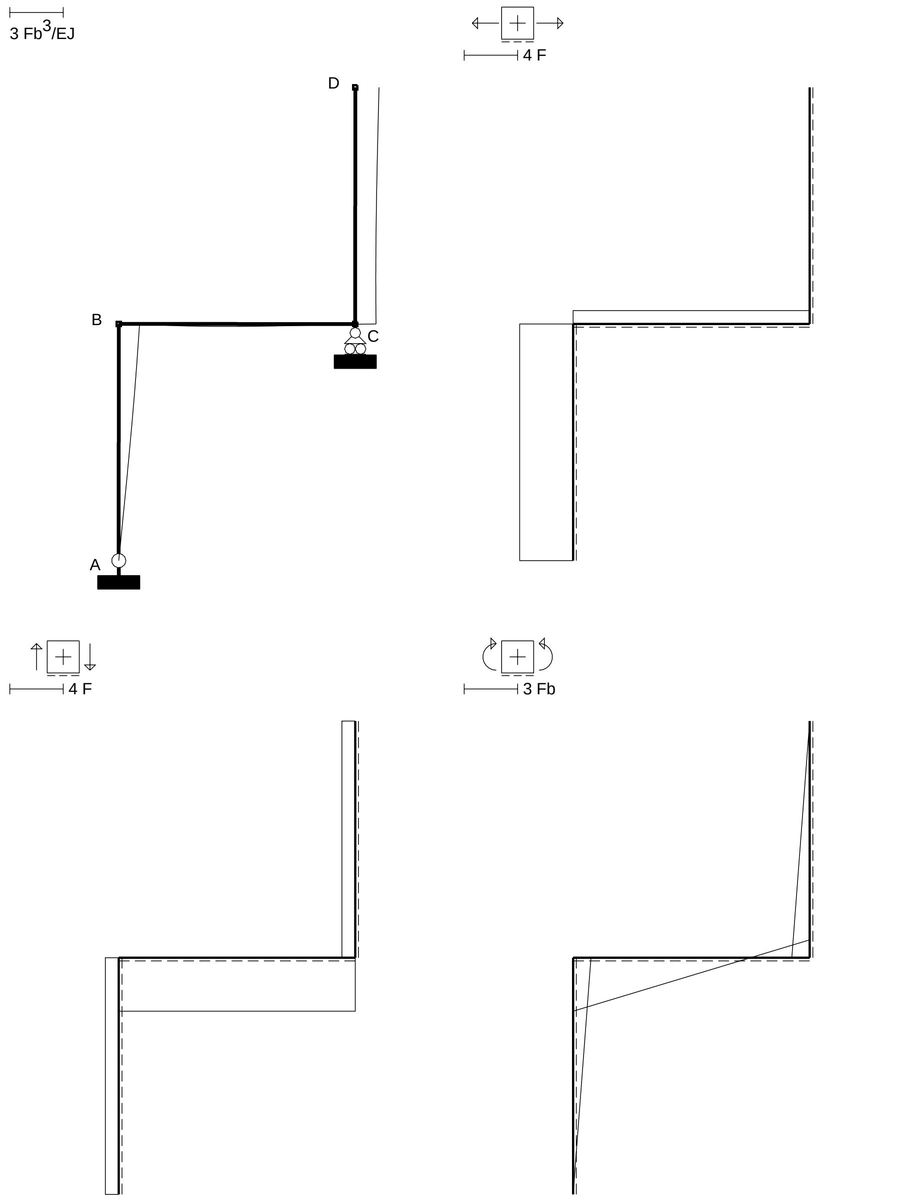
## REAZIONI VINCOLARI





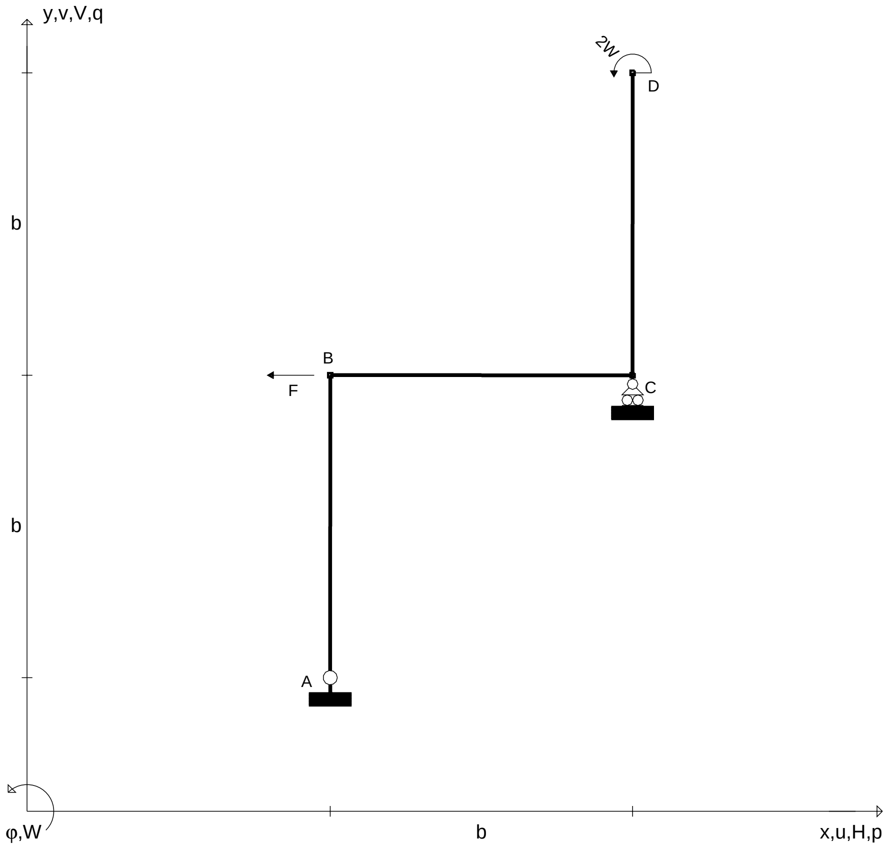

## DEFORMATA E DIAGRAMMI AZIONI INTERNE

TePCS1 08.07.04-001



AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 4F$ | $N_{BC} = F$ | $N_{CD} = 0$ |
| $T_{AB} = F$ | $T_{BC} = -4F$ | $T_{CD} = F$ |
| $M_{AB} = Fx$ | $M_{BC} = 3Fb - 4Fx$ | $M_{CD} = -Fb + Fx$ |



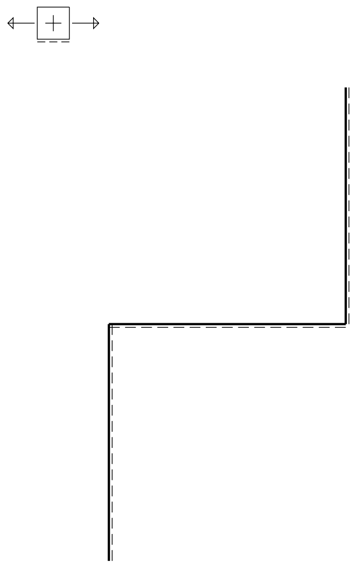

$H_B = -F$ $EJ_{AB} = EJ$ $EJ_{CD} = EJ$

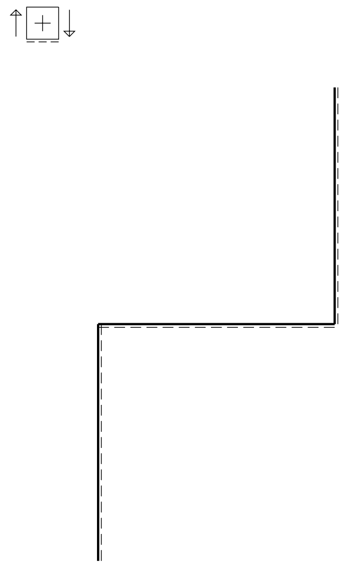
$W_D = 2W = 2Fb$ $EJ_{BC} = EJ$

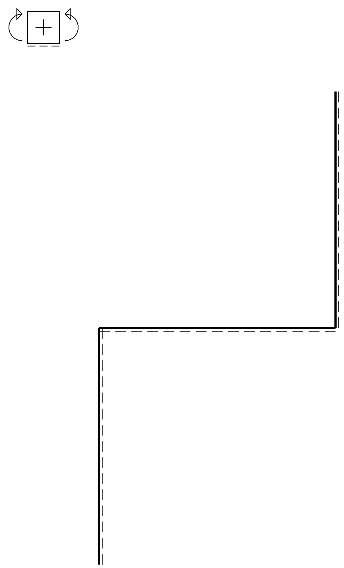
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

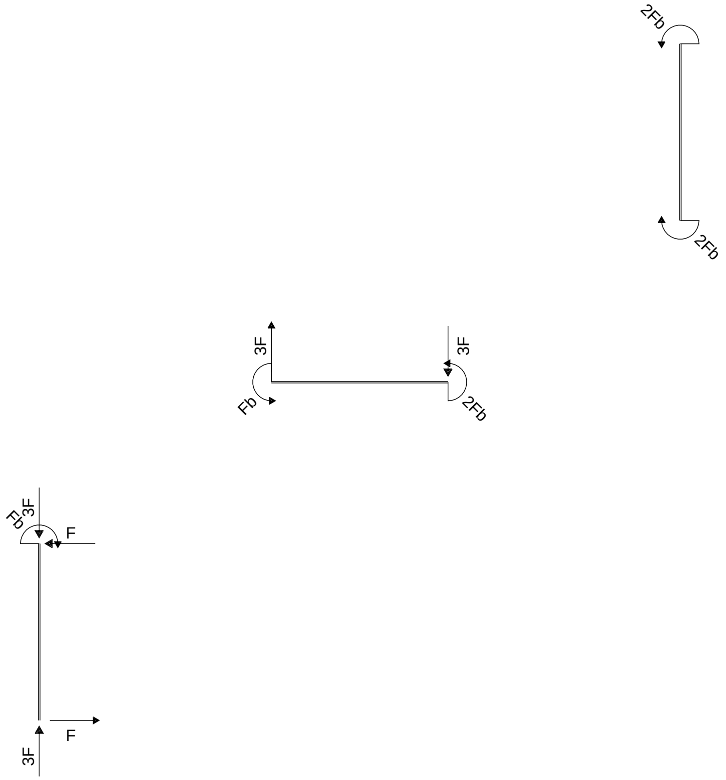
MANTENERE I RISULTATI IN FORMA FRAZIONARIA



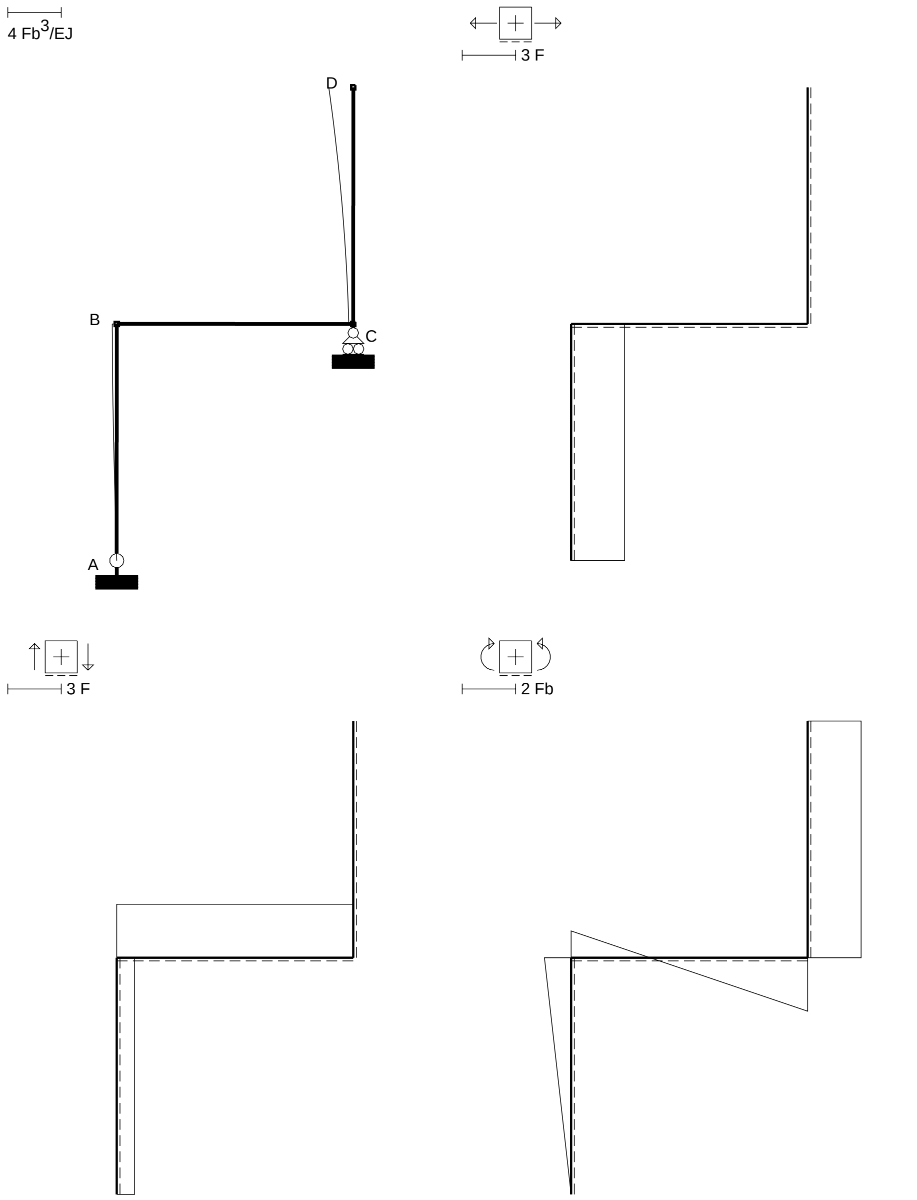






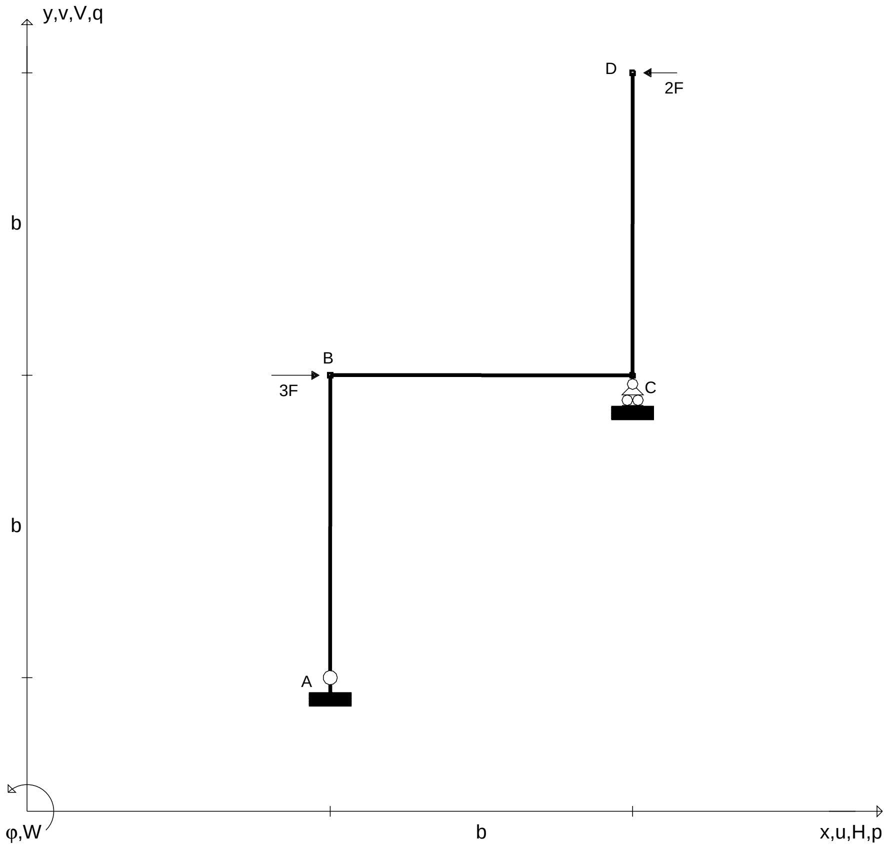

2Fb
2Fb
3F
3F
Fb
2Fb
Fb
3F
F
F
3F




4 Fb3/EJ
3 F
D
B
C
A
3 F
2 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = -3F$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = -F$ | $T_{BC} = 3F$ | $T_{CD} = 0$ |
| $M_{AB} = -Fx$ | $M_{BC} = -Fb + 3Fx$ | $M_{CD} = 2Fb$ |

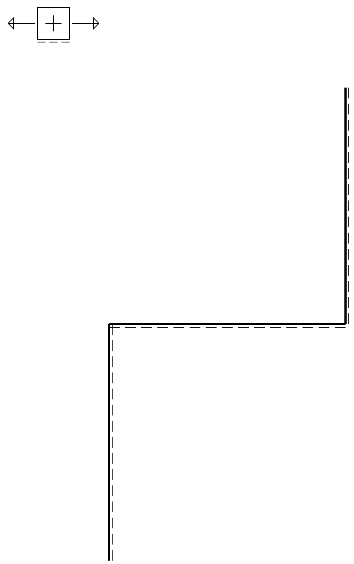


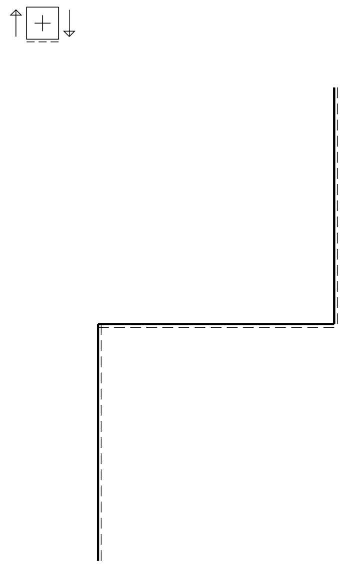

$H_B = 3F$    $H_D = -2F$    $EJ_{AB} = EJ$    $EJ_{BC} = EJ$    $EJ_{CD} = EJ$

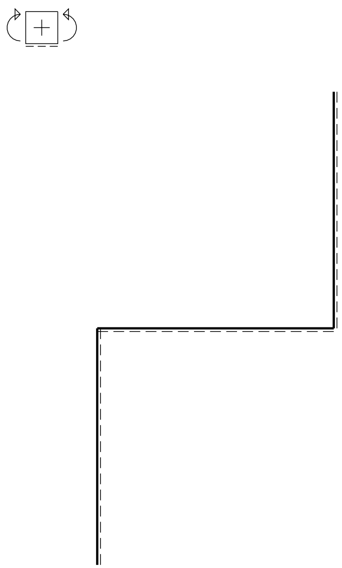
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

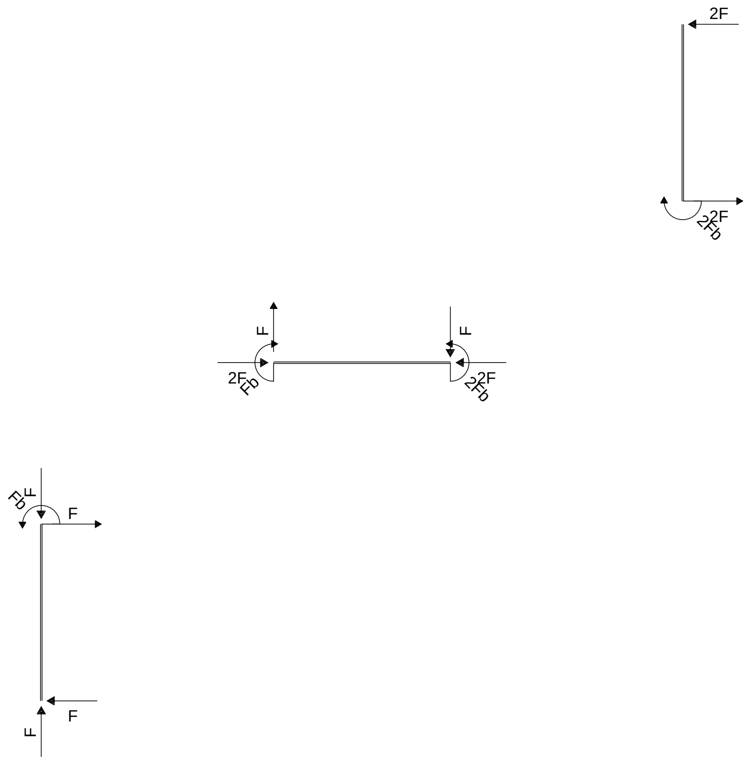
MANTENERE I RISULTATI IN FORMA FRAZIONARIA



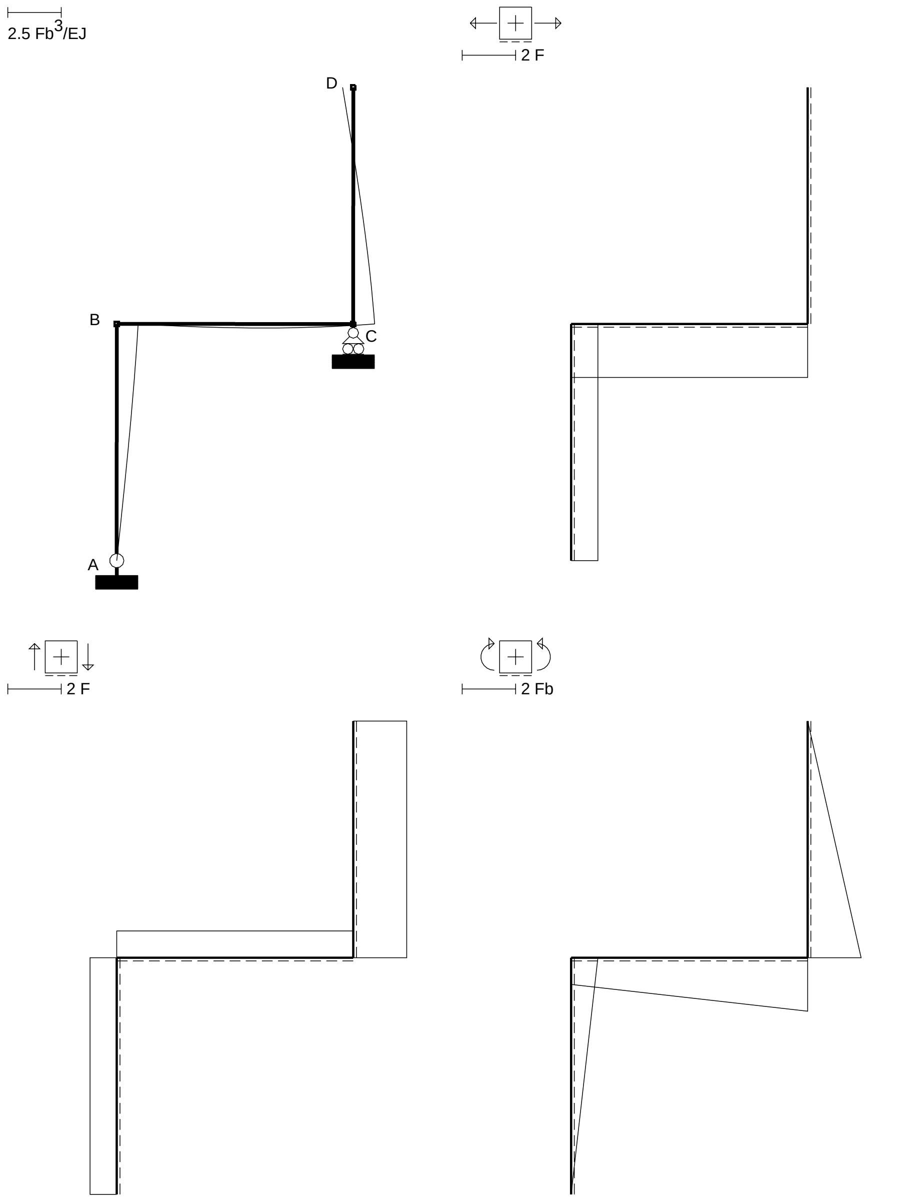






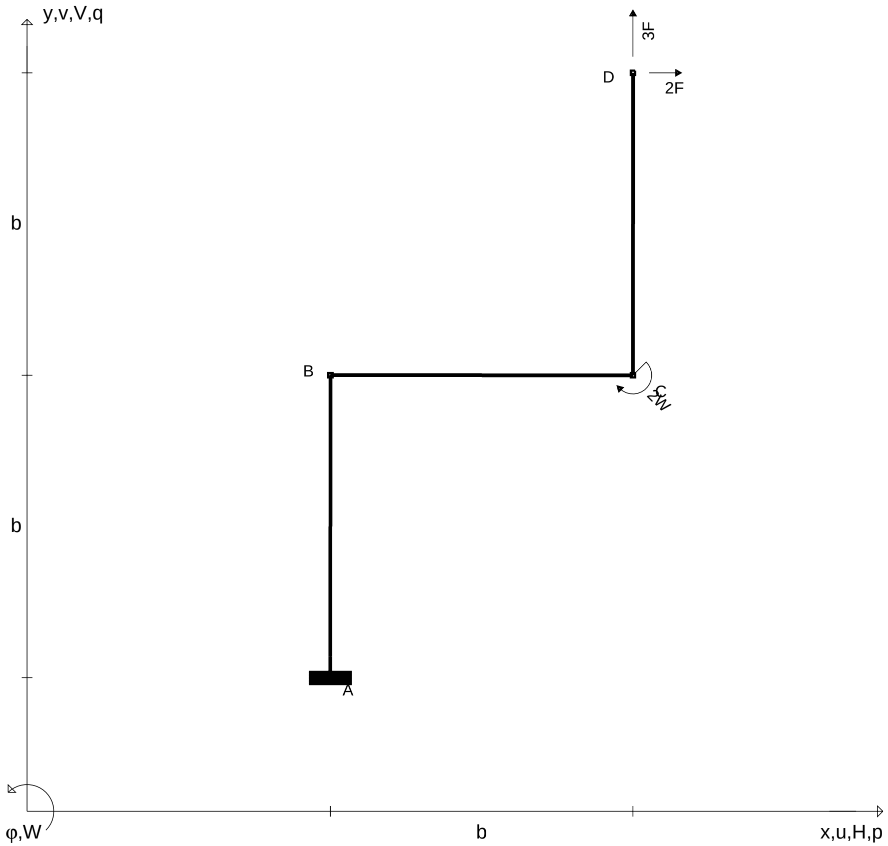

2F
2F
2Fb
F
F
2F
Fb
2F
2Fb
F
Fb
F
F
F




2.5 Fb$^3$/EJ
2 F
D
B
C
A
2 F
2 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = -F$ | $N_{BC} = -2F$ | $N_{CD} = 0$ |
| $T_{AB} = F$ | $T_{BC} = F$ | $T_{CD} = -2F$ |
| $M_{AB} = Fx$ | $M_{BC} = Fb + Fx$ | $M_{CD} = 2Fb - 2Fx$ |

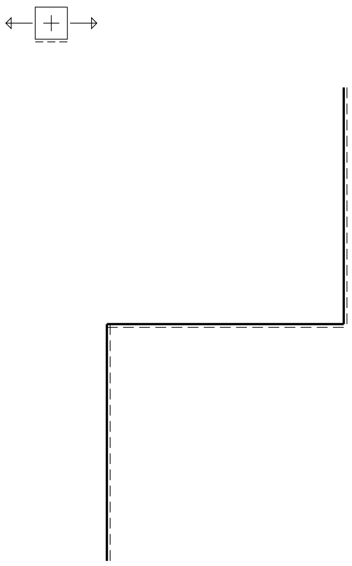


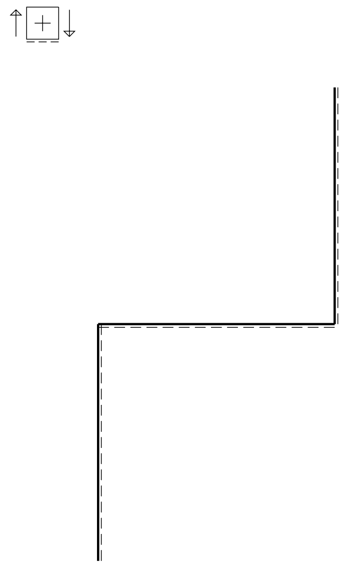

$V_D = 3F$ $W_C = -2W = -2Fb$ $EJ_{BC} = EJ$
$H_D = 2F$ $EJ_{AB} = EJ$ $EJ_{CD} = EJ$

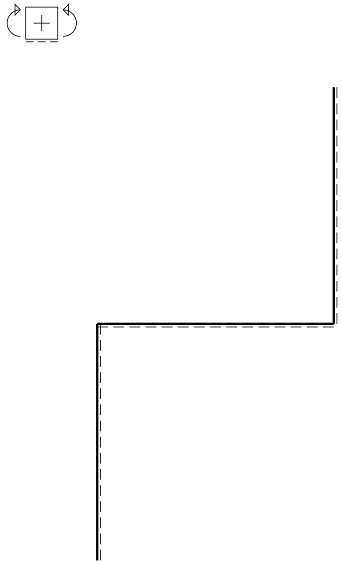
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

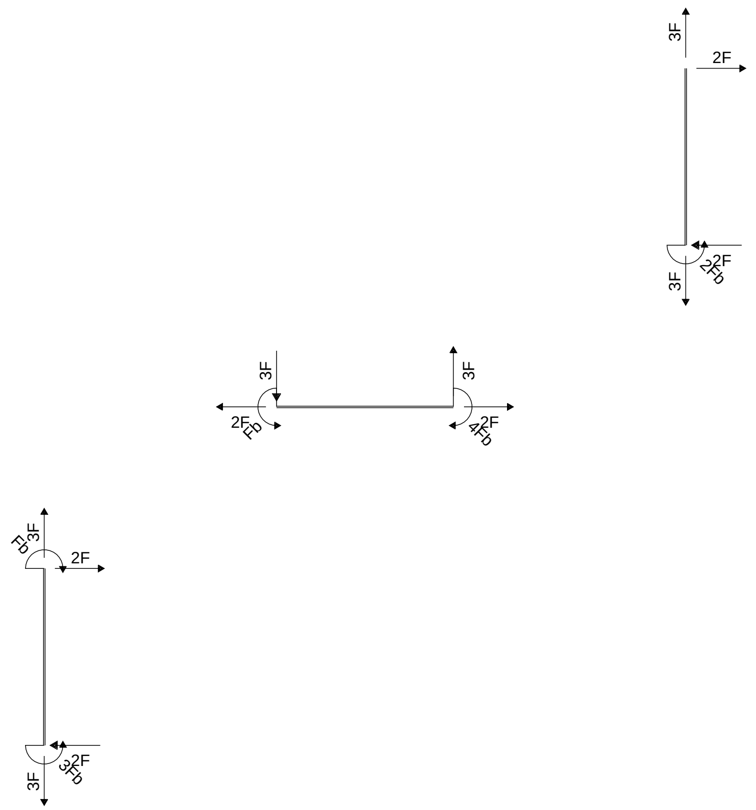
MANTENERE I RISULTATI IN FORMA FRAZIONARIA



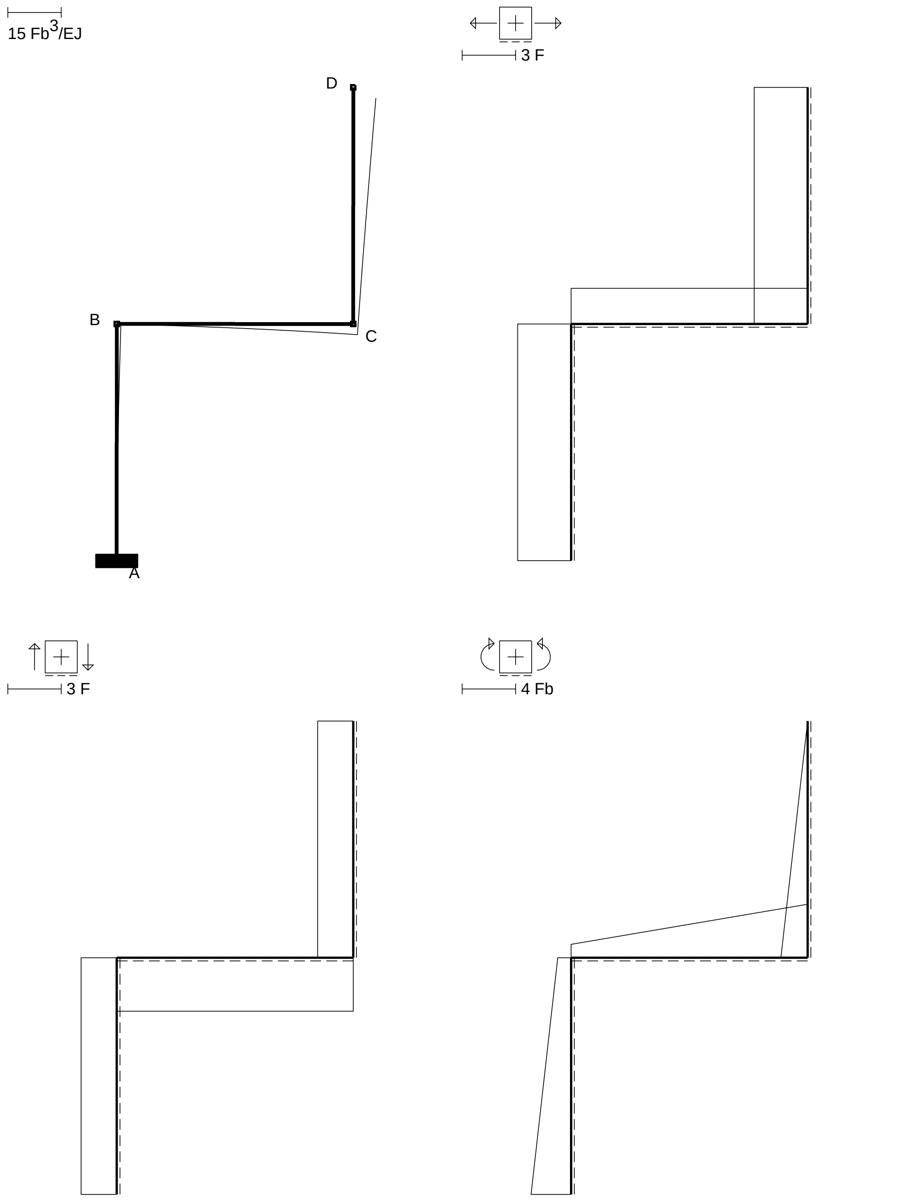






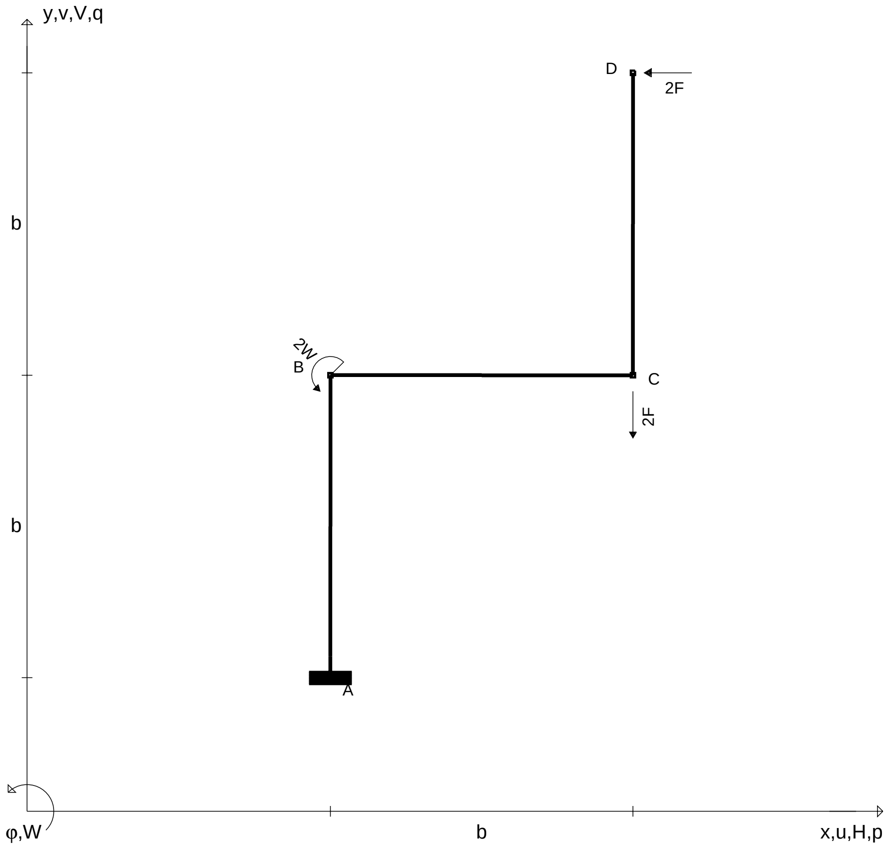

3F
2F
2F
2Fb
3F
3F
3F
2F
Fb
2F
4Fb
3F
Fb
2F
2F
3Fb
3F




15 Fb3/EJ
D
B
C
A
3 F
3 F
4 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB}$ = 3F | $N_{BC}$ = 2F | $N_{CD}$ = 3F |
| $T_{AB}$ = 2F | $T_{BC}$ = -3F | $T_{CD}$ = 2F |
| $M_{AB}$ = -3Fb +2Fx | $M_{BC}$ = -Fb -3Fx | $M_{CD}$ = -2Fb +2Fx |

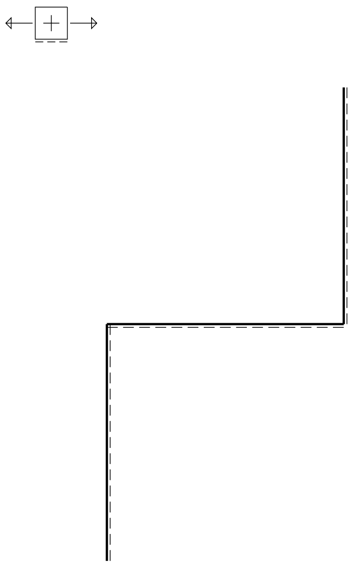


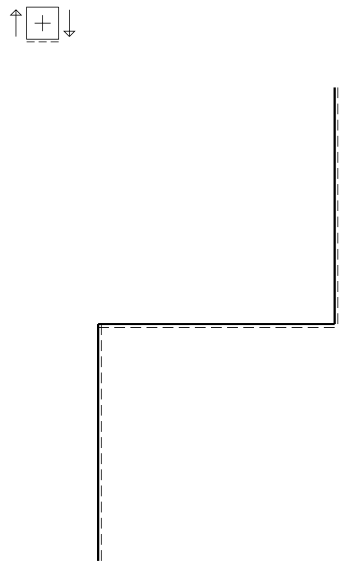

$H_D = -2F$  $W_B = 2W = 2Fb$  $EJ_{BC} = EJ$
$V_C = -2F$  $EJ_{AB} = EJ$  $EJ_{CD} = EJ$

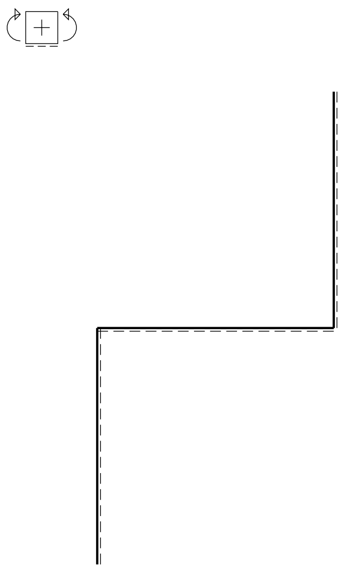
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

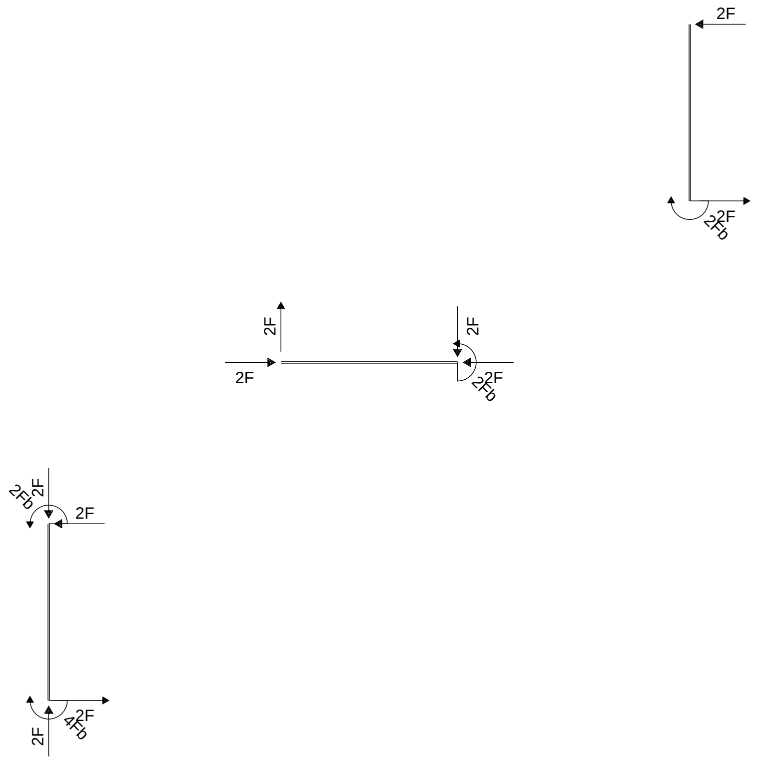
MANTENERE I RISULTATI IN FORMA FRAZIONARIA



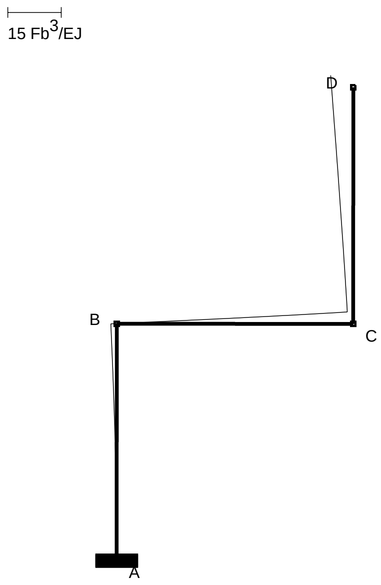


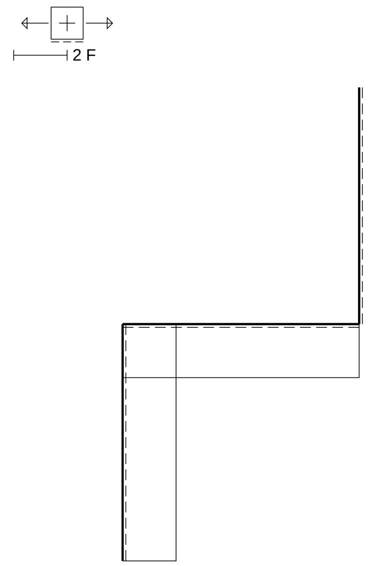


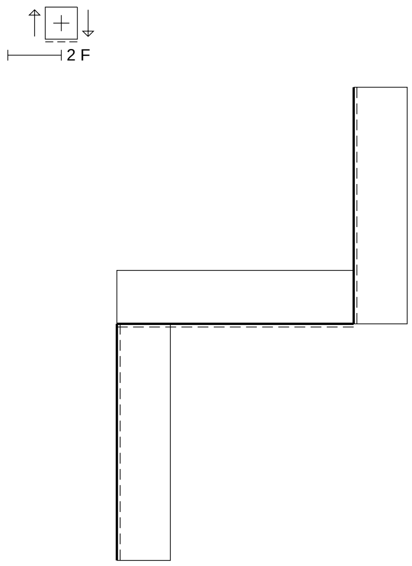


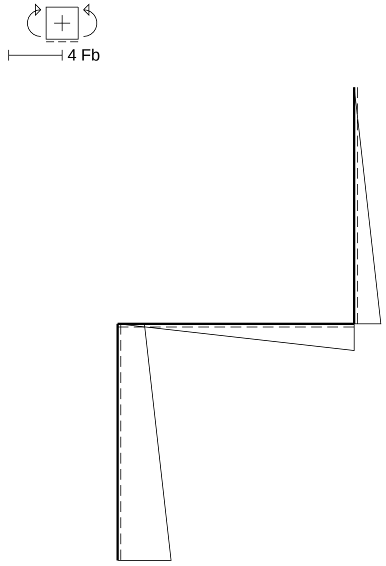

2F
2F
2Fb
2F
2F
2F
2F
2Fb
2Fb
2F
2F
2F
2F
4Fb




15 Fb3/EJ
D
B
C
A

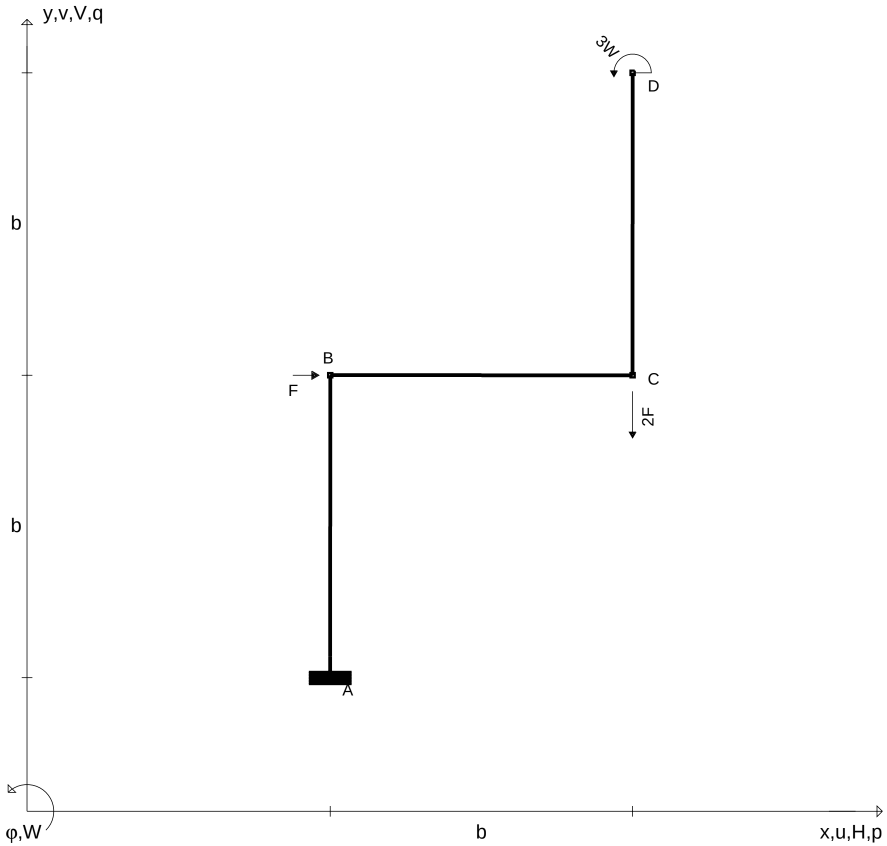

2 F


2 F


4 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB}$ = -2F | $N_{BC}$ = -2F | $N_{CD}$ = 0 |
| $T_{AB}$ = -2F | $T_{BC}$ = 2F | $T_{CD}$ = -2F |
| $M_{AB}$ = 4Fb -2Fx | $M_{BC}$ = 2Fx | $M_{CD}$ = 2Fb -2Fx |



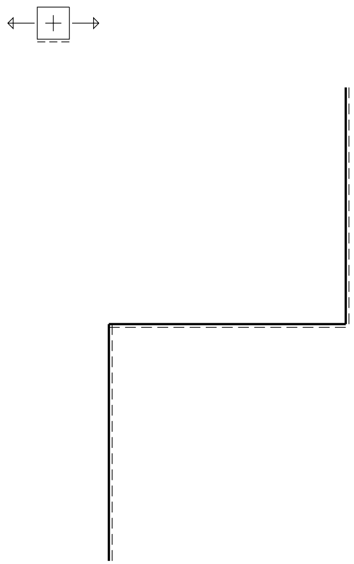

$V_C = -2F$ $W_D = 3W = 3Fb$ $EJ_{BC} = EJ$

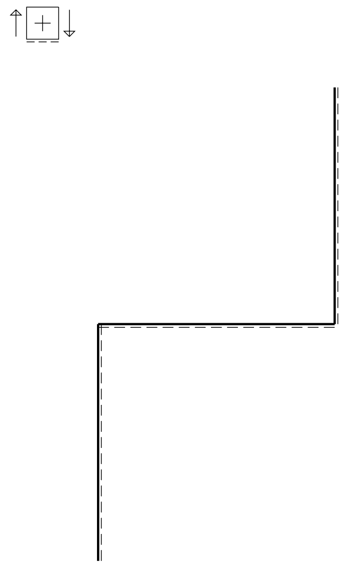
$H_B = F$ $EJ_{AB} = EJ$ $EJ_{CD} = EJ$

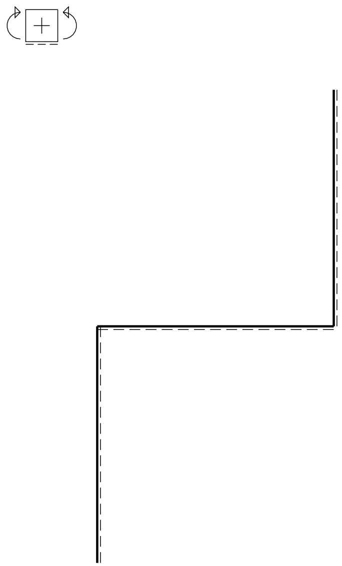
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

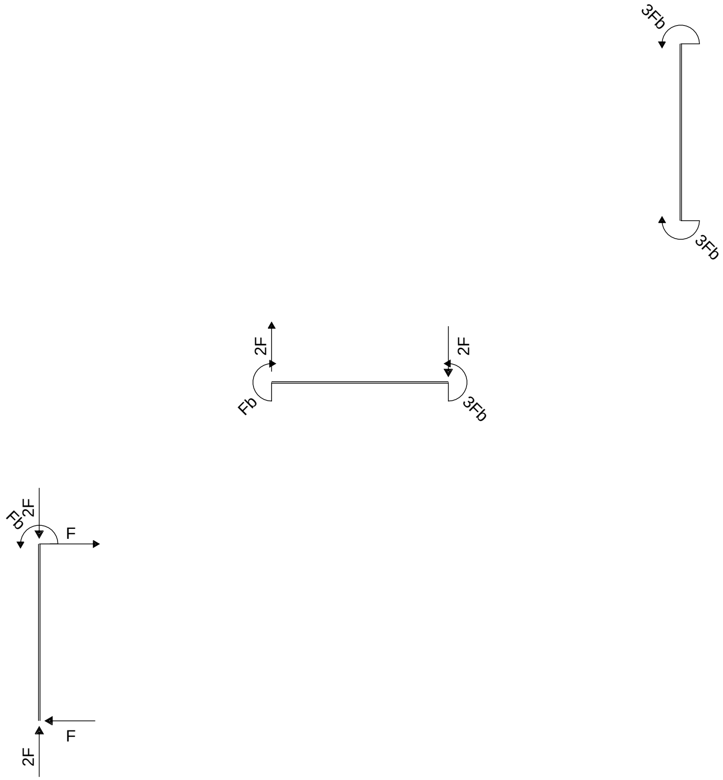
MANTENERE I RISULTATI IN FORMA FRAZIONARIA



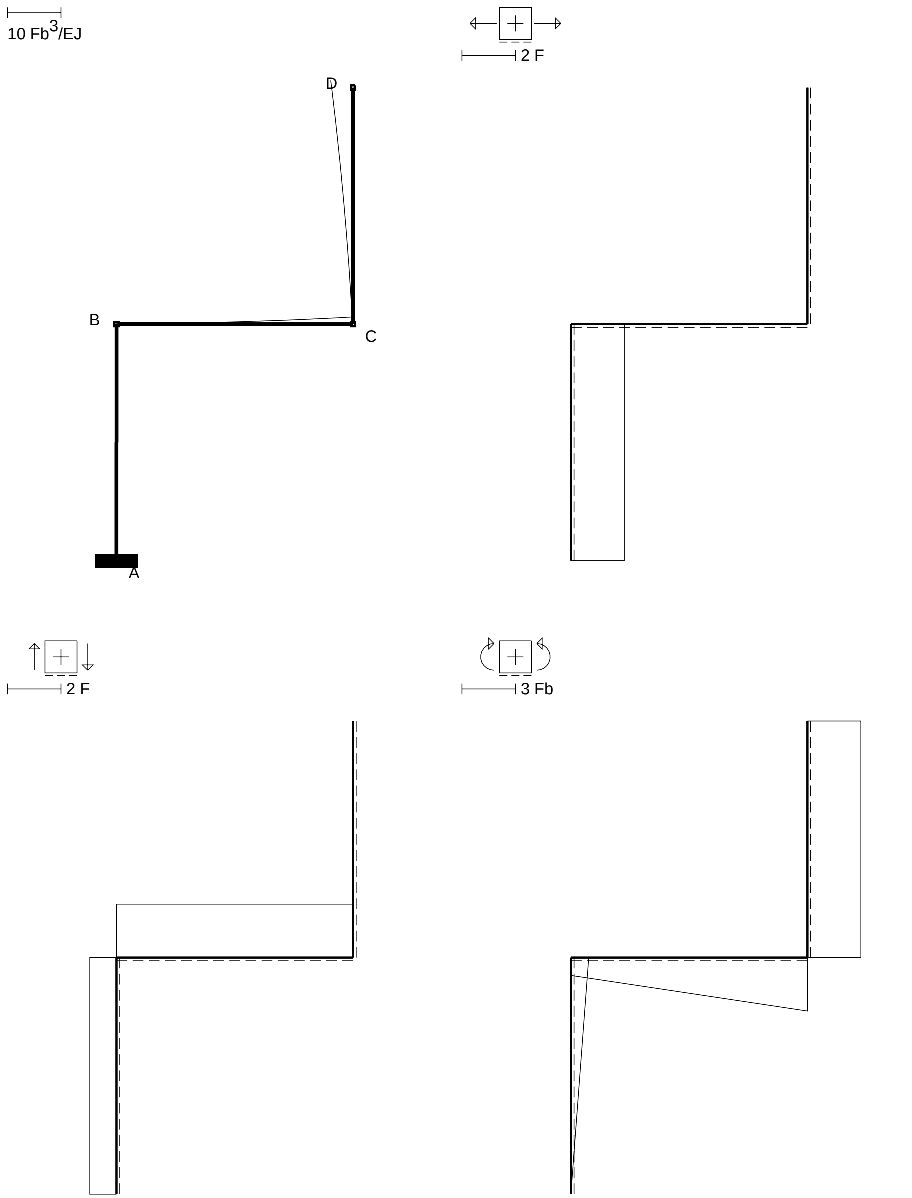






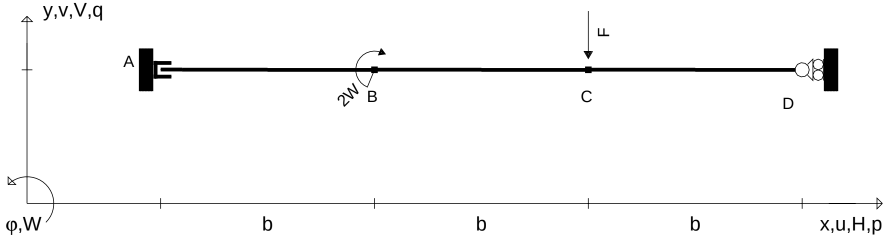

3Fb
3Fb
2F
2F
Fb
3Fb
2F
Fb
F
F
2F




10 Fb3/EJ
2 F
D
B
C
A
2 F
3 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = -2F$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = F$ | $T_{BC} = 2F$ | $T_{CD} = 0$ |
| $M_{AB} = Fx$ | $M_{BC} = Fb + 2Fx$ | $M_{CD} = 3Fb$ |



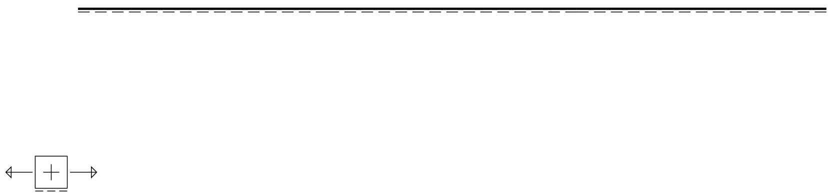

$V_C = -F$ $EJ_{AB} = EJ$ $EJ_{CD} = EJ$

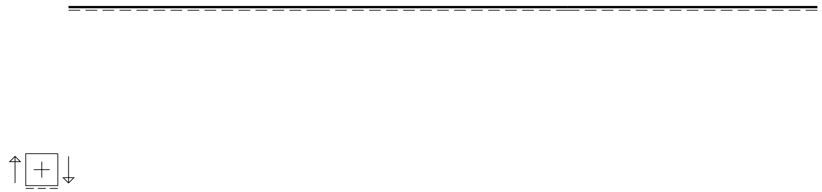
$W_B = -2W = -2Fb$ $EJ_{BC} = EJ$

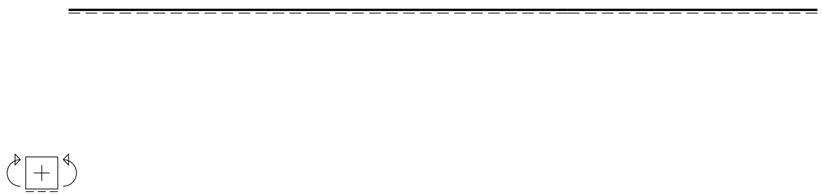
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

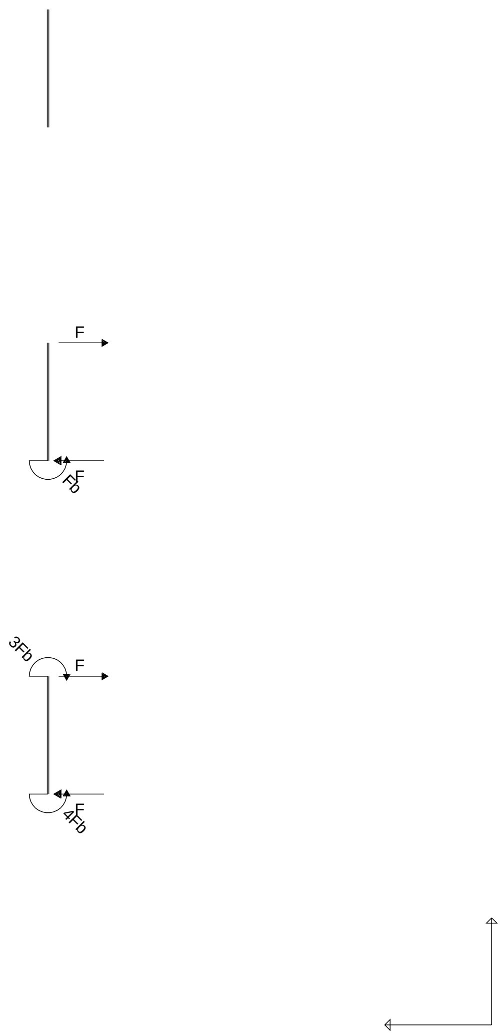
MANTENERE I RISULTATI IN FORMA FRAZIONARIA



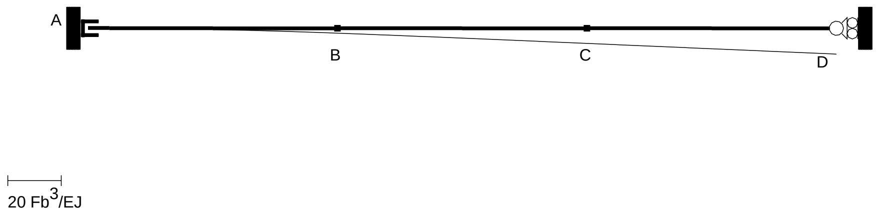


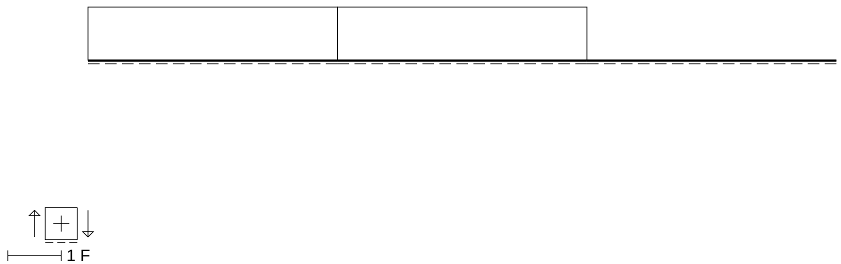


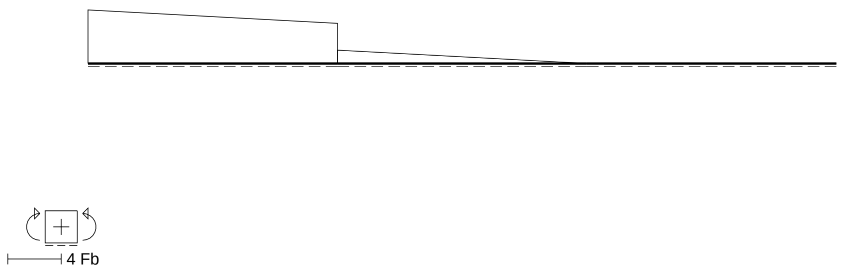



F
F
Fb
3Fb
F
F
4Fb



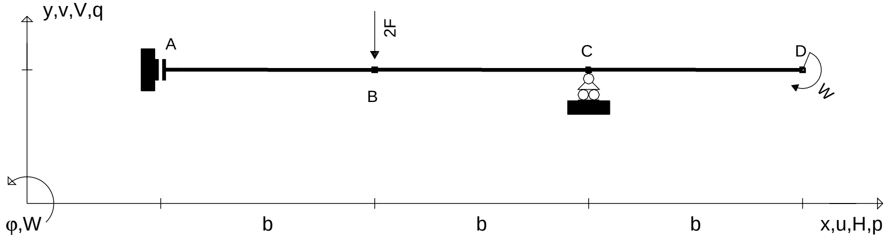

A
B
C
D
20 Fb3/EJ


1 F


4 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 0$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = F$ | $T_{BC} = F$ | $T_{CD} = 0$ |
| $M_{AB} = -4Fb + Fx$ | $M_{BC} = -Fb + Fx$ | $M_{CD} = 0$ |

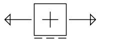


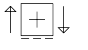

$V_B = -2F$ $W_D = -W = -Fb$ $EJ_{AB} = EJ$ $EJ_{BC} = EJ$ $EJ_{CD} = EJ$

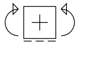
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

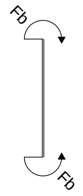
MANTENERE I RISULTATI IN FORMA FRAZIONARIA

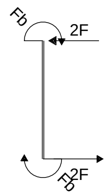


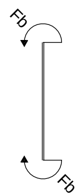


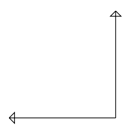




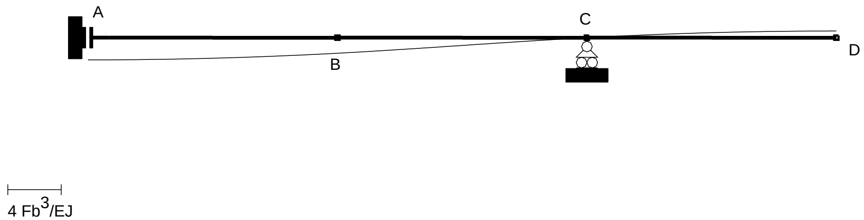

Fb
Fb

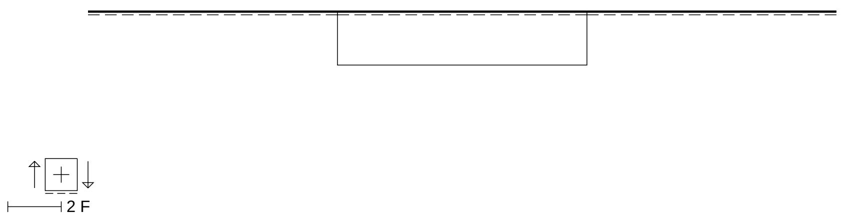

Fb
2F
2F
Fb

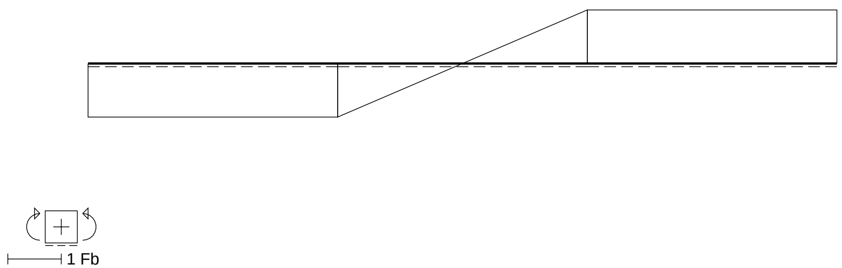

Fb
Fb





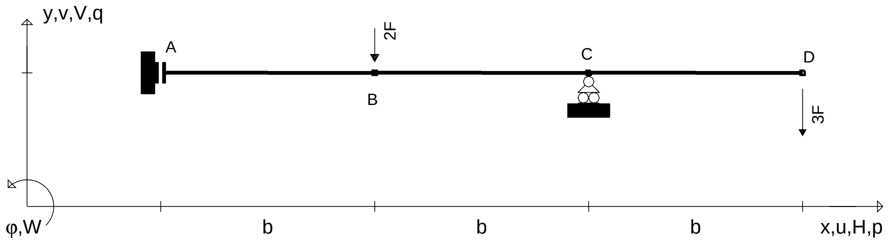

A
C
B
D
4 Fb3/EJ


2 F


1 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 0$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = 0$ | $T_{BC} = -2F$ | $T_{CD} = 0$ |
| $M_{AB} = Fb$ | $M_{BC} = Fb - 2Fx$ | $M_{CD} = -Fb$ |

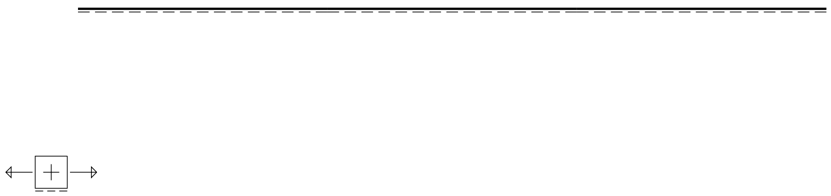


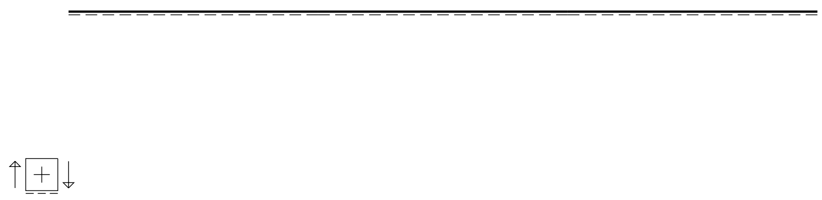

$V_B$ = -2F $V_D$ = -3F $EJ_{AB}$ = EJ $EJ_{BC}$ = EJ $EJ_{CD}$ = EJ

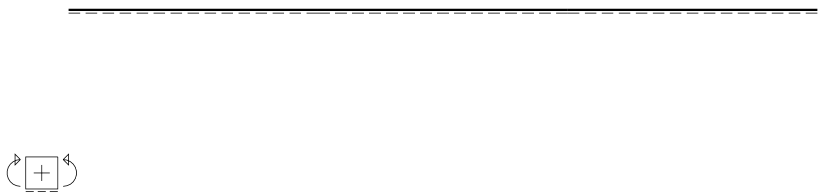
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

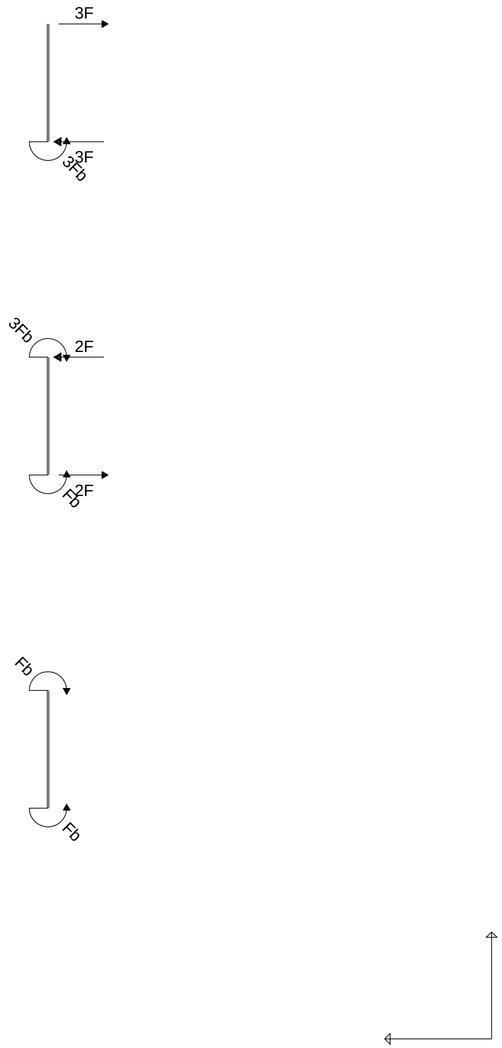
MANTENERE I RISULTATI IN FORMA FRAZIONARIA



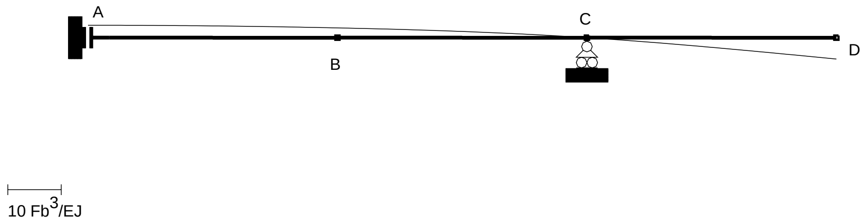


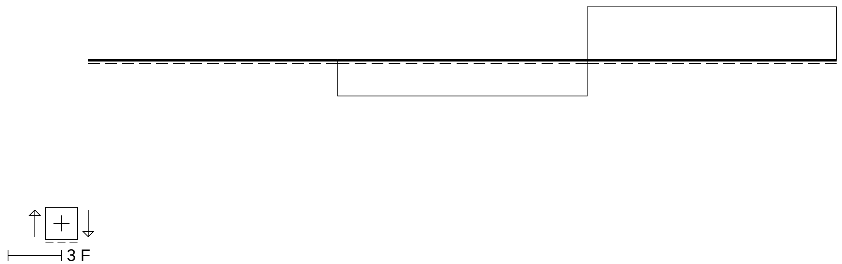


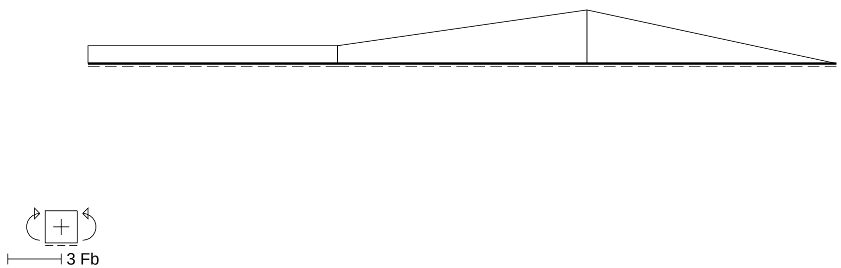



3F
3F
3Fb
3Fb
2F
2F
Fb
Fb
Fb




A
B
C
D
10 Fb3/EJ


3 F

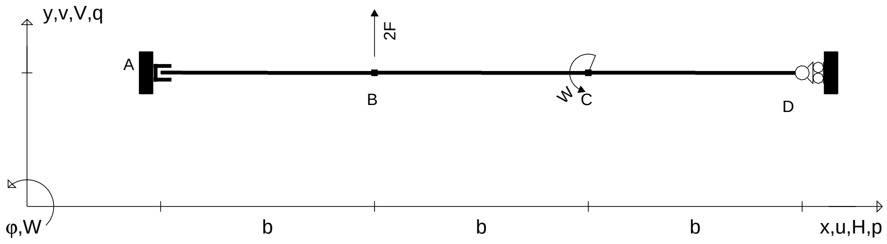

3 Fb

AZIONI INTERNE (coordinate locali)

$N_{AB} = 0$
$T_{AB} = 0$
$M_{AB} = -Fb$

$N_{BC} = 0$
$T_{BC} = -2F$
$M_{BC} = -Fb -2Fx$

$N_{CD} = 0$
$T_{CD} = 3F$
$M_{CD} = -3Fb +3Fx$

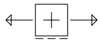


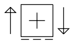

$V_B = 2F$ $W_C = W = Fb$ $EJ_{AB} = EJ$ $EJ_{BC} = EJ$ $EJ_{CD} = EJ$

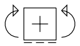
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

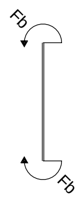
MANTENERE I RISULTATI IN FORMA FRAZIONARIA

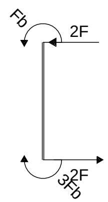


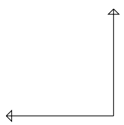




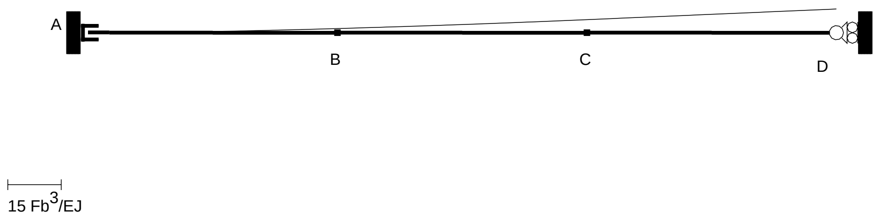


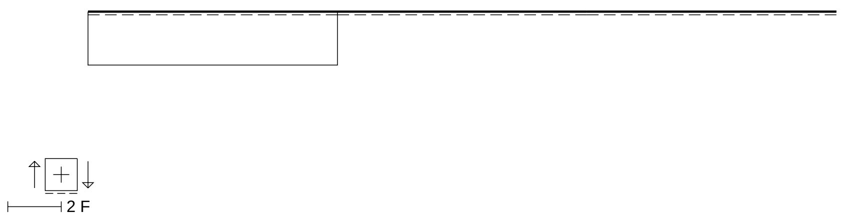

Fb
Fb

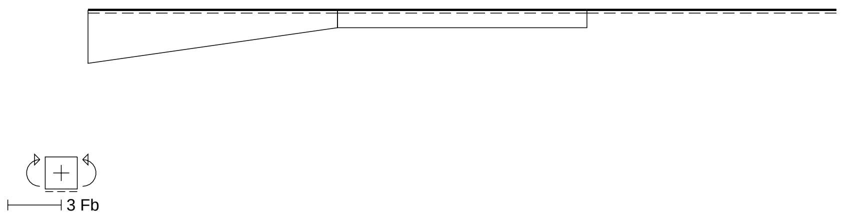

Fb
2F
2F
3Fb





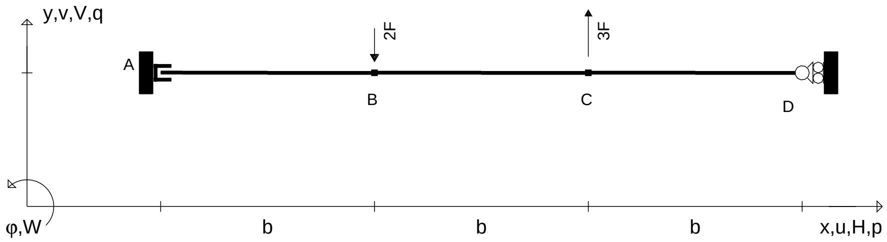

A
B
C
D
15 Fb3/EJ


2 F


3 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 0$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = -2F$ | $T_{BC} = 0$ | $T_{CD} = 0$ |
| $M_{AB} = 3Fb - 2Fx$ | $M_{BC} = Fb$ | $M_{CD} = 0$ |

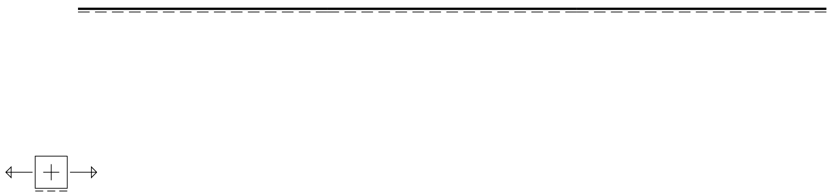


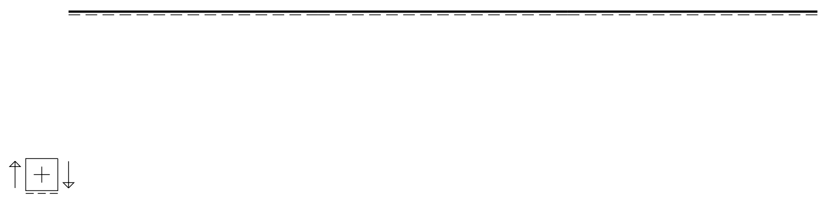

$V_C = 3F$ $V_B = -2F$ $EJ_{AB} = EJ$ $EJ_{BC} = EJ$ $EJ_{CD} = EJ$

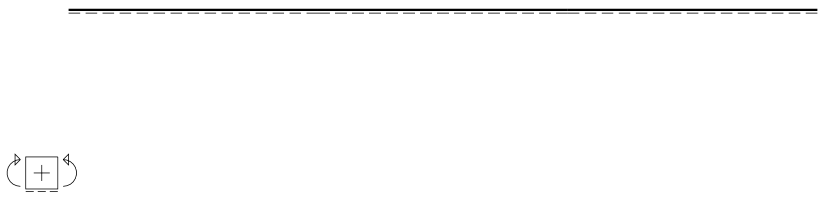
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

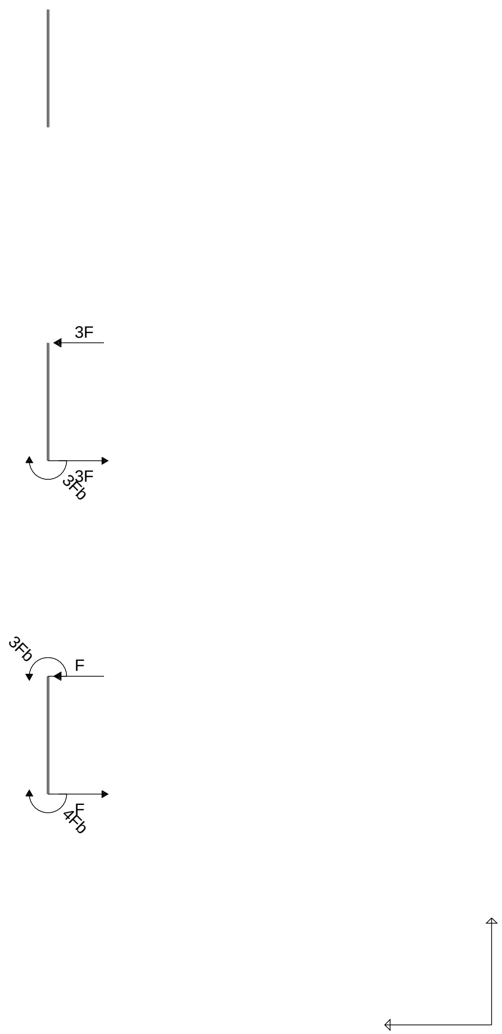
MANTENERE I RISULTATI IN FORMA FRAZIONARIA



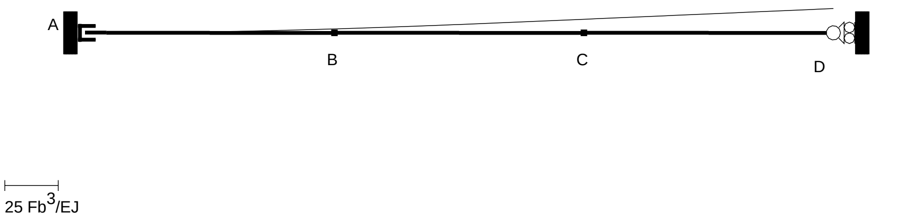


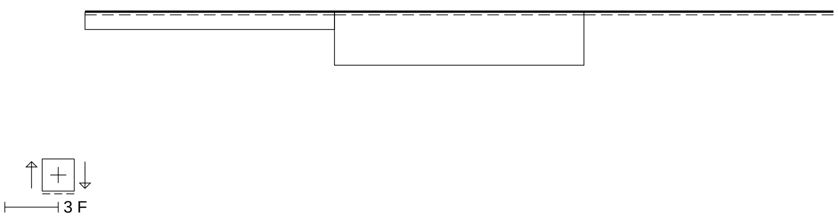


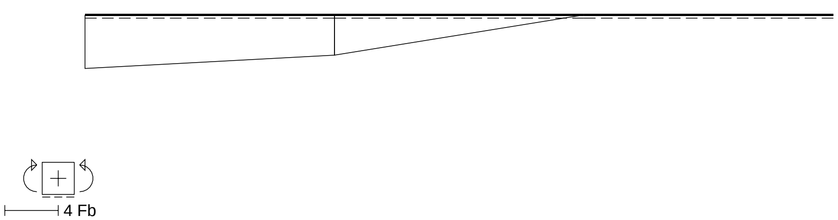



3F
3F
3Fb
3Fb
F
F
4Fb



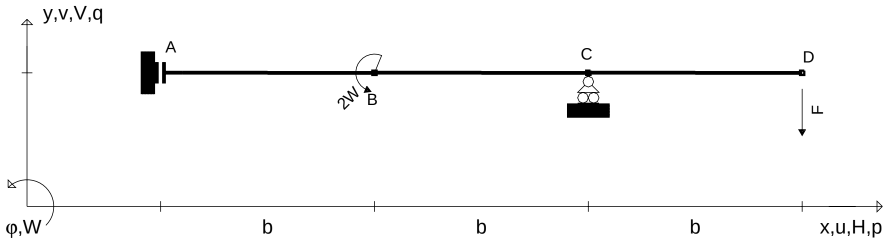

A
B
C
D
25 Fb3/EJ


3 F


4 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 0$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = -F$ | $T_{BC} = -3F$ | $T_{CD} = 0$ |
| $M_{AB} = 4Fb - Fx$ | $M_{BC} = 3Fb - 3Fx$ | $M_{CD} = 0$ |



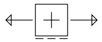

$V_D$ = -F  $EJ_{AB}$ = EJ  $EJ_{CD}$ = EJ

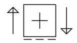
$W_B$ = 2W = 2Fb  $EJ_{BC}$ = EJ

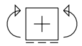
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

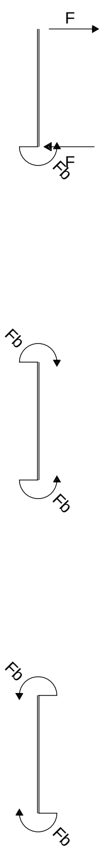
MANTENERE I RISULTATI IN FORMA FRAZIONARIA

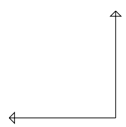




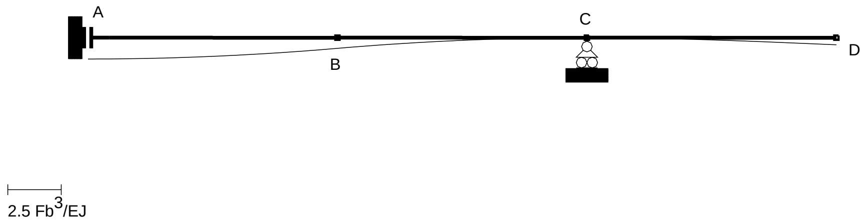


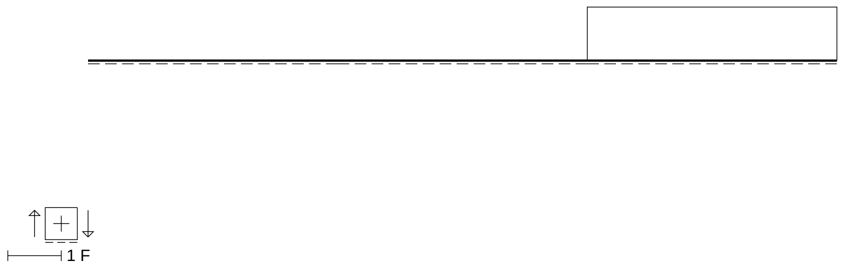


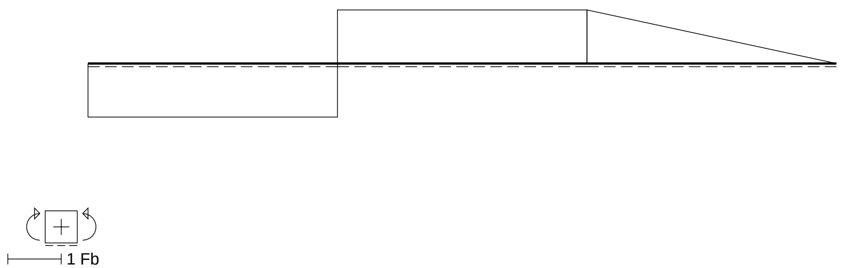

F
F
Fb
Fb
Fb
Fb
Fb





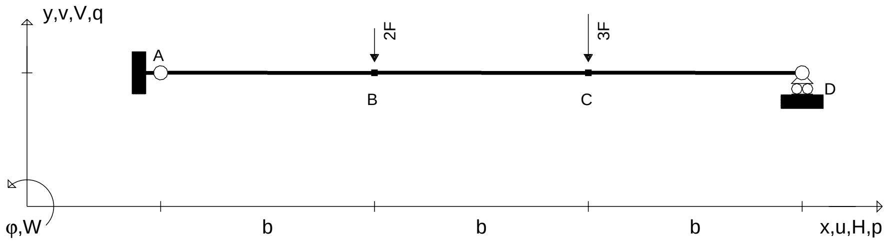

A
B
C
D
2.5 Fb3/EJ


1 F


1 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 0$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = 0$ | $T_{BC} = 0$ | $T_{CD} = F$ |
| $M_{AB} = Fb$ | $M_{BC} = -Fb$ | $M_{CD} = -Fb + Fx$ |

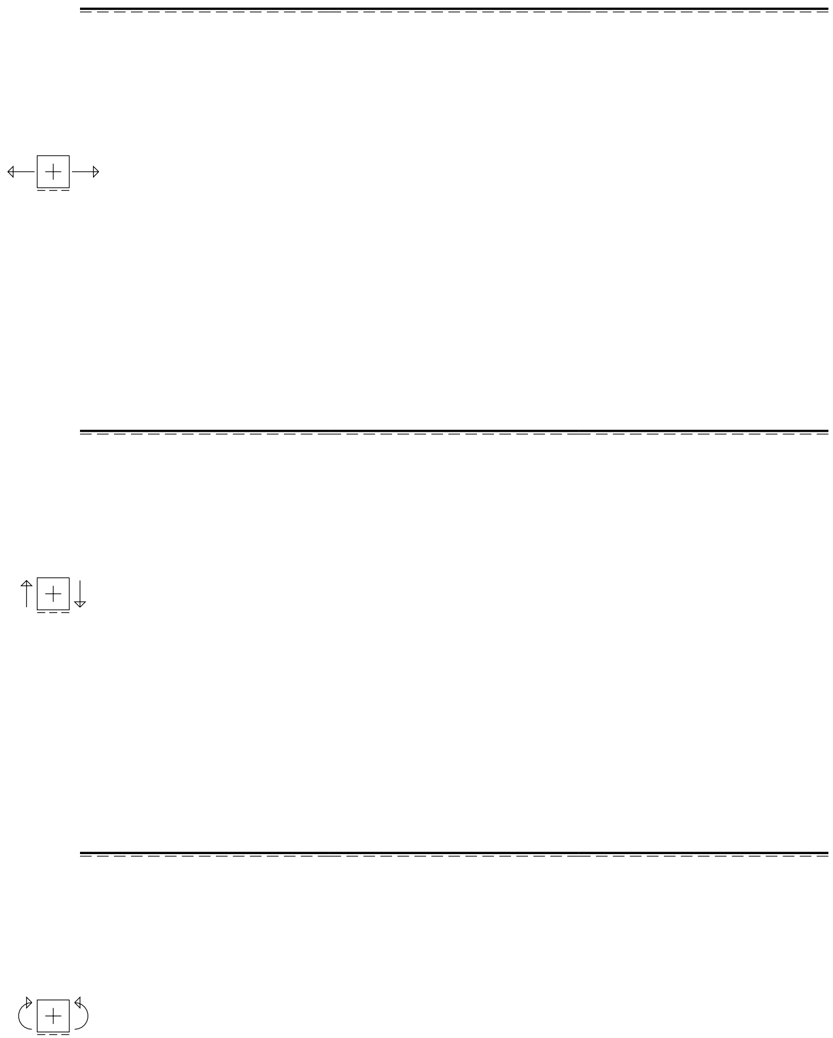


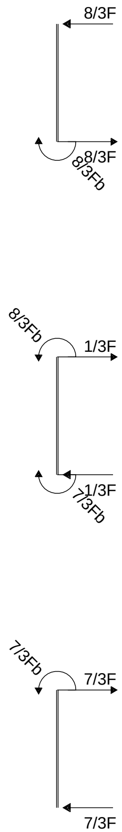

$V_B = -2F$ $V_C = -3F$ $EJ_{AB} = EJ$ $EJ_{BC} = EJ$ $EJ_{CD} = EJ$

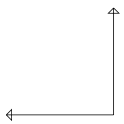
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

MANTENERE I RISULTATI IN FORMA FRAZIONARIA

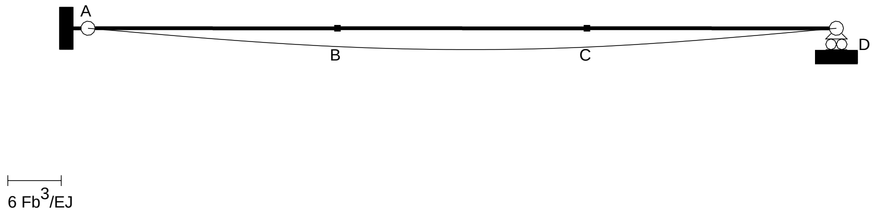


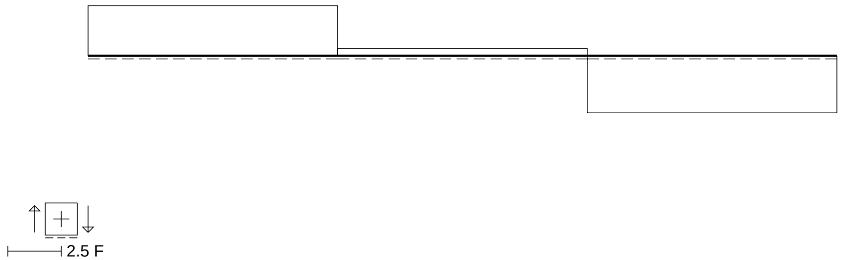


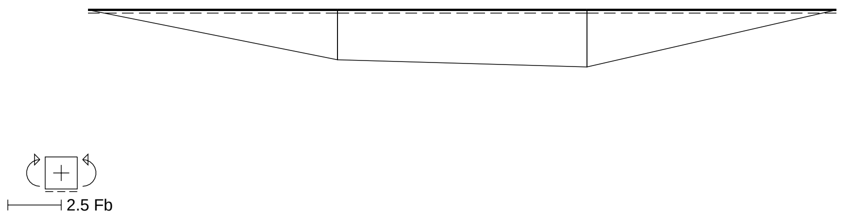

8/3F
8/3F
8/3Fb
8/3Fb
1/3F
1/3F
7/3Fb
7/3Fb
7/3F
7/3F






A
B
C
D
6 Fb3/EJ


2.5 F

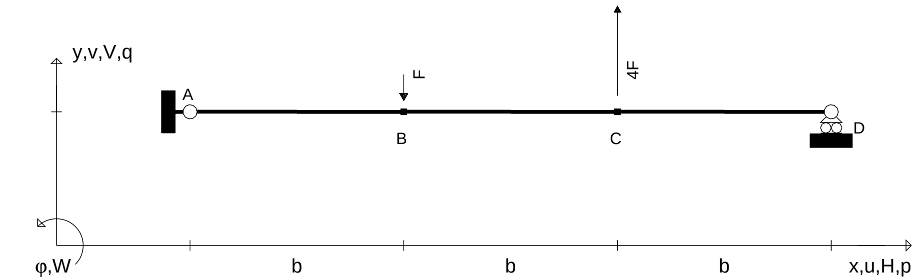

2.5 Fb

AZIONI INTERNE (coordinate locali)

$N_{AB}$ = 0
$T_{AB}$ = 7/3F
$M_{AB}$ = 7/3Fx

$N_{BC}$ = 0
$T_{BC}$ = 1/3F
$M_{BC}$ = 7/3Fb +1/3Fx

$N_{CD}$ = 0
$T_{CD}$ = -8/3F
$M_{CD}$ = 8/3Fb -8/3Fx

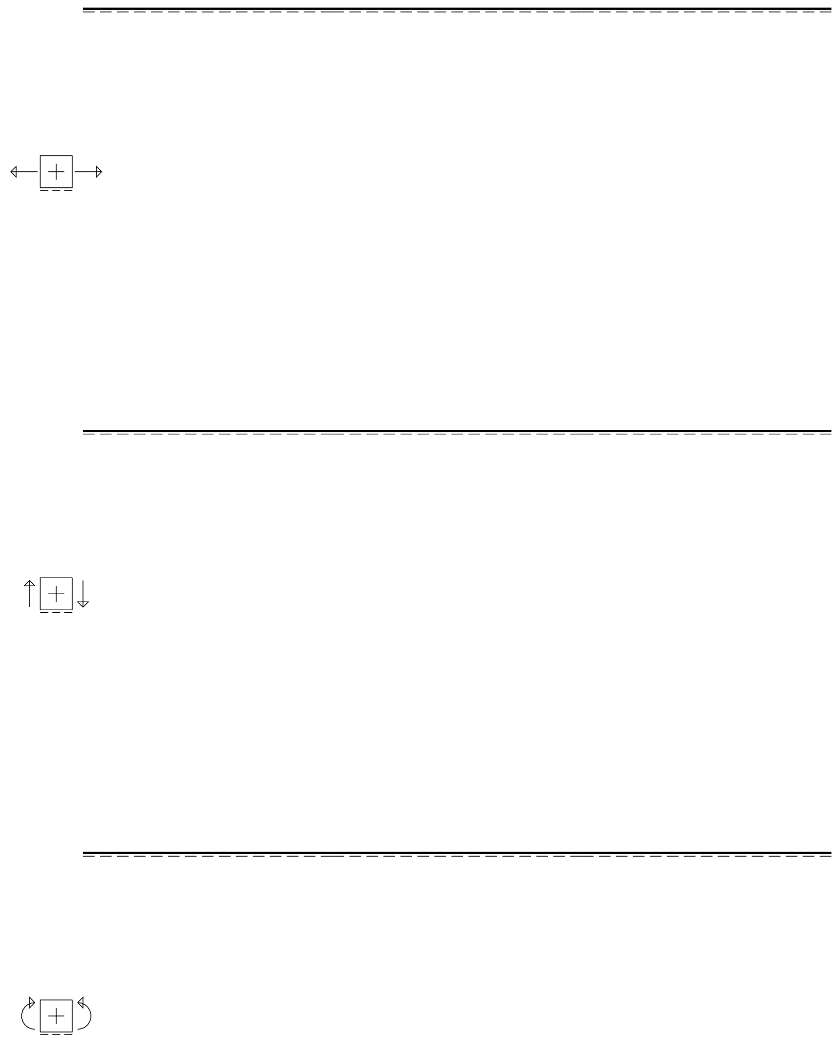


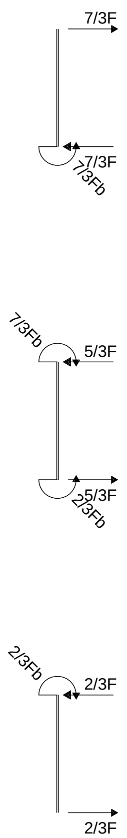

$V_B = -F$ $V_C = 4F$ $EJ_{AB} = EJ$ $EJ_{BC} = EJ$ $EJ_{CD} = EJ$

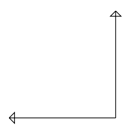
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

MANTENERE I RISULTATI IN FORMA FRAZIONARIA

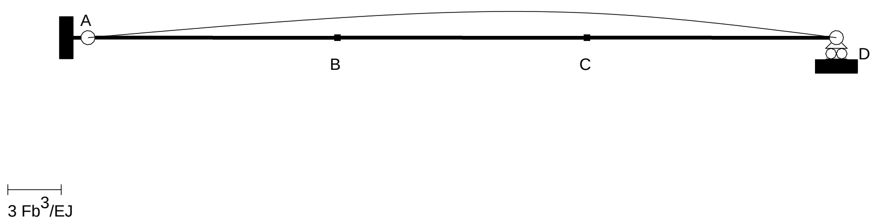


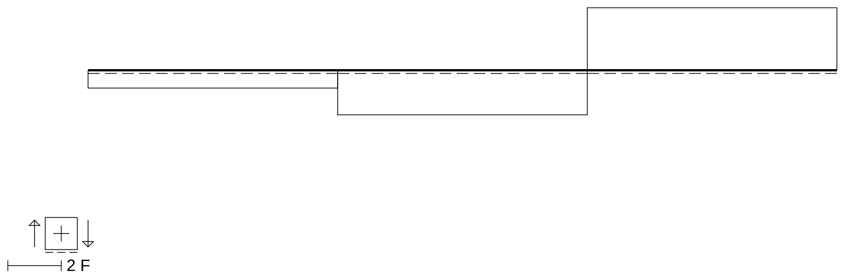


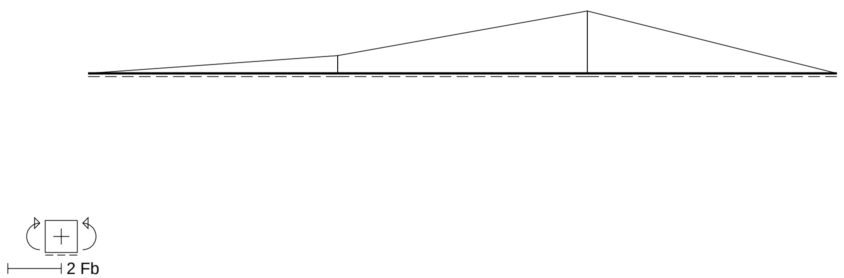

7/3F
7/3F
7/3Fb
7/3Fb
5/3F
5/3F
2/3Fb
2/3Fb
2/3F
2/3F





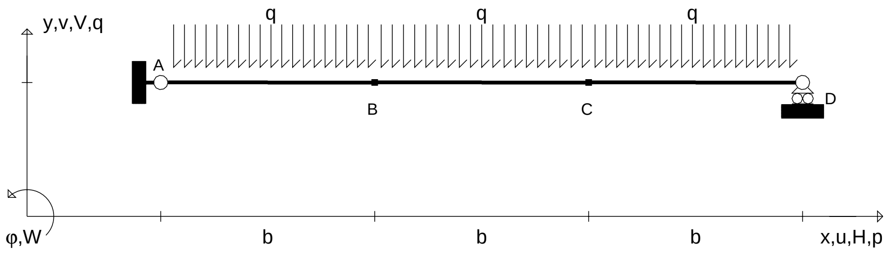

A
B
C
D
3 Fb3/EJ


2 F


2 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 0$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = -2/3F$ | $T_{BC} = -5/3F$ | $T_{CD} = 7/3F$ |
| $M_{AB} = -2/3Fx$ | $M_{BC} = -2/3Fb -5/3Fx$ | $M_{CD} = -7/3Fb +7/3Fx$ |

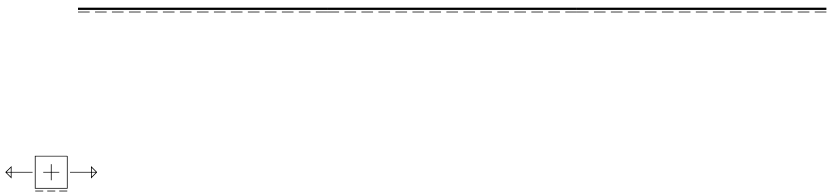


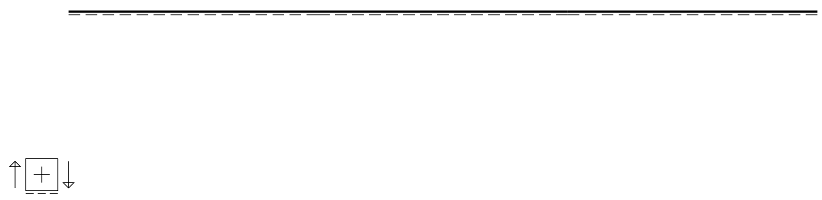

$q_{AB} = -q$ $q_{BC} = -q$ $q_{CD} = -q$ $EJ_{AB} = EJ$ $EJ_{BC} = EJ$ $EJ_{CD} = EJ$

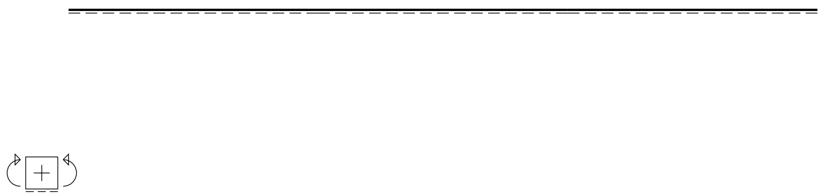
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

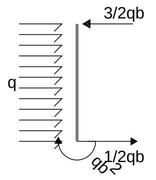
MANTENERE I RISULTATI IN FORMA FRAZIONARIA

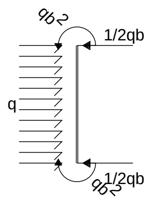


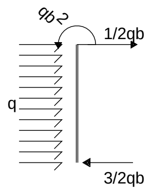


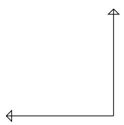




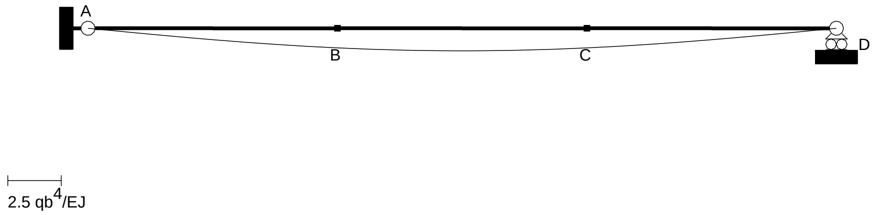

3/2qb
q
1/2qb
qb 2

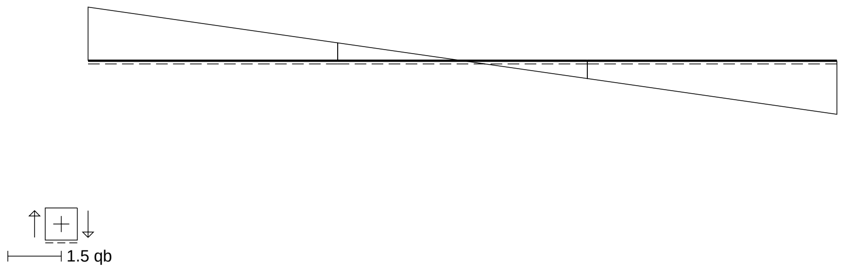

qb 2
1/2qb
q
1/2qb
qb 2

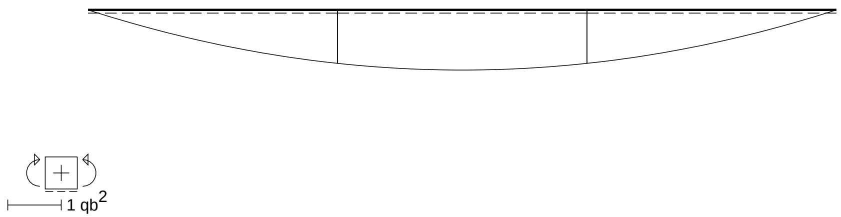

qb 2
1/2qb
q
3/2qb






A
B
C
D
2.5 qb4/EJ


1.5 qb

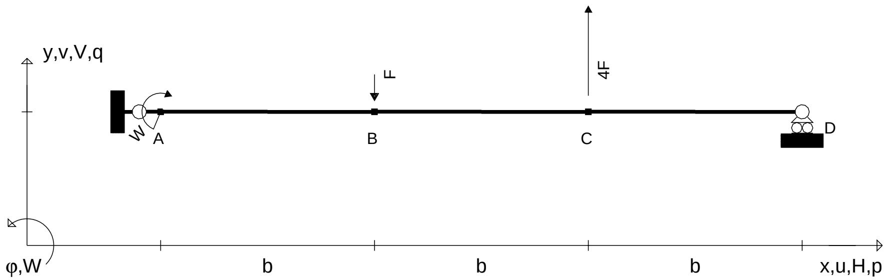

1 qb2

AZIONI INTERNE (coordinate locali)

$N_{AB} = 0$
$T_{AB} = 3/2qb - qx$
$M_{AB} = 3/2qbx - 1/2qx^2$

$N_{BC} = 0$
$T_{BC} = 1/2qb - qx$
$M_{BC} = qb^2 + 1/2qbx - 1/2qx^2$

$N_{CD} = 0$
$T_{CD} = -1/2qb - qx$
$M_{CD} = qb^2 - 1/2qbx - 1/2qx^2$



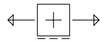

$V_B = -F$ $W_A = -W = -Fb$ $EJ_{BC} = EJ$

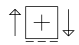
$V_C = 4F$ $EJ_{AB} = EJ$ $EJ_{CD} = EJ$

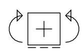
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

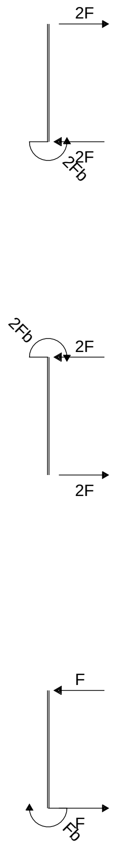
MANTENERE I RISULTATI IN FORMA FRAZIONARIA

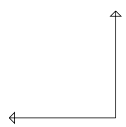




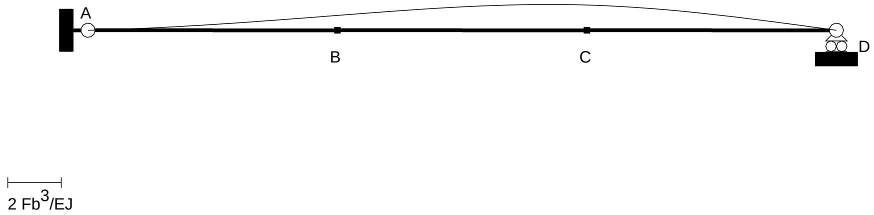


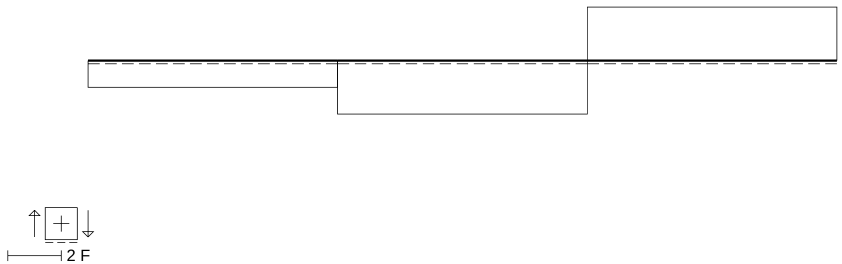


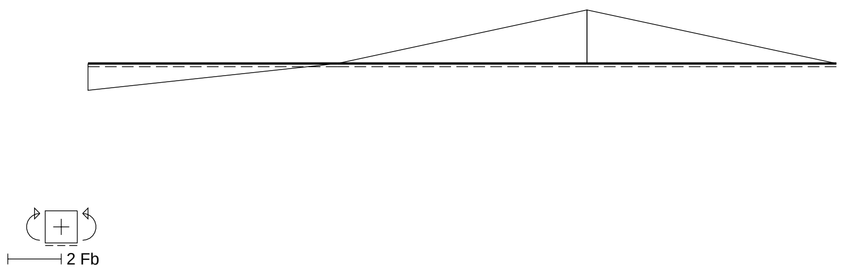

2F
2F
2Fb
2Fb
2F
2F
F
F
Fb





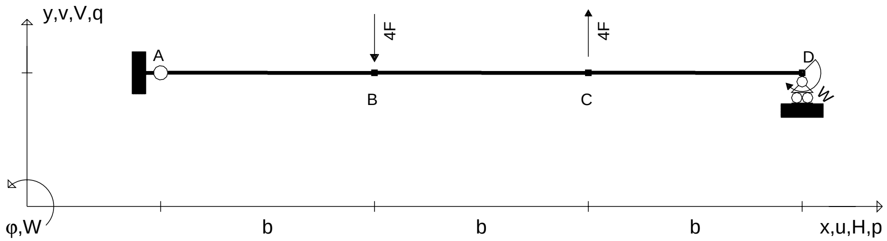

A
B
C
D
2 Fb3/EJ


2 F


2 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB}$ = 0 | $N_{BC}$ = 0 | $N_{CD}$ = 0 |
| $T_{AB}$ = -F | $T_{BC}$ = -2F | $T_{CD}$ = 2F |
| $M_{AB}$ = Fb -Fx | $M_{BC}$ = -2Fx | $M_{CD}$ = -2Fb +2Fx |




$V_B = -4F$ $\quad$ $W_D = -W = -Fb$ $\quad$ $EJ_{BC} = EJ$

$V_C = 4F$ $\quad$ $EJ_{AB} = EJ$ $\quad$ $EJ_{CD} = EJ$

Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
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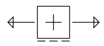
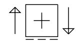
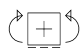
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

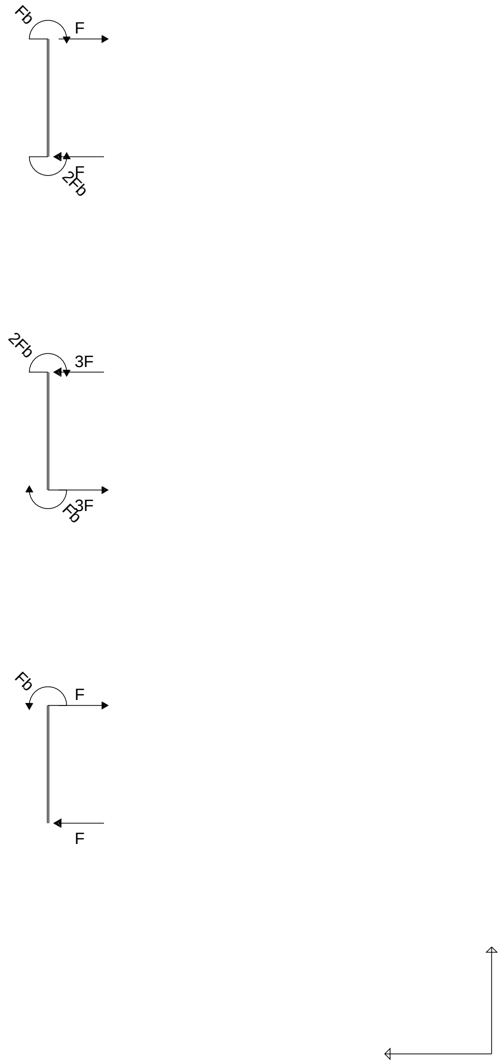
MANTENERE I RISULTATI IN FORMA FRAZIONARIA



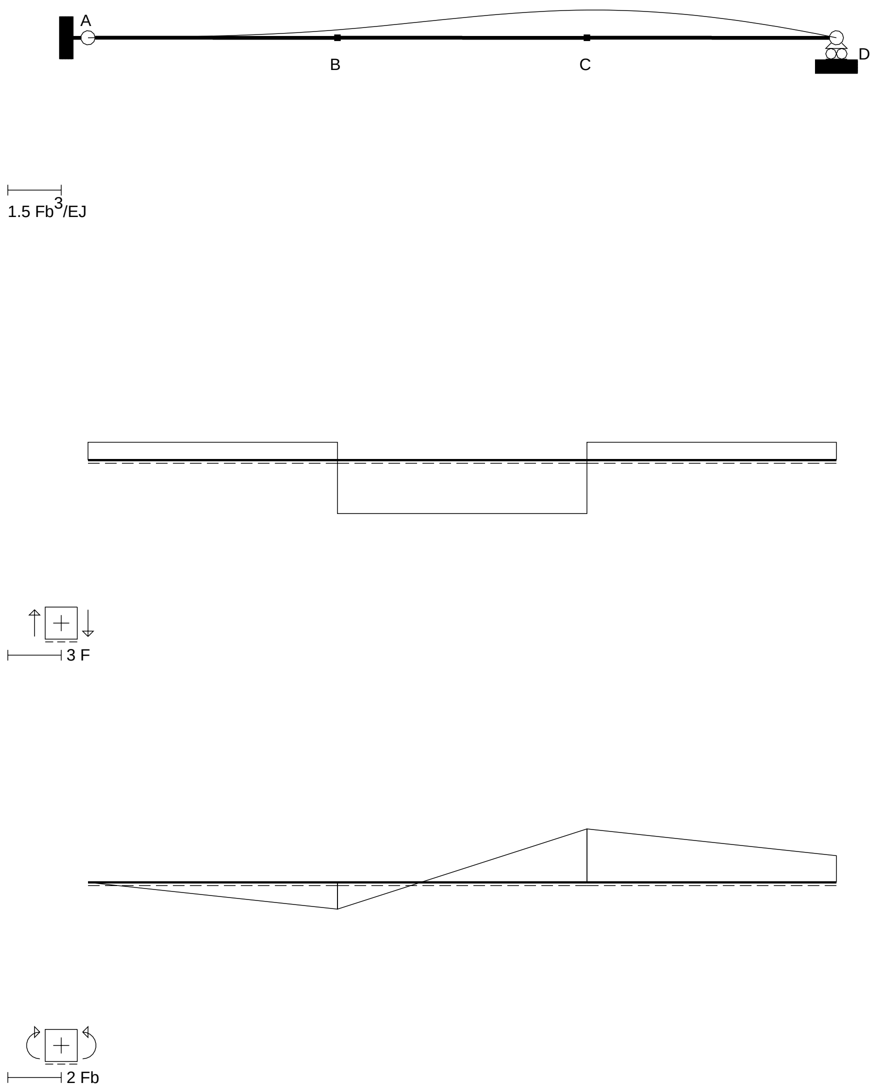






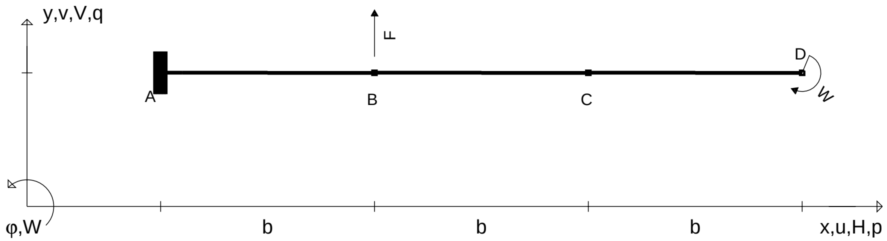

Fb
F
F
2Fb
2Fb
3F
3F
Fb
Fb
F
F




A
B
C
D
1.5 Fb3/EJ
3 F
2 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 0$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = F$ | $T_{BC} = -3F$ | $T_{CD} = F$ |
| $M_{AB} = Fx$ | $M_{BC} = Fb - 3Fx$ | $M_{CD} = -2Fb + Fx$ |




$V_B = F$ $W_D = -W = -Fb$ $EJ_{AB} = EJ$ $EJ_{BC} = EJ$ $EJ_{CD} = EJ$

Verso effettivo dei carichi riportato nel disegno.
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$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

MANTENERE I RISULTATI IN FORMA FRAZIONARIA

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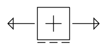
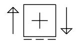
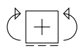
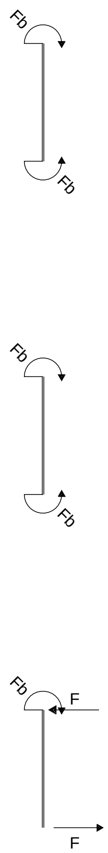
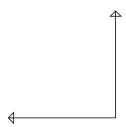




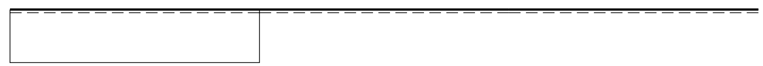


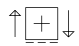


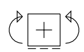



$6\ Fb^3/EJ$





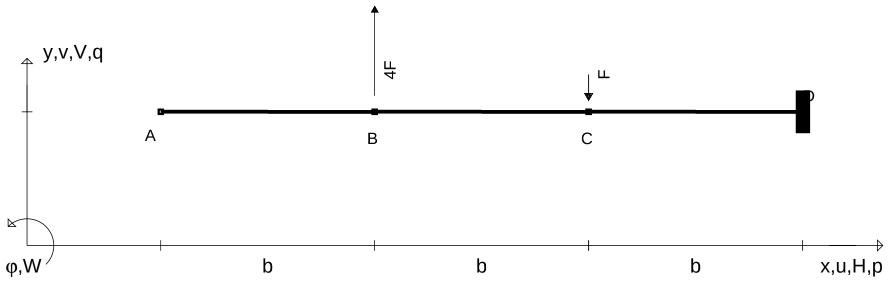
1 F



1 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 0$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = -F$ | $T_{BC} = 0$ | $T_{CD} = 0$ |
| $M_{AB} = -Fx$ | $M_{BC} = -Fb$ | $M_{CD} = -Fb$ |

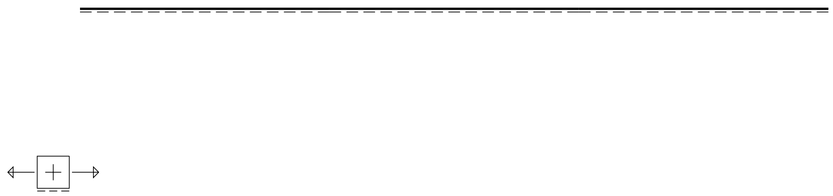


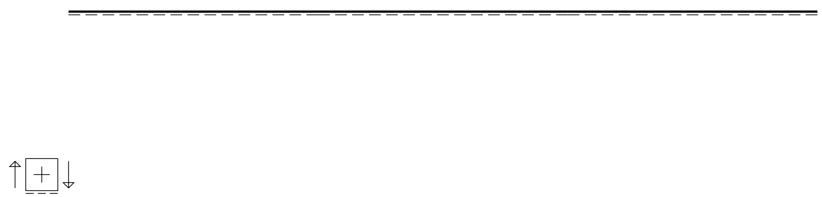

$V_C = -F$ $V_B = 4F$ $EJ_{AB} = EJ$ $EJ_{BC} = EJ$ $EJ_{CD} = EJ$

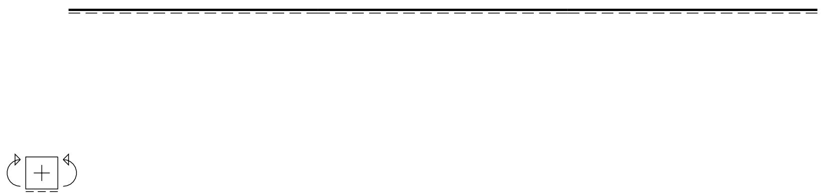
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

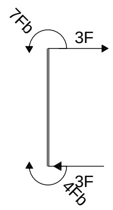
MANTENERE I RISULTATI IN FORMA FRAZIONARIA

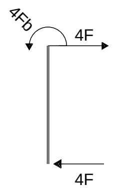




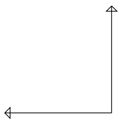




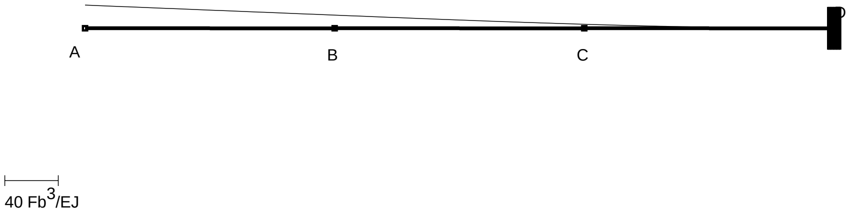

7Fb
3F
3F
4Fb

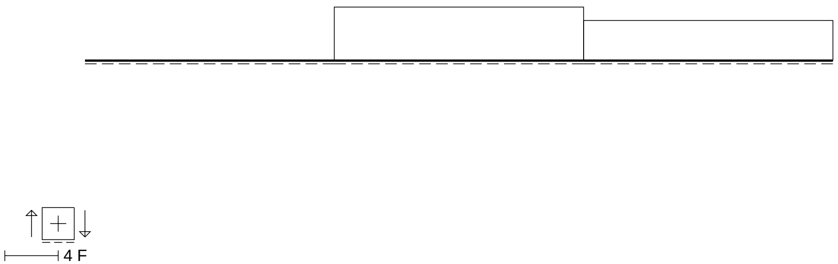

4Fb
4F
4F

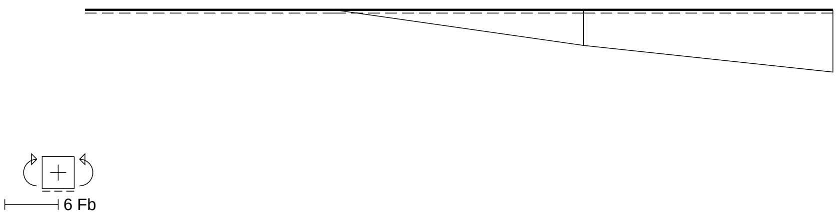







A
B
C
D
40 Fb3/EJ


4 F


6 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 0$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = 0$ | $T_{BC} = 4F$ | $T_{CD} = 3F$ |
| $M_{AB} = 0$ | $M_{BC} = 4Fx$ | $M_{CD} = 4Fb + 3Fx$ |

*Politecnico di Milano - Corso di Laurea in Architettura (N.O.)*

Campus Mantova

**CORSO DI T. E P. DI COSTRUZIONI E STRUTTURE**

A.A. 2003-04

I Prova di Recupero – 14.07.2004

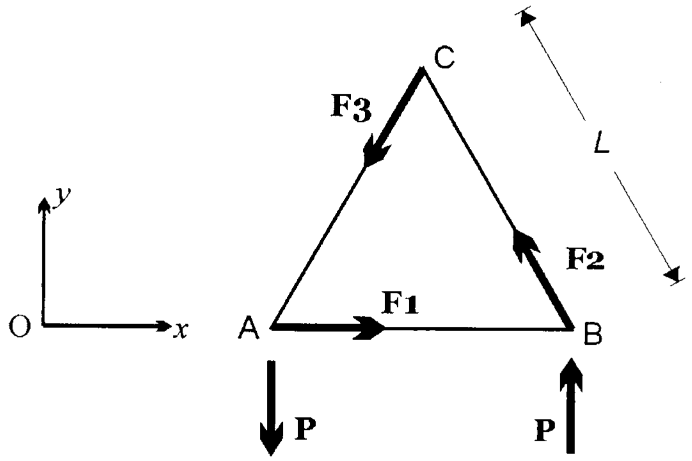
*Nota: I risultati numerici (in forma frazionaria o con 3 cifre decimali) vanno riportati su questo stesso foglio, nei riquadri predisposti.*

| Allievo:...................................................... Matricola:....... |
|---|

FILA 1

**Esercizio n.1** (18 punti)

Tre forze di ugual modulo $F$ = 200N sono applicate lungo i lati di un triangolo equilatero di lato $L$ = 200 mm.

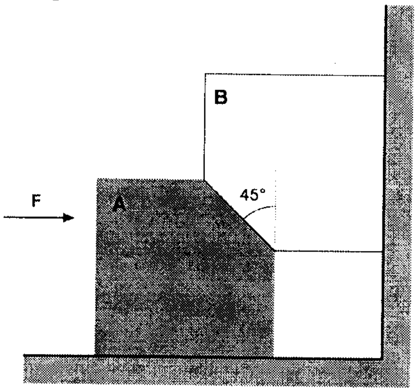



Determinare le componenti delle 3 forze $\mathbf{F_1}$, $\mathbf{F_2}$, $\mathbf{F_3}$, nel sistema di riferimento $Oxy$.
Determinare le componenti della risultante delle tre forze.
Determinare il momento generato dalle 3 forze rispetto ai punti A, B e C.
Determinare il modulo $P$ delle due forze $\mathbf{P}$ necessario a garantire l'equilibrio.

| | | |
|---|---|---|
| $F_{1,x}$ = ........................; | $F_{2,x}$ = ........................; | $F_{3,x}$ = ........................; |
| $F_{1,y}$ = ........................; | $F_{2,y}$ = ........................; | $F_{3,y}$ = ........................; |
| $R_x$ = ........................; | $R_y$ = ........................; | $P$ = ........................; |
| $M_A$ = ........................; | $M_B$ = ........................; | $M_C$ = ........................ |

**Esercizio n.2** (12 punti)

Nel sistema in figura le masse dei due blocchi sono $m_A = 42$ kg e $m_B = 50$ kg.
I due blocchi, assimilabili a punti materiali, sono lisci e trasmettono quindi azioni solo in direzione ortogonale alle superfici di contatto.

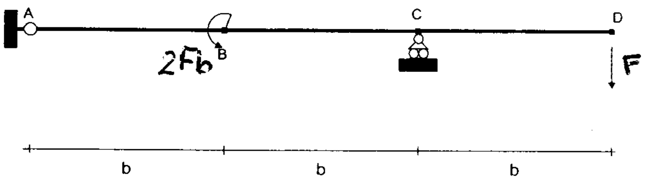



Determinare il valore dei moduli della forza $F$ necessaria per garantire l'equilibrio del sistema, dell'azione mutua $R_{AB}$ che si scambiano i due blocchi, della reazione del pavimento $R_A$ sul blocco A e della reazione della parete $R_B$ sul blocco B.

| |
|---|
| $F =$ ......................; $R_{AB} =$ ......................; $R_A =$ ......................; $R_B =$ ...................... . |

**Esercizio n.3** (15 punti)

Per la struttura in figura, riportare le reazioni vincolari e gli andamenti ed i diagrammi delle azioni interne M, N, T.




N

T

M

| |
|---|
| $V_A =$ ......................; $H_A =$ ......................; $V_C =$ ...................... . |

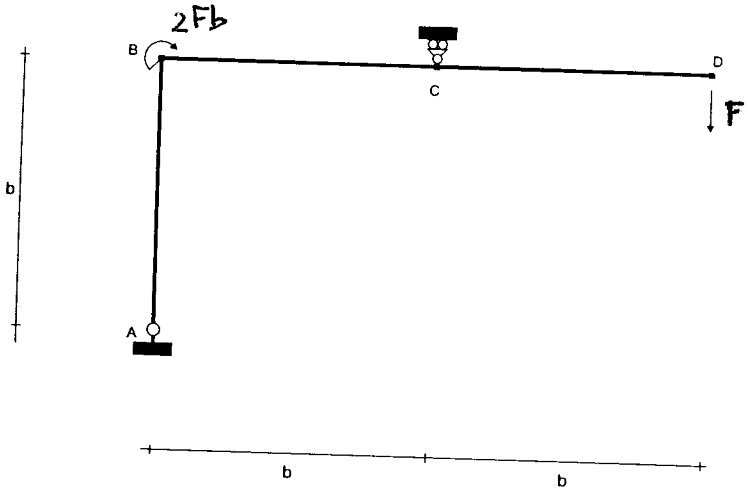
$N_{AB} =$ $N_{BC} =$ $N_{CD} =$

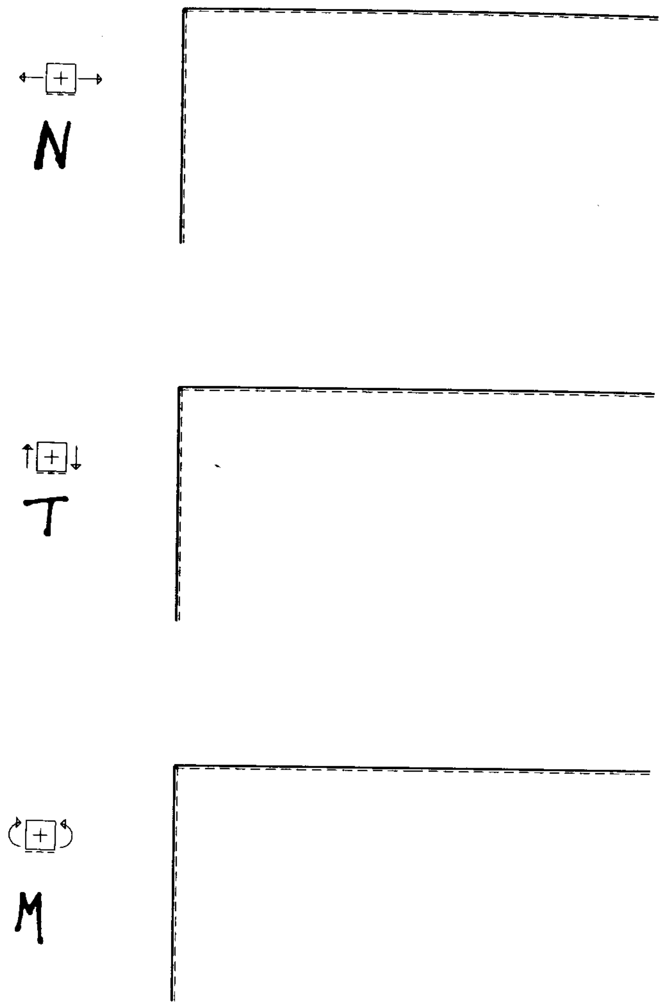
$T_{AB} =$ $T_{BC} =$ $T_{CD} =$

$M_{AB} =$ $M_{BC} =$ $M_{CD} =$

2/1

**Esercizio n.4** (15 punti)
Per la struttura in figura, riportare le reazioni vincolari e gli andamenti ed i diagrammi delle azioni interne M, N, T.




$N_{AB} =$ $\qquad$ $N_{BC} =$ $\qquad$ $N_{CD} =$

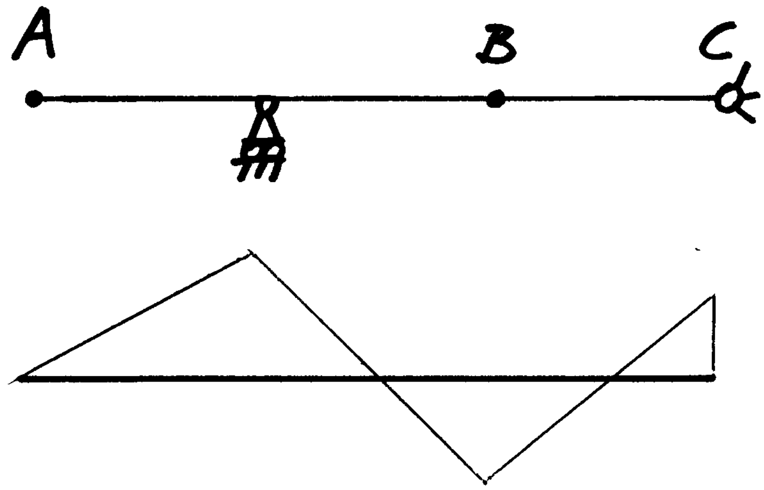
$T_{AB} =$ $\qquad$ $T_{BC} =$ $\qquad$ $T_{CD} =$

$M_{AB} =$ $\qquad$ $M_{BC} =$ $\qquad$ $M_{CD} =$

| |
|---|
| $V_A$ = ……………………; $H_A$ = ……………………; $Vc$ = …………………… . |

**Esercizio n.5** (3 punti)

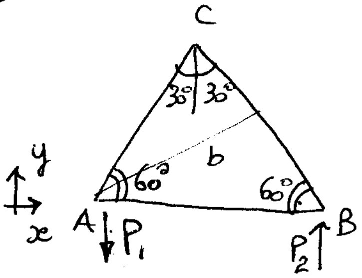
Si consideri la struttura data in figura con i rispettivi vincoli. Si indichi quali azioni e' necessario applicare nei punti *A*,*B* e *C* per ottenere la distribuzione di momento flettente data in figura.




| | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| TOT | |

# I RECUPERO DEL 14.07.04

①




$A \equiv (0,0)$
$B \equiv (L,0)$
$C \equiv \left(\frac{L}{2}, \frac{\sqrt{3}}{2}L\right)$

$b = \frac{\sqrt{3}}{2}L$

$\vec{F}_1 = F\vec{i}$

$\vec{F}_2 = -F\cos 60°\,\vec{i} + F\sin 60°\,\vec{j} = -\frac{1}{2}F\vec{i} + \frac{\sqrt{3}}{2}F\vec{j}$

$\vec{F}_3 = -F\sin 30°\,\vec{i} - F\cos 60°\,\vec{j} = -\frac{1}{2}F\vec{i} - \frac{\sqrt{3}}{2}F\vec{j}$

1. $F_{1x} = F \qquad F_{2x} = -\frac{1}{2}F \qquad F_{3x} = -\frac{1}{2}F$

   $F_{1y} = 0 \qquad F_{2y} = +\frac{\sqrt{3}}{2}F \qquad F_{3y} = -\frac{\sqrt{3}}{2}F$

2. $\vec{R} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3$

   $\vec{R} = R_x\vec{i} + R_y\vec{j}$

   $\left.\begin{aligned} R_x &= F_{1x} + F_{2x} + F_{3x} = F - \frac{1}{2}F - \frac{1}{2}F = 0 \\ R_y &= F_{1y} + F_{2y} + F_{3y} = 0 + \frac{\sqrt{3}}{2}F - \frac{\sqrt{3}}{2}F = 0 \end{aligned}\right\} \Rightarrow \vec{R} = \vec{0}\ !$

3. $\circlearrowleft M_{z(A)} = +F_2 b = +F_{2y}\cdot L = \frac{\sqrt{3}}{2}FL$

   $\circlearrowleft M_{z(B)} = +F_3 b = -F_{3y}\cdot\frac{L}{2} - F_{3x}\cdot\frac{\sqrt{3}}{2}L = \frac{\sqrt{3}}{2}F\cdot\frac{L}{2} + \frac{F}{2}\cdot\frac{\sqrt{3}}{2}L = 2\frac{\sqrt{3}}{4}FL = \frac{\sqrt{3}}{2}FL$

   $\circlearrowleft M_{z(C)} = +F_1\cdot b = F_{1x}\cdot\frac{\sqrt{3}}{2}L = \frac{\sqrt{3}}{2}FL$

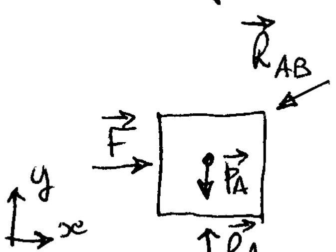
4. $\vec{P}_2 = P_2\vec{j} \qquad \vec{P}_1 = -P_1\vec{j}$

   $\vec{R} = \vec{0} \iff \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \vec{P}_1 + \vec{P}_2 = 0 \qquad \vec{P}_1 + \vec{P}_2 = 0 \qquad \vec{P}_1 = -\vec{P}_2$

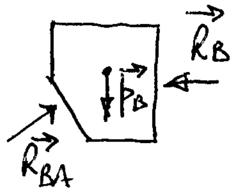
   $M_{z(A)} = 0 \iff F_2 b + P_2\cdot L = 0 \qquad P_2 = -F_2\frac{b}{L} = -F_2\cdot\frac{\sqrt{3}}{2}\frac{L}{L} = -F\frac{\sqrt{3}}{2}$

$|\vec{P}_2| = |\vec{P}_1| = |\vec{P}| = +F\frac{\sqrt{3}}{2} \quad , \quad F = |\vec{F}|$

② Diagrammi di corpo libero:




"A"




"B"

$\vec{P}_B = -m_B g\vec{j}$

$\vec{R}_B = -R_B\vec{i}$

$\vec{R}_{BA} = +R_{AB}\left(\frac{\sqrt{2}}{2}\vec{i} + \frac{\sqrt{2}}{2}\vec{j}\right)$

NB: $\vec{R}_{BA} = -\vec{R}_{AB}$ perché sono forze interne $\Rightarrow$ vale principio di azione e reazione

$\vec{F} = F\vec{i}$

$\vec{P}_A = -m_A g\vec{j}$

$\vec{R}_A = +R_A\vec{j}$

$\vec{R}_{AB} = -R_{AB}\left(\frac{\sqrt{2}}{2}\vec{i} + \frac{\sqrt{2}}{2}\vec{j}\right)$

Equilibrio p.m. "A":

$$\begin{cases} R_x^{(A)} = 0 & F - R_{AB}\frac{\sqrt{2}}{2} = 0 \quad [1] \\ R_y^{(A)} = 0 & -m_A g + R_A - R_{AB}\frac{\sqrt{2}}{2} = 0 \quad [2] \end{cases}$$

Equilibrio p.m. "B":

$$\begin{cases} R_x^{(B)} = 0 & R_{AB} \cdot \frac{\sqrt{2}}{2} - R_B = 0 \quad [3] \\ R_y^{(B)} = 0 & R_{AB} \cdot \frac{\sqrt{2}}{2} - m_B g = 0 \quad [4] \end{cases}$$

Per [4]: $R_{AB} = m_B g \cdot \frac{2}{\sqrt{2}} = \sqrt{2} m_B g$

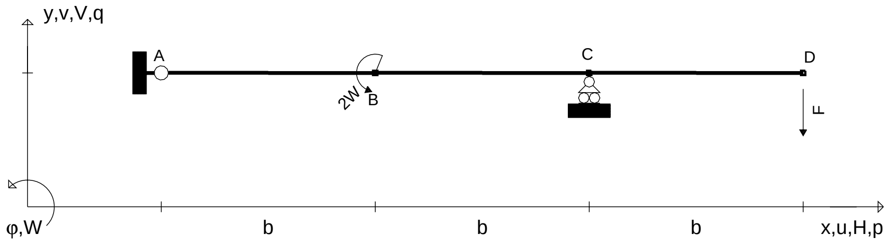
Per [3]: $R_B = \frac{\sqrt{2}}{2}(\sqrt{2} m_B g) = m_B g$

Per [2]: $R_A = m_A g + m_B g \sqrt{2} \cdot \frac{\sqrt{2}}{2} = (m_A + m_B) g$

Per [1]: $F = R_{AB} \cdot \frac{\sqrt{2}}{2} = \sqrt{2} m_B g \cdot \frac{\sqrt{2}}{2} = m_B g$

| Esercizio 1 | | Testo 1 | Testo 2 | Testo 3 | Testo 4 |
|---|---|---|---|---|---|
| F | [N] | 200 | 400 | 1400 | 1200 |
| L | [mm] | 200 | 100 | 400 | 300 |
| **F_1x** | **[N]** | **200.000** | **400.000** | **1400.000** | **1200.000** |
| **F_1y** | **[N]** | **0.000** | **0.000** | **0.000** | **0.000** |
| **F_2x** | **[N]** | **-100.000** | **-200.000** | **-700.000** | **-600.000** |
| **F_2y** | **[N]** | **173.205** | **346.410** | **1212.436** | **1039.230** |
| **F_3x** | **[N]** | **-100.000** | **-200.000** | **-700.000** | **-600.000** |
| **F_3y** | **[N]** | **-173.205** | **-346.410** | **-1212.436** | **-1039.230** |
| **R_x** | **[N]** | **0.000** | **0.000** | **0.000** | **0.000** |
| **R_y** | **[N]** | **0.000** | **0.000** | **0.000** | **0.000** |
| **\|P\|** | **[N]** | **173.205** | **346.410** | **1212.436** | **1039.230** |
| **M_A** | **[N·mm]** | **34641.016** | **34641.016** | **484974.226** | **311769.145** |
| **M_B** | **[N·mm]** | **34641.016** | **34641.016** | **484974.226** | **311769.145** |
| **M_C** | **[N·mm]** | **34641.016** | **34641.016** | **484974.226** | **311769.145** |

| Esercizio 2 | | Testo 1 | Testo 2 | Testo 3 | Testo 4 |
|---|---|---|---|---|---|
| m_A | [kg] | 42 | 24 | 124 | 142 |
| m_B | [kg] | 50 | 30 | 80 | 60 |
| g | [m/s^2] | 9.81 | 9.81 | 9.81 | 9.81 |
| **F** | **[N]** | **490.500** | **294.300** | **784.800** | **588.600** |
| **R_A** | **[N]** | **902.520** | **529.740** | **2001.240** | **1981.620** |
| **R_B** | **[N]** | **490.500** | **294.300** | **784.800** | **588.600** |
| **R_AB** | **[N]** | **693.672** | **416.203** | **1109.875** | **832.406** |




$V_D = -F$ $EJ_{AB} = EJ$ $EJ_{CD} = EJ$

$W_B = 2W = 2Fb$ $EJ_{BC} = EJ$

Verso effettivo dei carichi riportato nel disegno.
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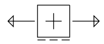
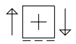
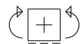
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

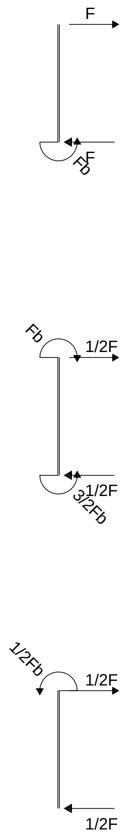
MANTENERE I RISULTATI IN FORMA FRAZIONARIA

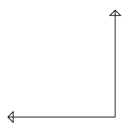










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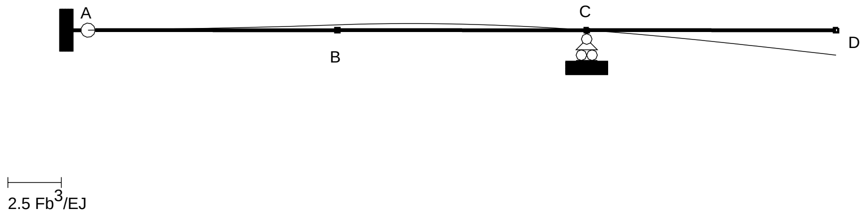
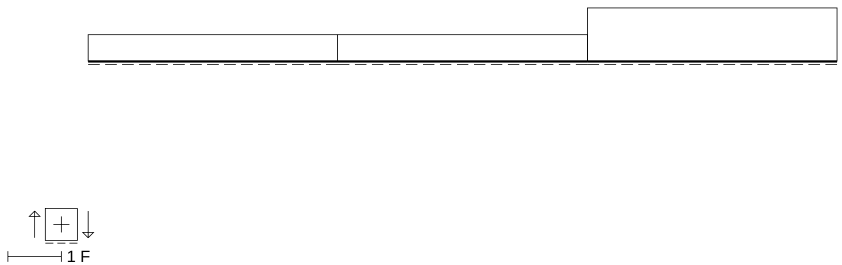
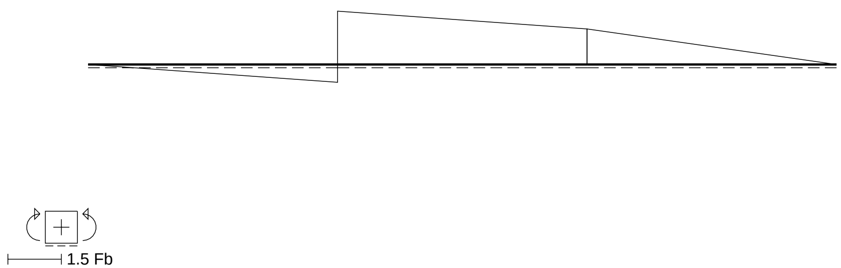


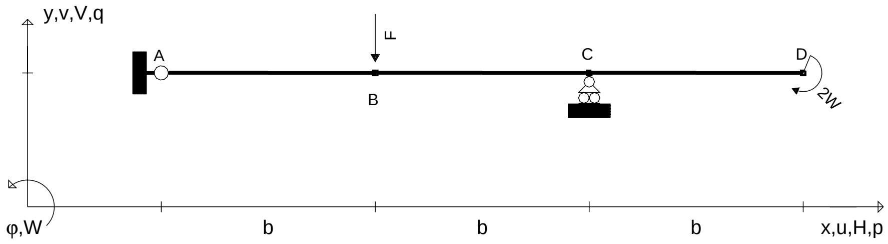



AZIONI INTERNE (coordinate locali)

$N_{AB}$ = 0
$T_{AB}$ = 1/2F
$M_{AB}$ = 1/2Fx

$N_{BC}$ = 0
$T_{BC}$ = 1/2F
$M_{BC}$ = -3/2Fb +1/2Fx

$N_{CD}$ = 0
$T_{CD}$ = F
$M_{CD}$ = -Fb +Fx



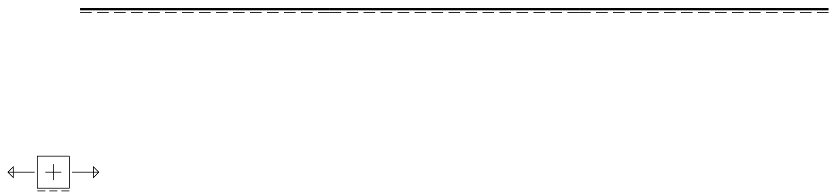

$V_B$ = -F    $EJ_{AB}$ = EJ    $EJ_{CD}$ = EJ

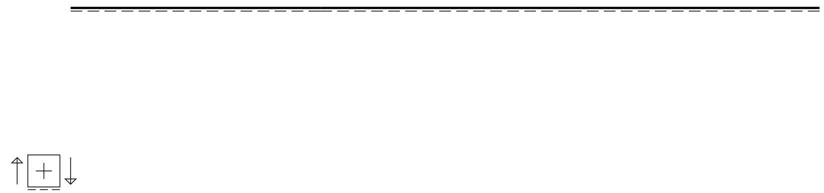
$W_D$ = -2W = -2Fb    $EJ_{BC}$ = EJ

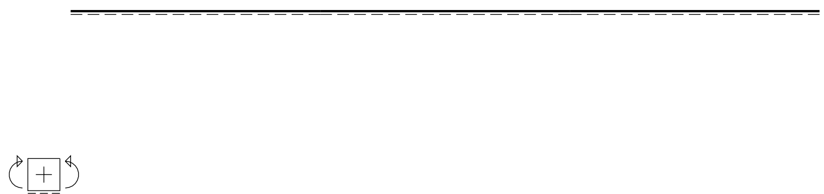
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

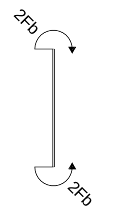
MANTENERE I RISULTATI IN FORMA FRAZIONARIA

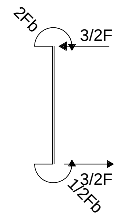


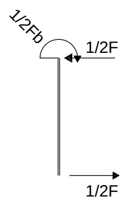


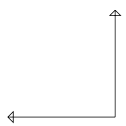




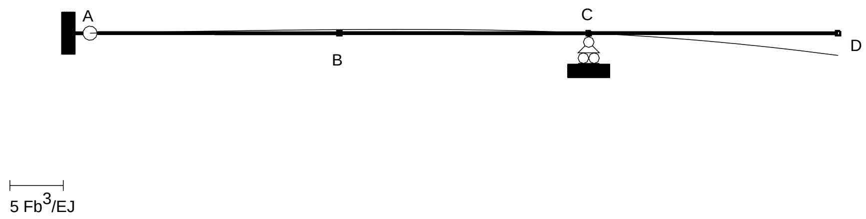

2Fb
2Fb

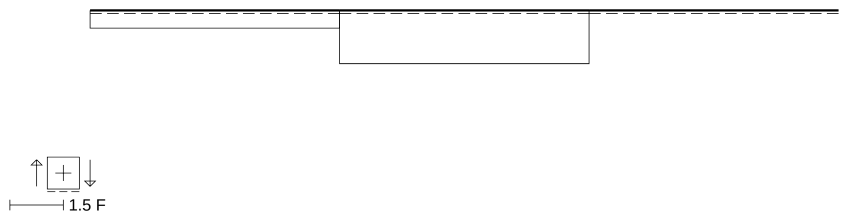

2Fb
3/2F
3/2F
1/2Fb

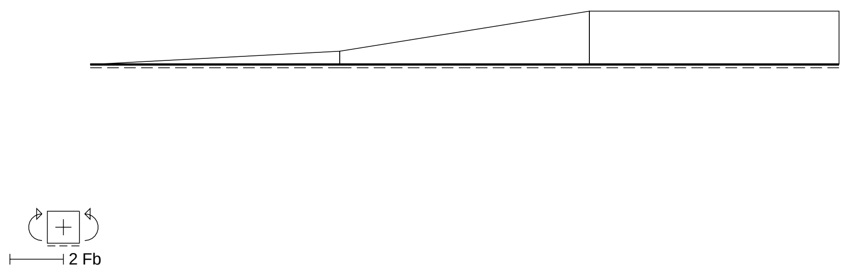

1/2Fb
1/2F
1/2F





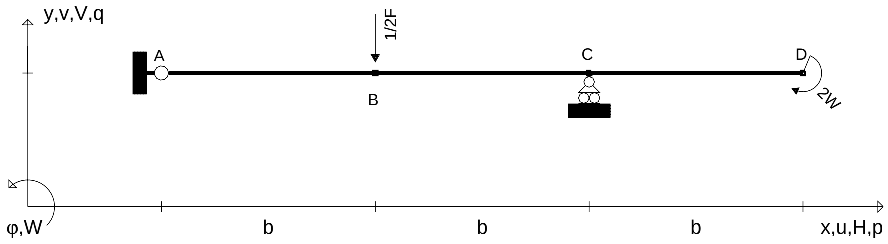

A
B
C
D
5 Fb3/EJ


1.5 F


2 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 0$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = -1/2F$ | $T_{BC} = -3/2F$ | $T_{CD} = 0$ |
| $M_{AB} = -1/2Fx$ | $M_{BC} = -1/2Fb -3/2Fx$ | $M_{CD} = -2Fb$ |




$V_B$ = -1/2F

$W_D$ = -2W = -2Fb

$EJ_{AB}$ = EJ

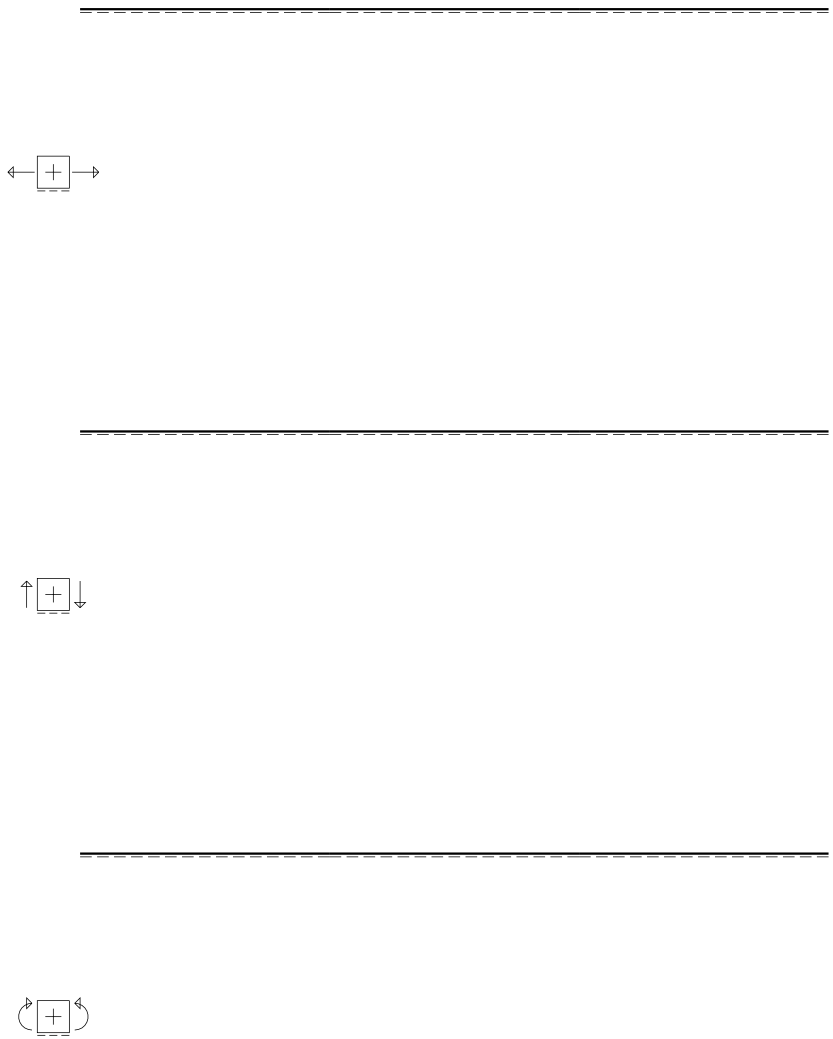
$EJ_{BC}$ = EJ

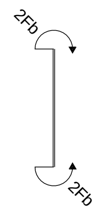
$EJ_{CD}$ = EJ

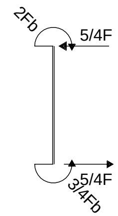
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

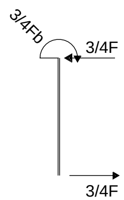
MANTENERE I RISULTATI IN FORMA FRAZIONARIA

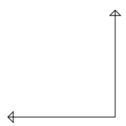




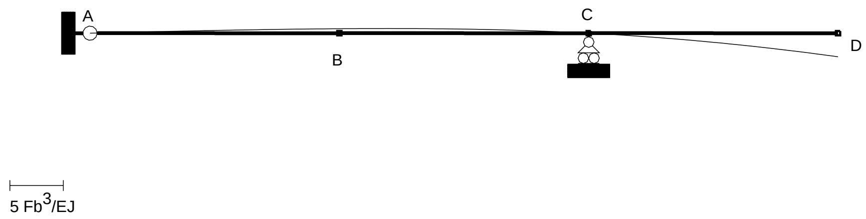

2Fb
2Fb

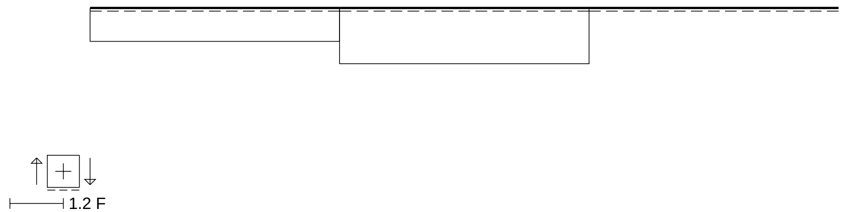

2Fb
5/4F
5/4F
3/4Fb

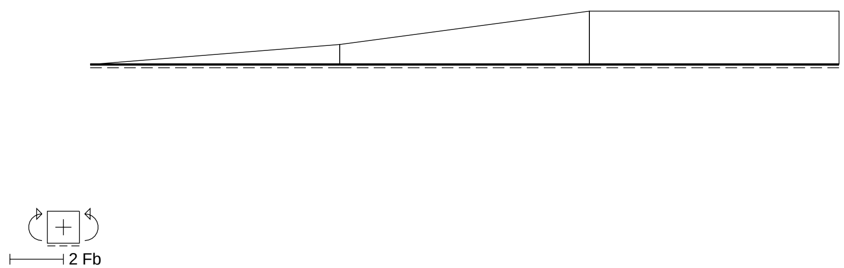

3/4Fb
3/4F
3/4F





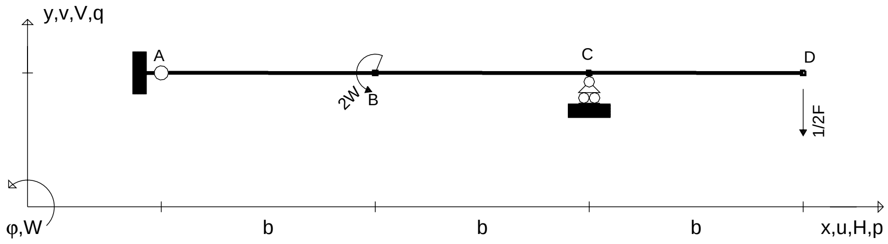

A
C
B
D
5 Fb3/EJ


1.2 F


2 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB}$ = 0 | $N_{BC}$ = 0 | $N_{CD}$ = 0 |
| $T_{AB}$ = -3/4F | $T_{BC}$ = -5/4F | $T_{CD}$ = 0 |
| $M_{AB}$ = -3/4Fx | $M_{BC}$ = -3/4Fb -5/4Fx | $M_{CD}$ = -2Fb |



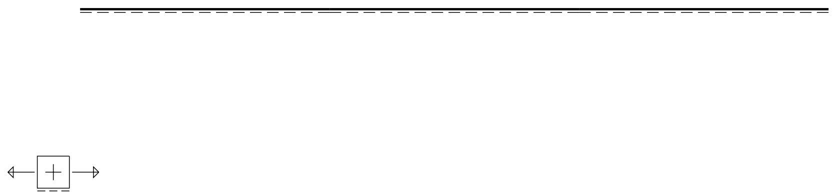

$V_D = -1/2F$ $EJ_{AB} = EJ$ $EJ_{CD} = EJ$

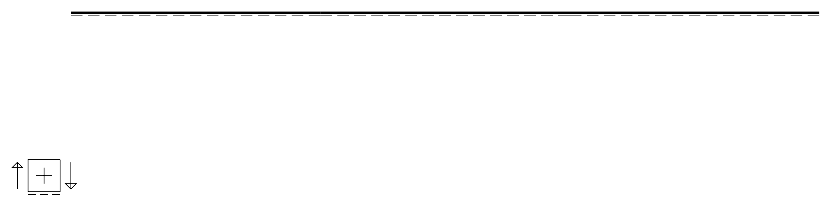
$W_B = 2W = 2Fb$ $EJ_{BC} = EJ$

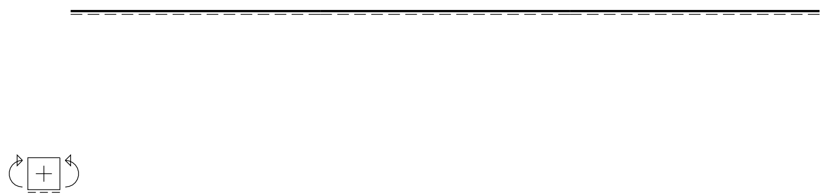
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

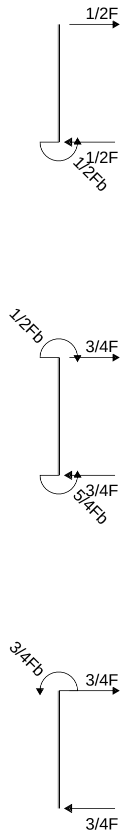
MANTENERE I RISULTATI IN FORMA FRAZIONARIA

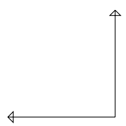




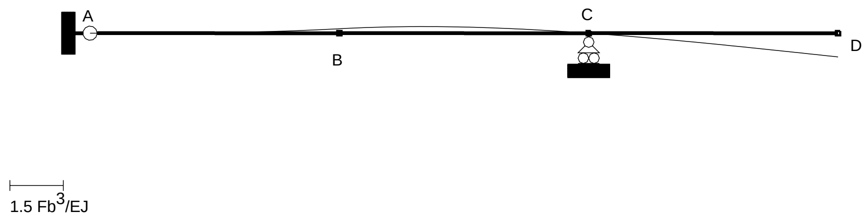


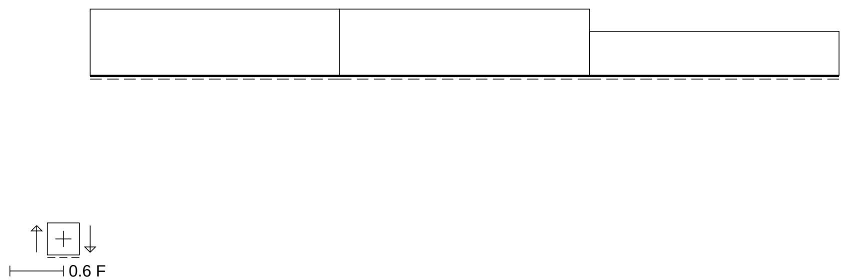


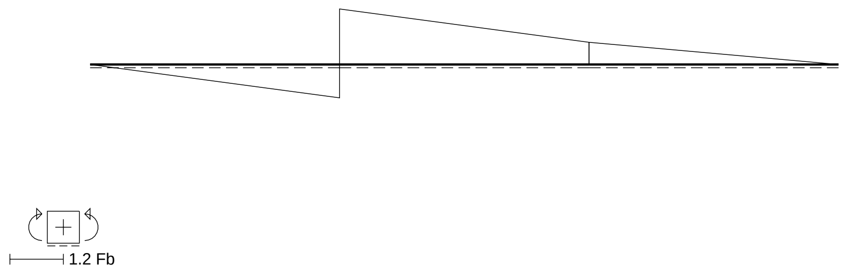

1/2F
1/2F
1/2Fb
1/2Fb
3/4F
3/4F
5/4Fb
3/4Fb
3/4F
3/4F





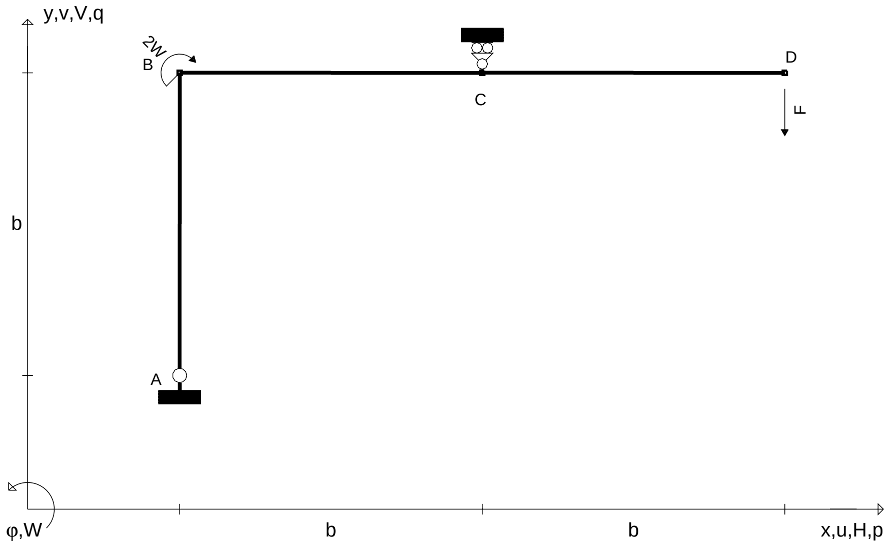

A
B
C
D
1.5 Fb^3/EJ


0.6 F


1.2 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB}$ = 0 | $N_{BC}$ = 0 | $N_{CD}$ = 0 |
| $T_{AB}$ = 3/4F | $T_{BC}$ = 3/4F | $T_{CD}$ = 1/2F |
| $M_{AB}$ = 3/4Fx | $M_{BC}$ = -5/4Fb +3/4Fx | $M_{CD}$ = -1/2Fb +1/2Fx |




$V_D$ = -F
$W_B$ = -2W = -2Fb

$EJ_{AB}$ = EJ
$EJ_{BC}$ = EJ

$EJ_{CD}$ = EJ

Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
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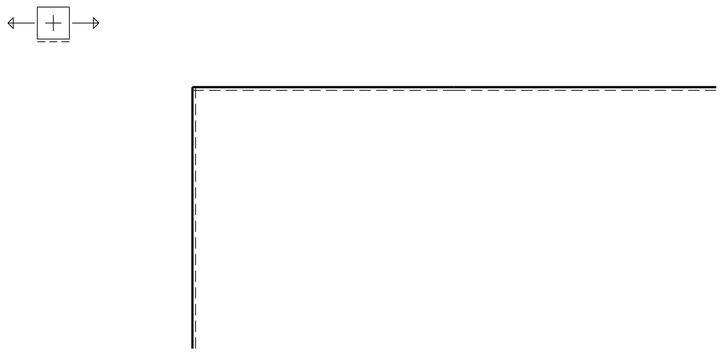
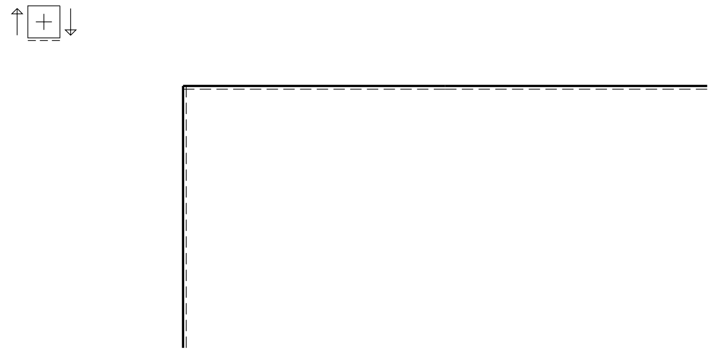
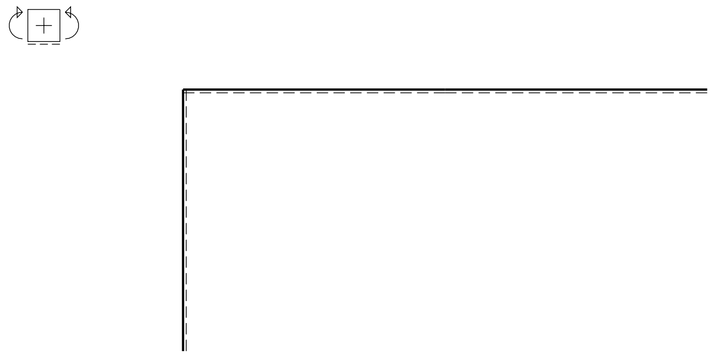
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

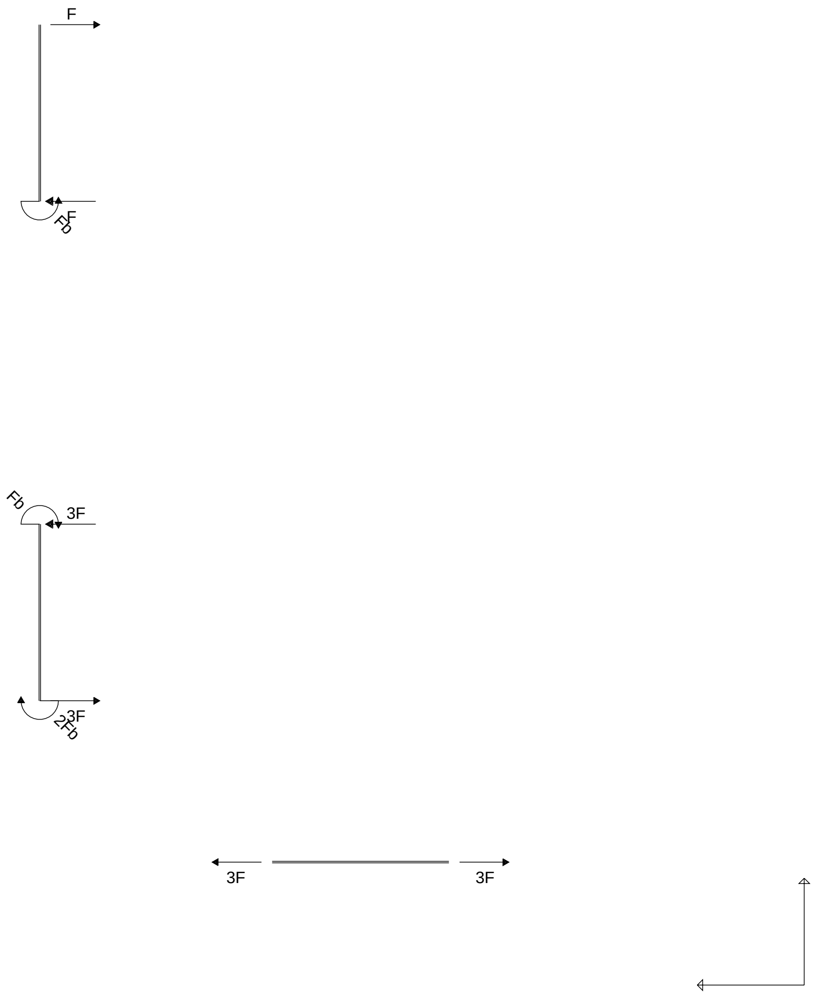
MANTENERE I RISULTATI IN FORMA FRAZIONARIA



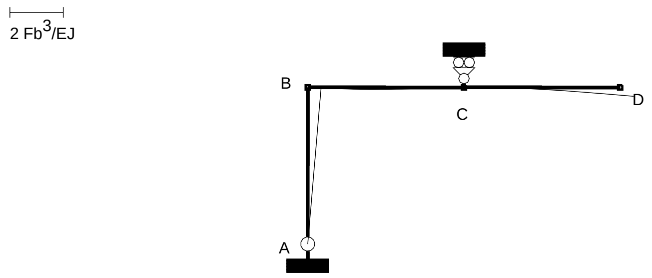


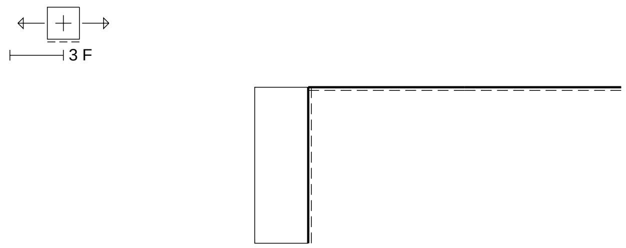


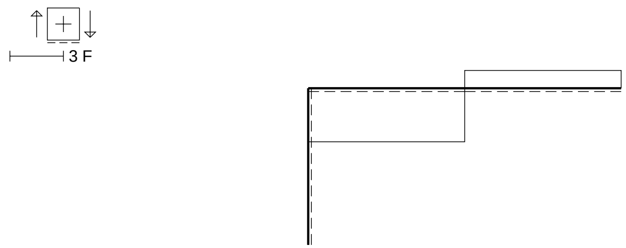


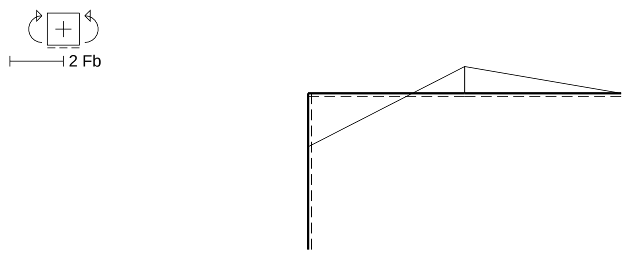

F
F
Fb
Fb
3F
3F
2Fb
3F
3F




2 Fb$^3$/EJ
B
C
D
A

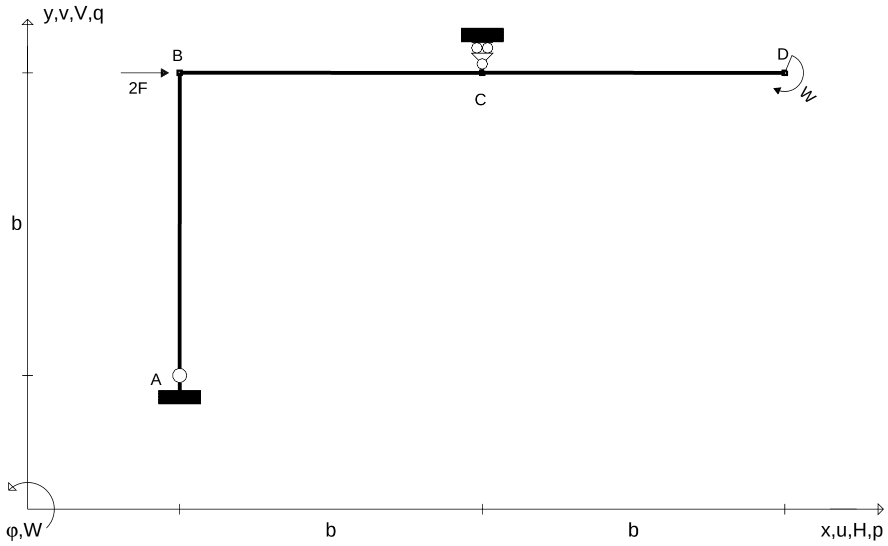

3 F


3 F


2 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 3F$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = 0$ | $T_{BC} = -3F$ | $T_{CD} = F$ |
| $M_{AB} = 0$ | $M_{BC} = 2Fb - 3Fx$ | $M_{CD} = -Fb + Fx$ |




$H_B = 2F$ $W_D = -W = -Fb$ $EJ_{AB} = EJ$ $EJ_{BC} = EJ$ $EJ_{CD} = EJ$

Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
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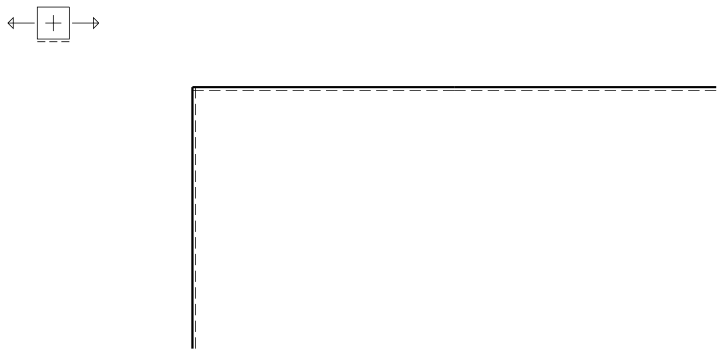
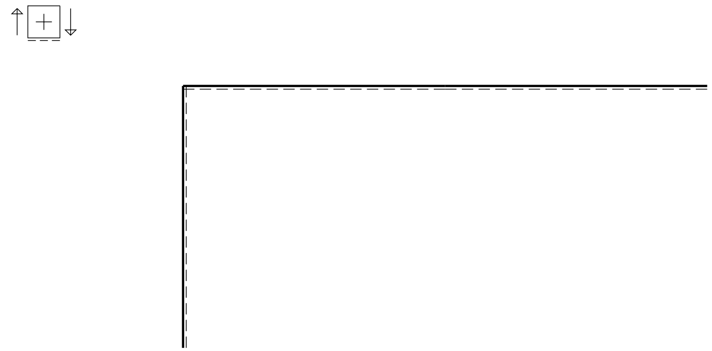
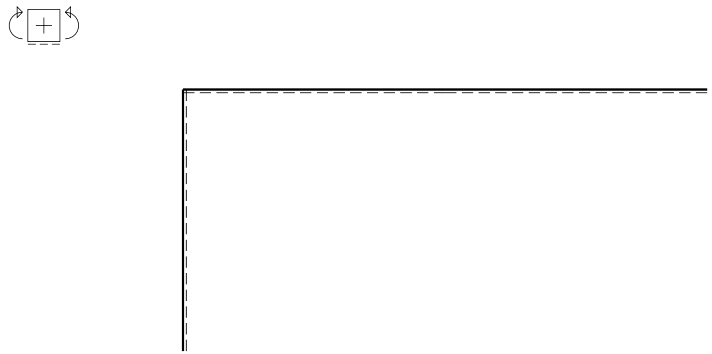
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

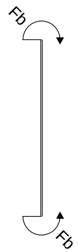
MANTENERE I RISULTATI IN FORMA FRAZIONARIA

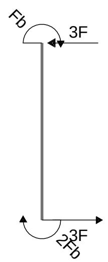


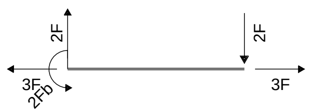


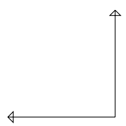




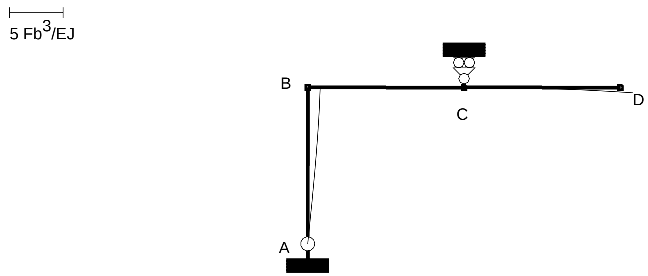

Fb
Fb

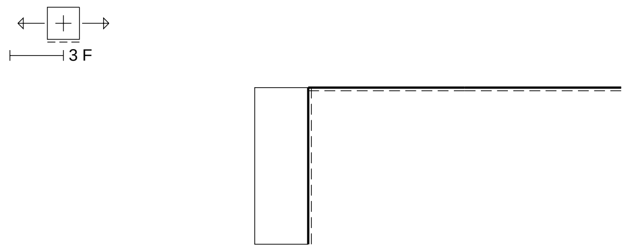

Fb
3F
3F
2Fb

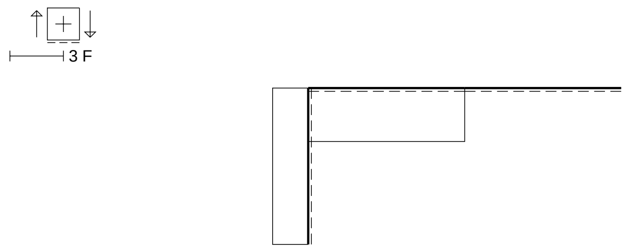

2F
2F
3F
2Fb
3F

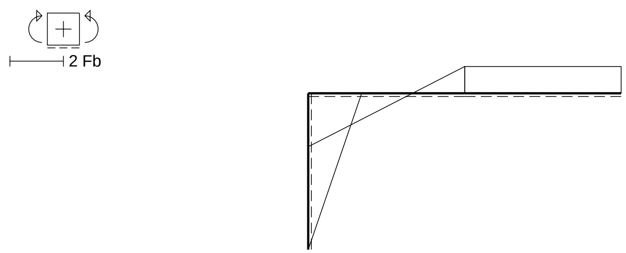





5 Fb3/EJ
B
C
D
A

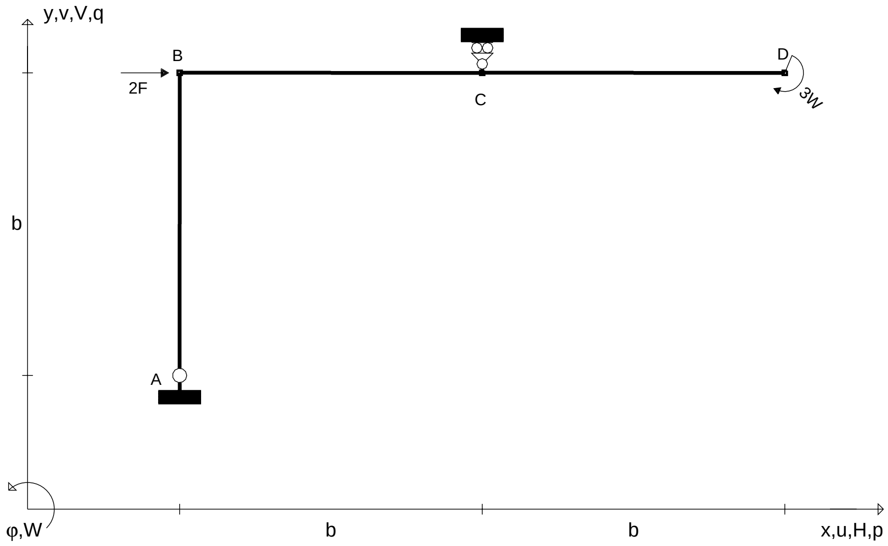

3 F


3 F


2 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 3F$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = 2F$ | $T_{BC} = -3F$ | $T_{CD} = 0$ |
| $M_{AB} = 2Fx$ | $M_{BC} = 2Fb - 3Fx$ | $M_{CD} = -Fb$ |



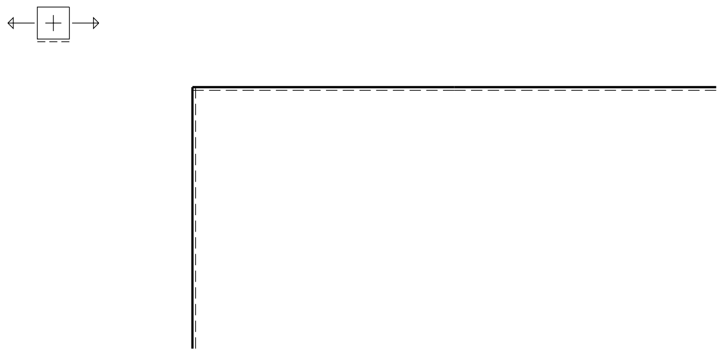

$H_B = 2F$ $EJ_{AB} = EJ$ $EJ_{CD} = EJ$

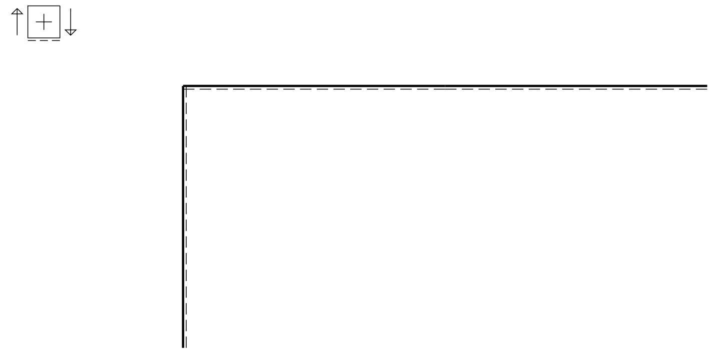
$W_D = -3W = -3Fb$ $EJ_{BC} = EJ$

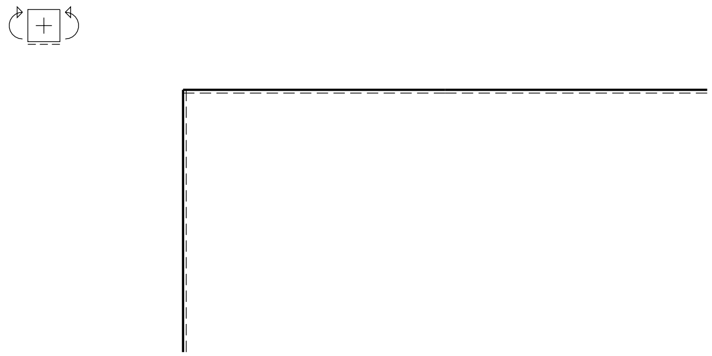
Verso effettivo dei carichi riportato nel disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.
Esprimere le funzioni delle azioni interne nelle aste.
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

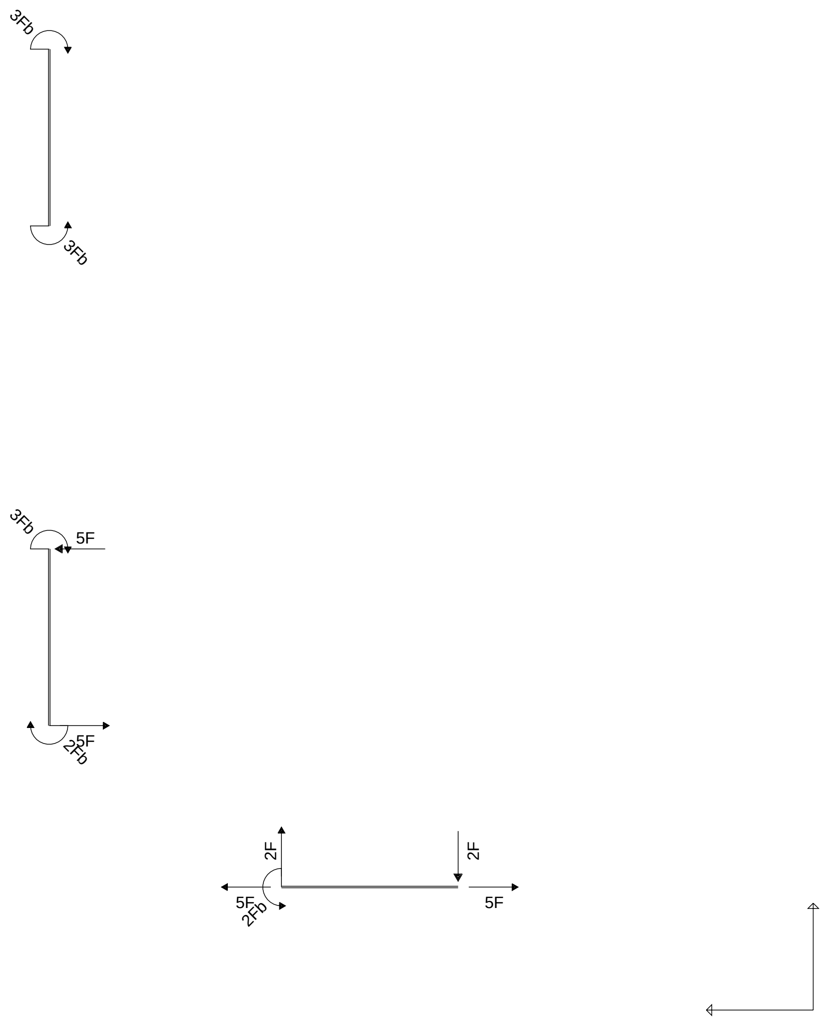
MANTENERE I RISULTATI IN FORMA FRAZIONARIA



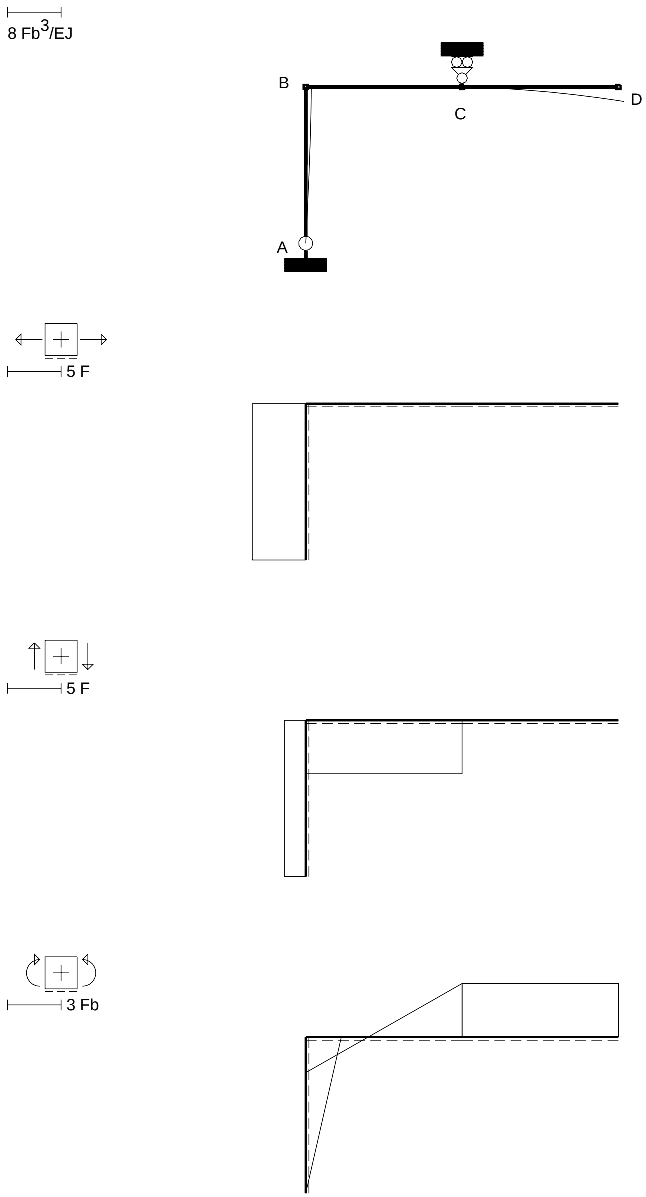






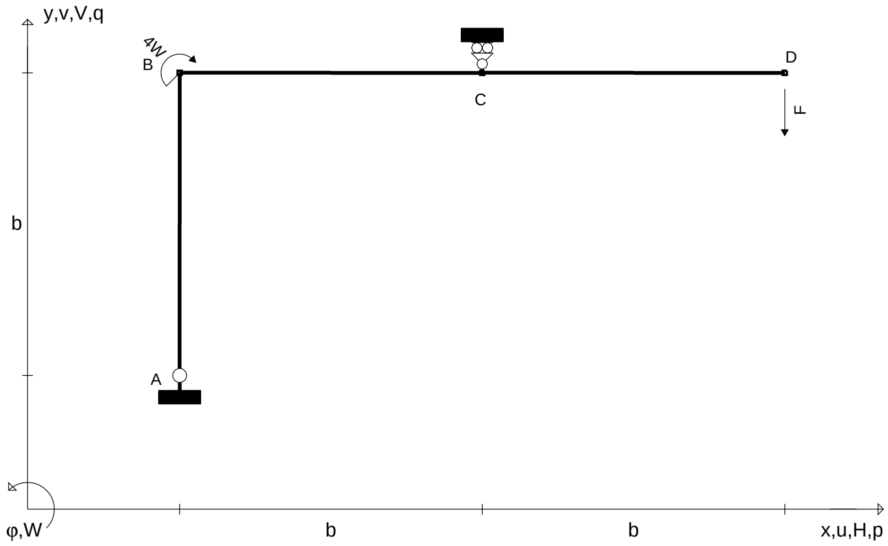

3Fb
3Fb
3Fb
5F
5F
2Fb
2F
2F
5F
2Fb
5F




8 Fb3/EJ
B
C
D
A
5 F
5 F
3 Fb

AZIONI INTERNE (coordinate locali)

| | | |
|---|---|---|
| $N_{AB} = 5F$ | $N_{BC} = 0$ | $N_{CD} = 0$ |
| $T_{AB} = 2F$ | $T_{BC} = -5F$ | $T_{CD} = 0$ |
| $M_{AB} = 2Fx$ | $M_{BC} = 2Fb - 5Fx$ | $M_{CD} = -3Fb$ |




$V_D$ = -F
$W_B$ = -4W = -4Fb
$EJ_{AB}$ = EJ
$EJ_{BC}$ = EJ
$EJ_{CD}$ = EJ

Verso effettivo dei carichi riportato nel disegno.
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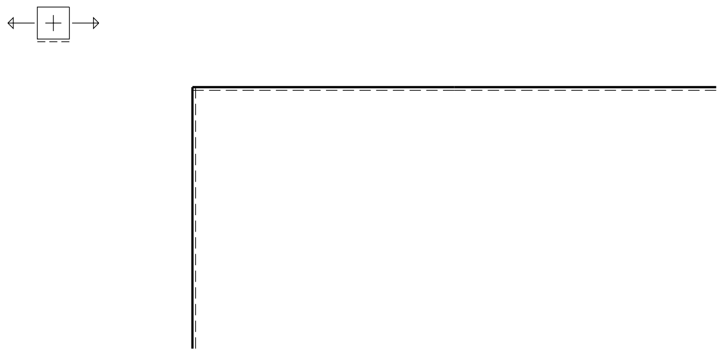
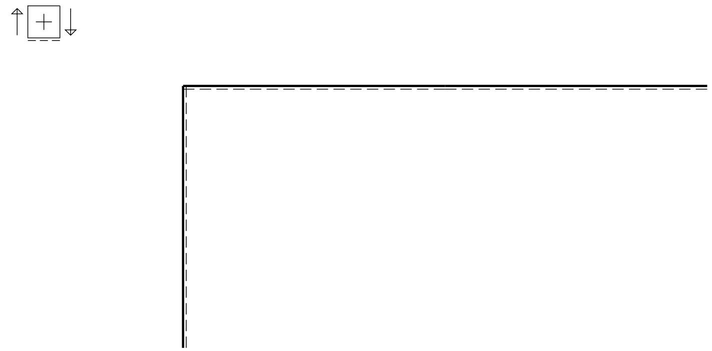
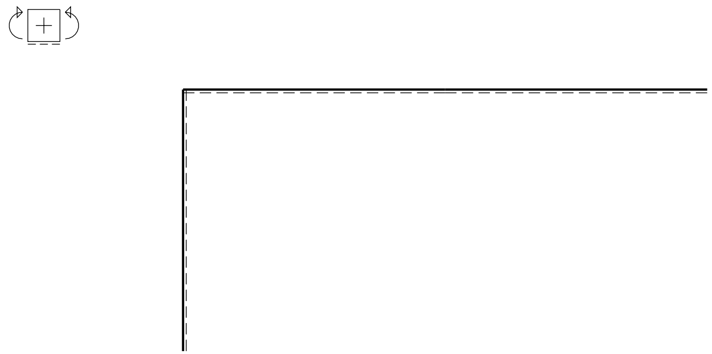
$J_{AB}$ $x_{AB}$ $\vartheta_{AB}$ riferimento locale asta AB con origine in A.

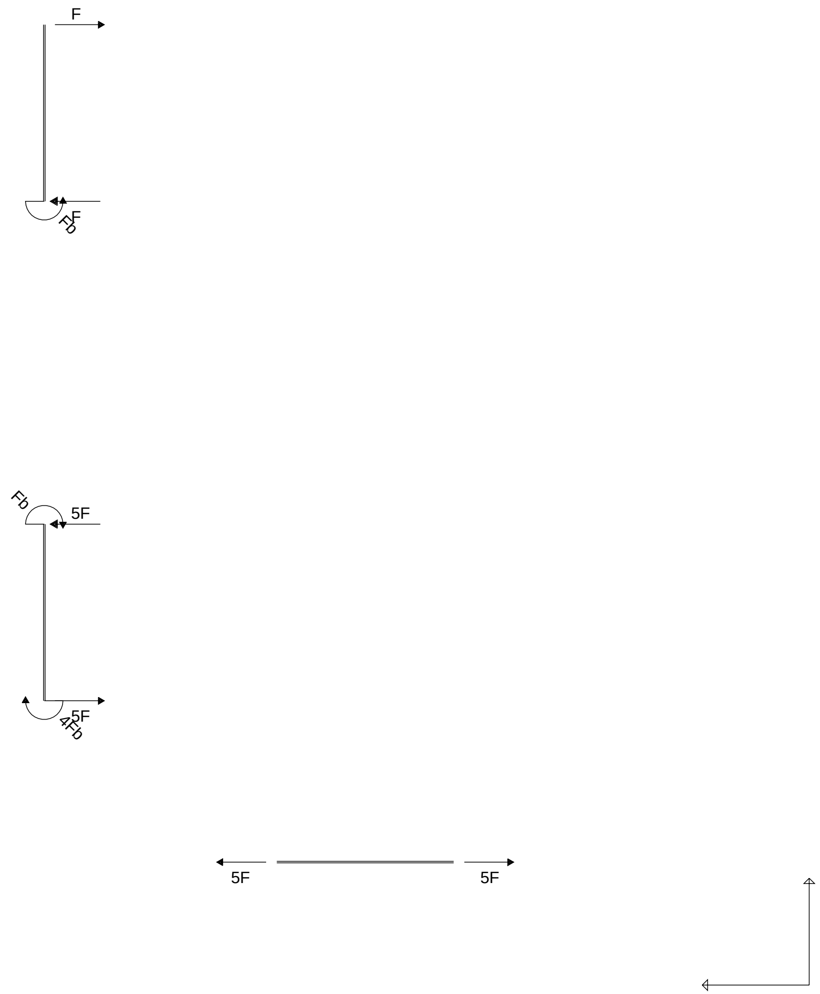
MANTENERE I RISULTATI IN FORMA FRAZIONARIA



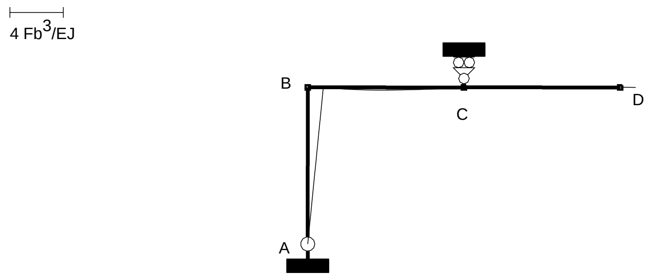


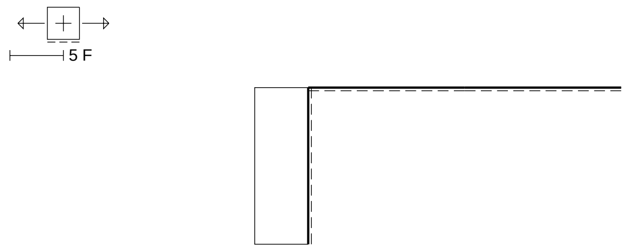


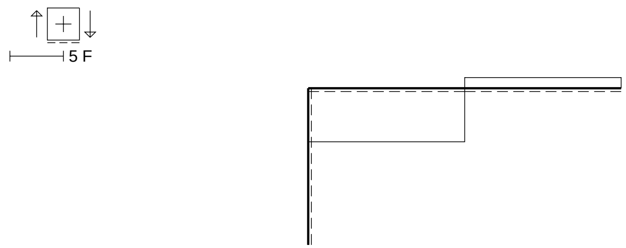


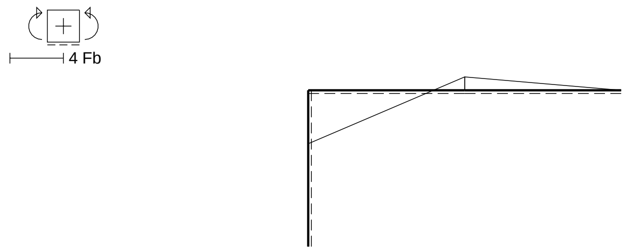

F
F
Fb
Fb
5F
5F
4Fb
5F
5F




4 Fb$^3$/EJ
B
C
D
A


5 F


5 F


4 Fb

AZIONI INTERNE (coordinate locali)

$N_{AB} = 5F$ $N_{BC} = 0$ $N_{CD} = 0$
$T_{AB} = 0$ $T_{BC} = -5F$ $T_{CD} = F$
$M_{AB} = 0$ $M_{BC} = 4Fb - 5Fx$ $M_{CD} = -Fb + Fx$