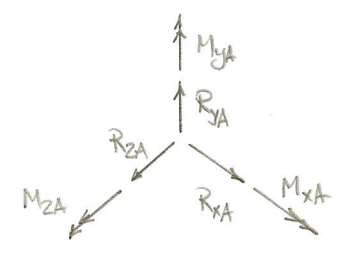


Reações de apoio em A:



$$\sum F_x = 0: -30 - 10 \cdot 2 + R_{xA} = 0 \Rightarrow R_{xA} = 50 \text{ kN}$$

$$\sum F_y = 0: R_{yA} - 20 = 0 \Rightarrow R_{yA} = 20 \text{ kN}$$

$$\sum F_z = 0: R_{zA} - 10 \cdot 2 = 0 \Rightarrow R_{zA} = 20 \text{ kN}$$

$$\sum M_{xA} = 0: M_{xA} + 20 \cdot 2 - 2 \cdot 10 \cdot 1 = 0 \Rightarrow M_{xA} + 40 - 20 = 0 \Rightarrow M_{xA} = -20 \text{ kNm}$$

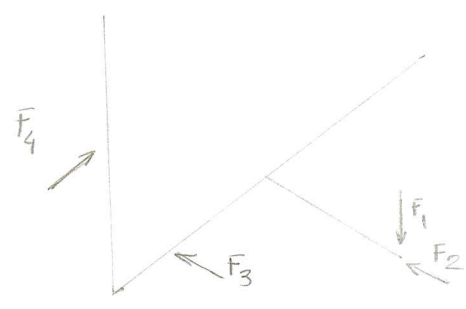
$$\sum M_{yA} = 0: M_{yA} - 30 \cdot 2 - 2 \cdot 10 \cdot 3 = 0 \Rightarrow M_{yA} = 120 \text{ kNm}$$

$$\sum M_{zA} = 0: M_{zA} - 20 \cdot 2 = 0 \Rightarrow M_{zA} = 40 \text{ kNm}$$

Método alternativo:

- $\vec{F}_1 = 20\vec{j}$ $\vec{r}_1 = 2\vec{i} + 2\vec{k}$
- $\vec{F}_2 = -30\vec{i}$ $\vec{r}_2 = 2\vec{i} + 2\vec{k}$
- $\vec{F}_3 = -20\vec{i}$ $\vec{r}_3 = 3\vec{k}$
- $\vec{F}_4 = -20\vec{k}$ $\vec{r}_4 = 1\vec{j} + 4\vec{k}$

$$\vec{M} = \sum_i \vec{r}_i \wedge \vec{F}_i$$

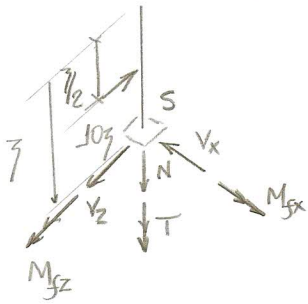


$$\begin{aligned} \vec{M} &= (2\vec{i} + 2\vec{k}) \wedge (-20\vec{j}) + (2\vec{i} + 2\vec{k}) \wedge (-30\vec{i}) + 3\vec{k} \wedge (-20\vec{i}) + (1\vec{j} + 4\vec{k}) \wedge (-20\vec{k}) = \\ &= -40\vec{k} + 40\vec{i} - 60\vec{j} - 60\vec{j} - 20\vec{i} = 20\vec{i} - 120\vec{j} - 40\vec{k} \end{aligned}$$

Logo: $M_{xA} = -20 \text{ kNm}$; $M_{yA} = 120 \text{ kNm}$; $M_{zA} = 40 \text{ kNm}$.

Diagramas:

Barra CD:



$$\sum F_x = 0: |V_x = 0|$$

$$\sum F_y = 0: |N = 0|$$

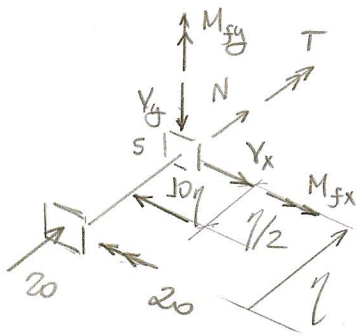
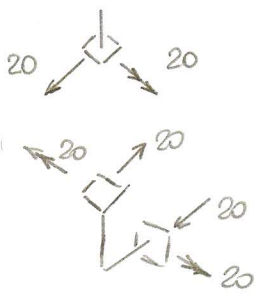
$$\sum F_z = 0: V_z - 103 = 0 \Rightarrow |V_z = 103|$$

$$\sum M_{S,x} = 0: M_{fx} - 103 \cdot \frac{7}{2} = 0 \Rightarrow |M_{fx} = 537^2| \text{ (}\oplus \text{ na frente)}$$

$$\sum M_{S,y} = 0: |T = 0|$$

$$\sum M_{S,z} = 0: |M_{fz} = 0|$$

Barra BC:



$$\sum F_x = 0: V_x - 107 = 0 \Rightarrow |V_x = 107|$$

$$\sum F_y = 0: |V_y = 0|$$

$$\sum F_z = 0: -20 - N = 0 \Rightarrow |N = -20 \text{ kN}|$$

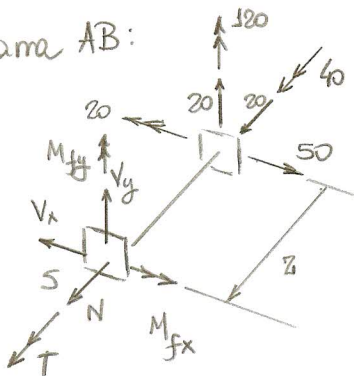
$$\sum M_{S,x} = 0: M_{fx} - 20 = 0 \Rightarrow |M_{fx} = 20 \text{ kNm}|$$

(⊕ em baixo)

$$\sum M_{S,y} = 0: M_{fy} - 107 \cdot \frac{7}{2} = 0 \Rightarrow |M_{fy} = 57^2| \text{ (}\oplus \text{ direito)}$$

$$\sum M_{S,z} = 0: |T = 0|$$

Barra AB:



$$\sum F_x = 0: -V_x + 50 = 0 \Rightarrow |V_x = 50 \text{ kN}|$$

$$\sum F_y = 0: V_y + 20 = 0 \Rightarrow |V_y = -20 \text{ kN}|$$

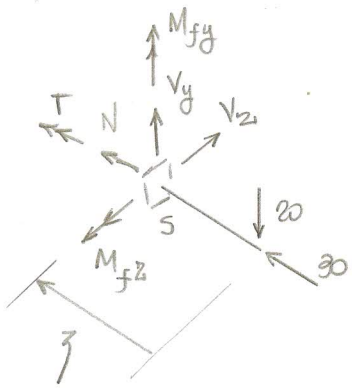
$$\sum F_z = 0: N + 20 = 0 \Rightarrow |N = -20 \text{ kN}|$$

$$\sum M_{S,x} = 0: M_{fx} - 20 + 20z = 0 \Rightarrow |M_{fx} = 20 - 20z| \text{ (}\oplus \text{ em cima)}$$

$$\sum M_{S,y} = 0: M_{fy} + 120 - 50z = 0 \Rightarrow |M_{fy} = 50z - 120| \text{ (}\oplus \text{ esquerda)}$$

$$\sum M_{S,z} = 0: T + 40 = 0 \Rightarrow |T = -40 \text{ kNm}|$$

Barras BE:



$$\sum F_x = 0: -N - 30 = 0 \Rightarrow \boxed{N = -30 \text{ kN}}$$

$$\sum F_y = 0: V_y - 20 = 0 \Rightarrow \boxed{V_y = 20 \text{ kN}}$$

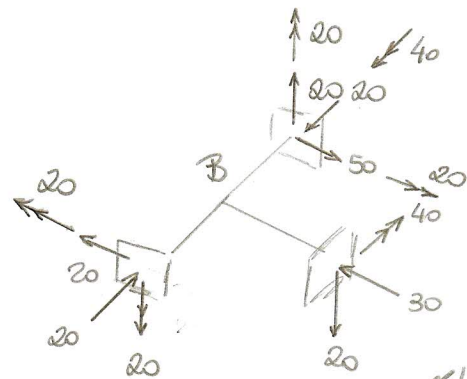
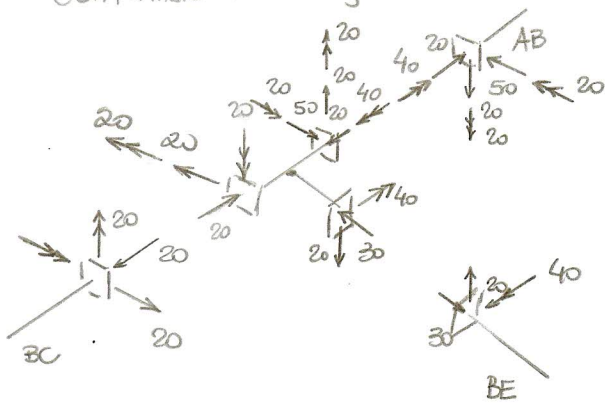
$$\sum F_z = 0: \boxed{V_z = 0}$$

$$\sum M_{S,x} = 0: \boxed{T = 0}$$

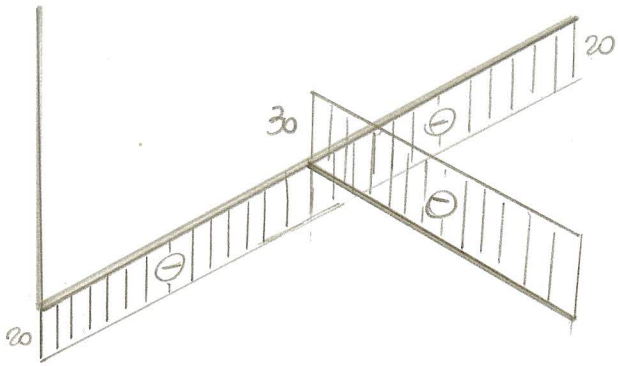
$$\sum M_{S,y} = 0: \boxed{M_{fy} = 0}$$

$$\sum M_{S,z} = 0: M_{fz} - 20z = 0 \Rightarrow \boxed{M_{fz} = 20z} \quad (\oplus \text{ em cima})$$

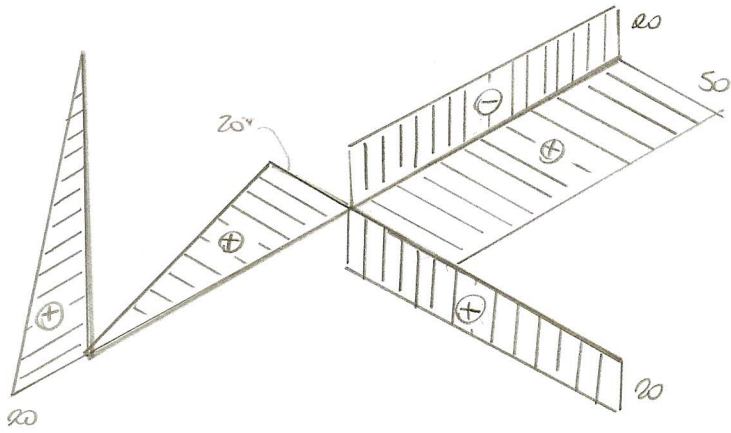
Conferindo os esforços em D:



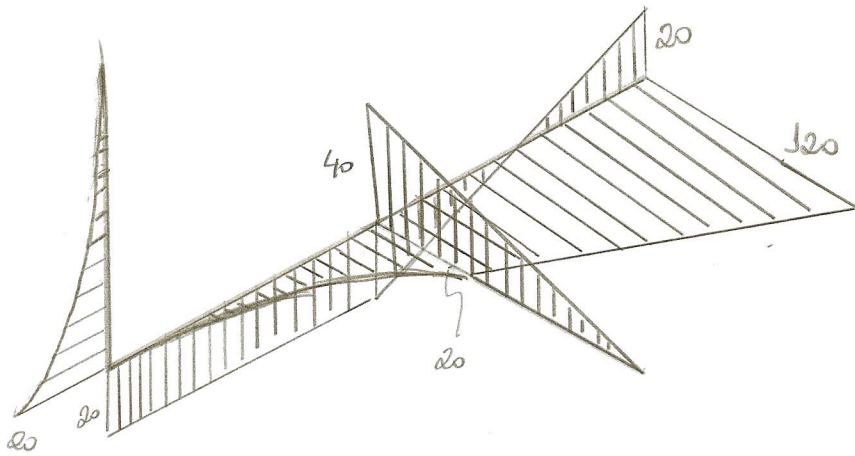
o seja, Basta em equilíbrio!



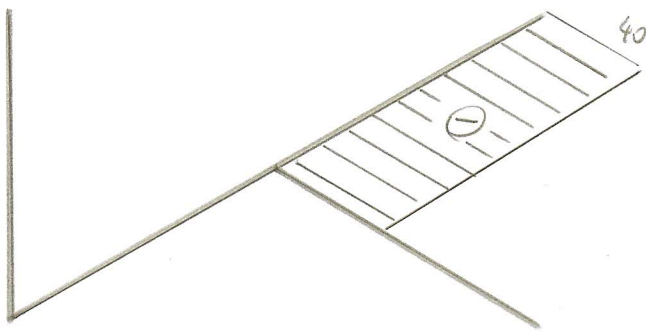
(N)



(V)



(M_f)



(T)