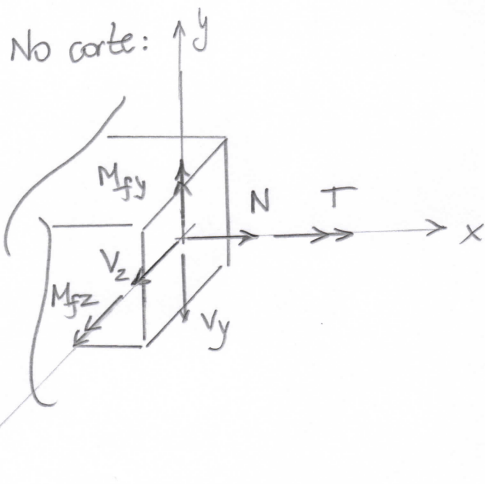
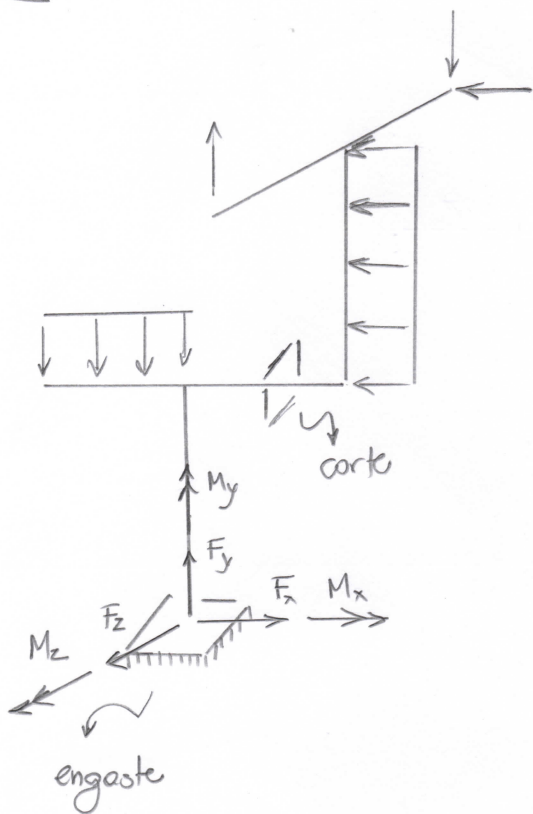


# Estruturas Tridimensionais



$N, V, M, T$ : esforços solicitantes

- $N$ : força normal
- $V$ : força cortante
- $M$ : momento fletor
- $T$ : momento torçor

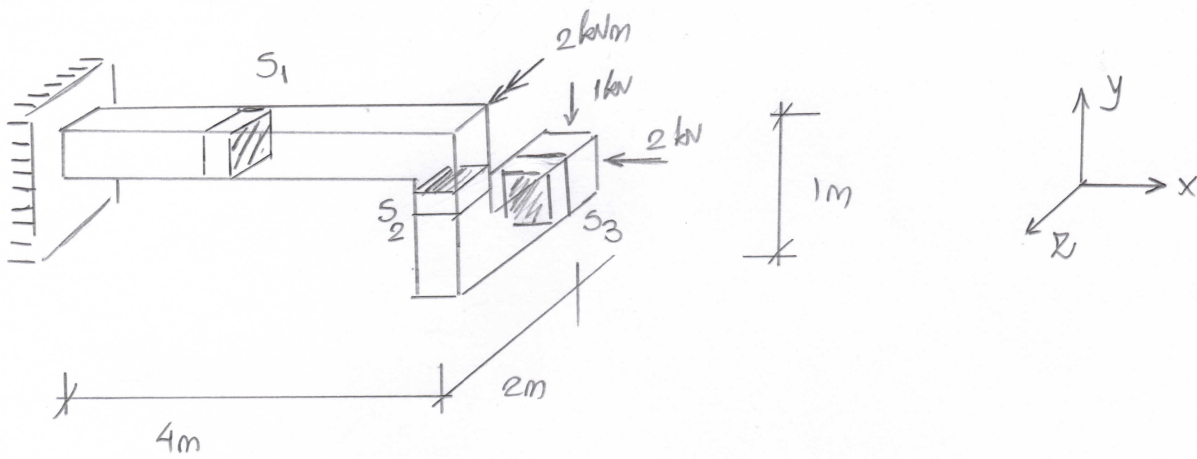
Convenções de sinais:

$N > 0$ : saindo da seção

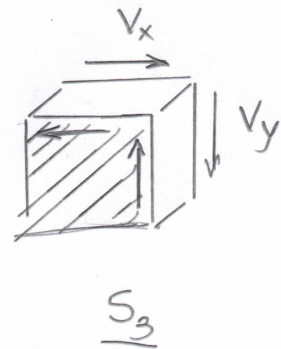
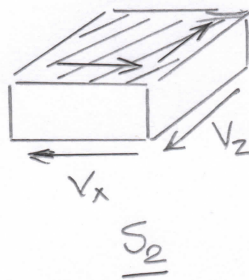
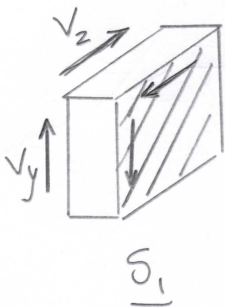
$T > 0$ : saindo da seção

$M_{fy}, M_{fz}$ : desenhado do lado tracionado

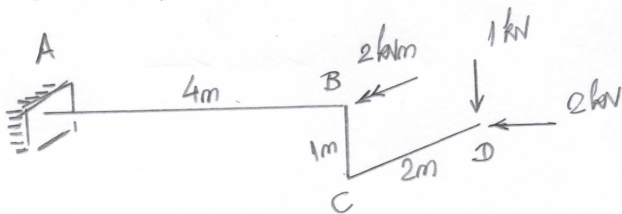
$V_y, V_z$ : positivas quando provocam um giro na seção transversal no sentido horário quando se está olhando no sentido contrário do eixo.



nas seções de corte ( $S_1, S_2, S_3$ ) as cortantes positivas são:

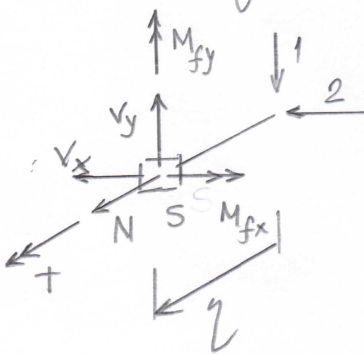


Podemos representar a estrutura anterior com barras:



Fazendo cortes:

- barra CD ( $0 < \eta < 2$ ):



$$\sum F_x = 0: V_x + 2 = 0 \Rightarrow \boxed{V_x = -2 \text{ kN}}$$

$$\sum F_y = 0: V_y - 1 = 0 \Rightarrow \boxed{V_y = 1 \text{ kN}}$$

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

$$\sum M_{S,x} = 0: M_{fx} - 1\eta = 0 \Rightarrow \boxed{M_{fx} = \eta}$$

⊕ em cima

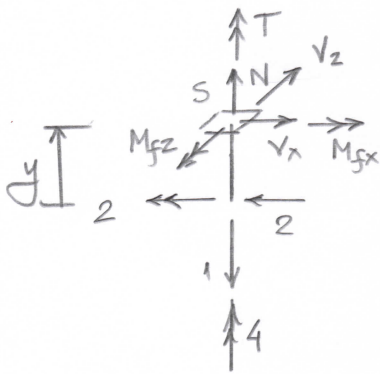
$$\sum M_{S,y} = 0: M_{fy} + 2\eta = 0 \Rightarrow \boxed{M_{fy} = -2\eta}$$

⊕ esquerda

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

- barra BC ( $0 < y < 1\text{m}$ )

\* transporte para C + corte:



$$\sum F_x = 0: V_x - 2 = 0 \Rightarrow \boxed{V_x = 2 \text{ kN}}$$

$$\sum F_y = 0: N - 1 = 0 \Rightarrow \boxed{N = 1 \text{ kN}}$$

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

$$\sum M_{S,x} = 0: M_{sx} - 2 = 0 \Rightarrow \boxed{M_{sx} = 2 \text{ kNm}}$$

⊕ atrás

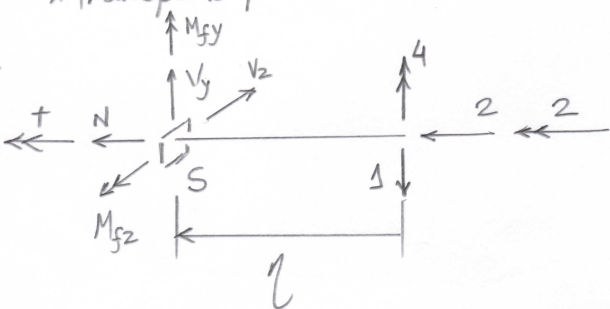
$$\sum M_{S,y} = 0: T + 4 = 0 \Rightarrow \boxed{T = -4 \text{ kNm}}$$

$$\sum M_{S,z} = 0: M_{sz} - 2y = 0 \Rightarrow \boxed{M_{sz} = 2y}$$

⊕ direita

- barra AB ( $0 < y < 4\text{m}$ ):

\* transporte para B + corte:



$$\sum F_x = 0: -N - 2 = 0 \Rightarrow \boxed{N = -2 \text{ kN}}$$

$$\sum F_y = 0: V_y - 1 = 0 \Rightarrow \boxed{V_y = 1 \text{ kN}}$$

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

$$\sum M_{S,x} = 0: -T - 2 = 0 \Rightarrow \boxed{T = -2 \text{ kNm}}$$

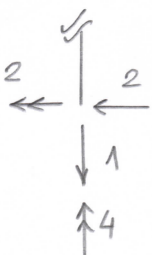
$$\sum M_{S,y} = 0: M_{sy} + 4 = 0 \Rightarrow \boxed{M_{sy} = -4 \text{ kNm}}$$

⊕ atrás

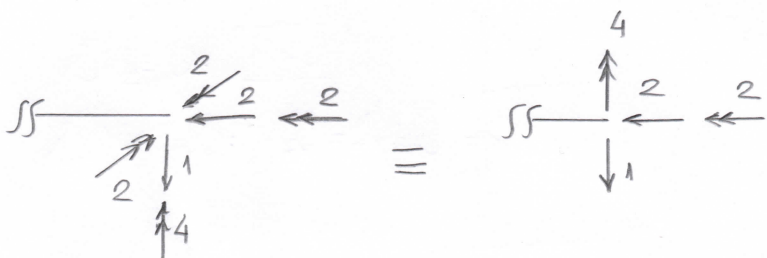
$$\sum M_{S,z} = 0: M_{sz} - 1 \cdot 1 = 0 \Rightarrow \boxed{M_{sz} = 1}$$

⊕ em cima

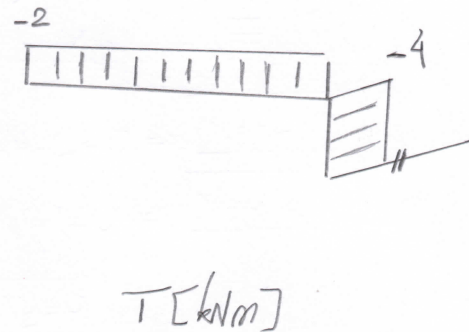
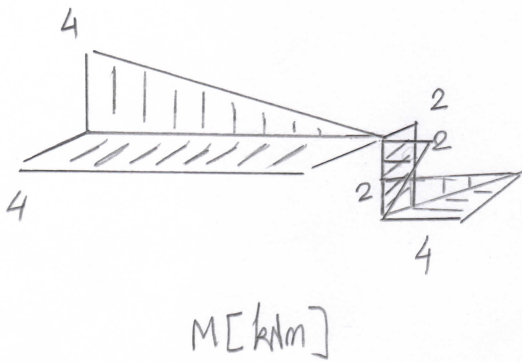
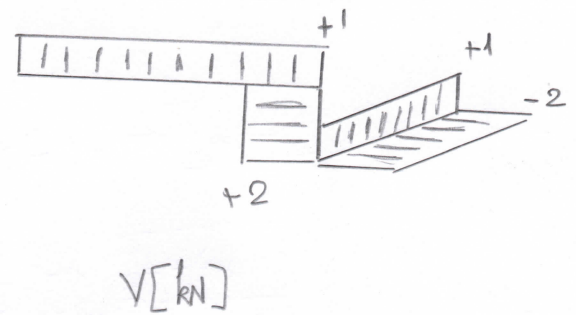
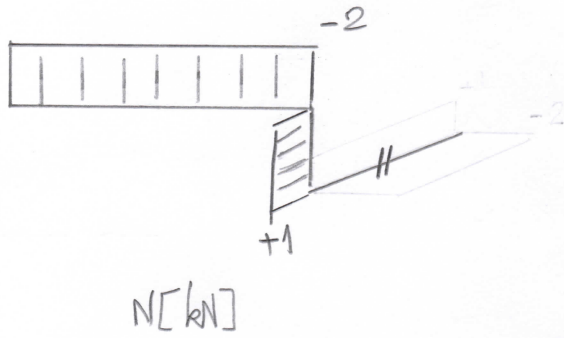
Transporte para C:



Transporte para B:



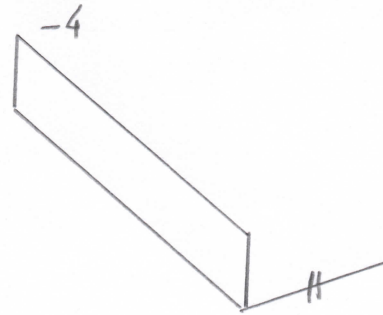
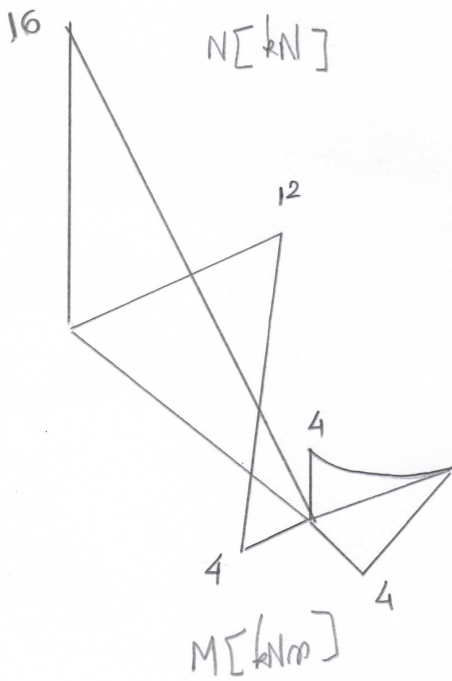
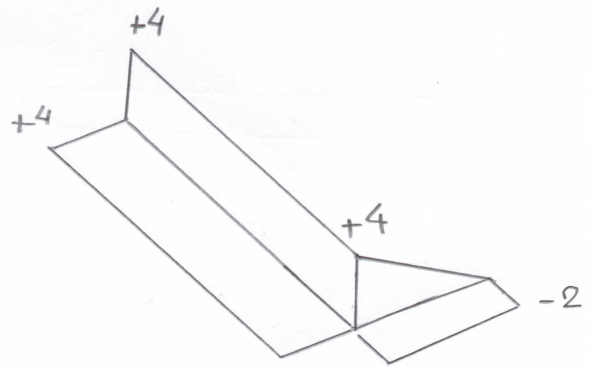
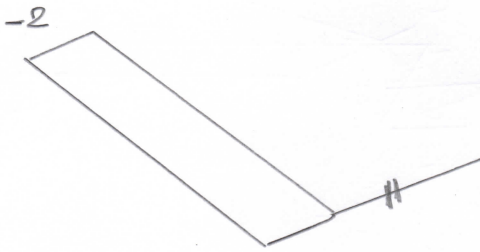
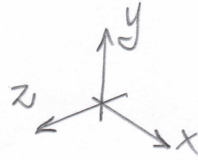
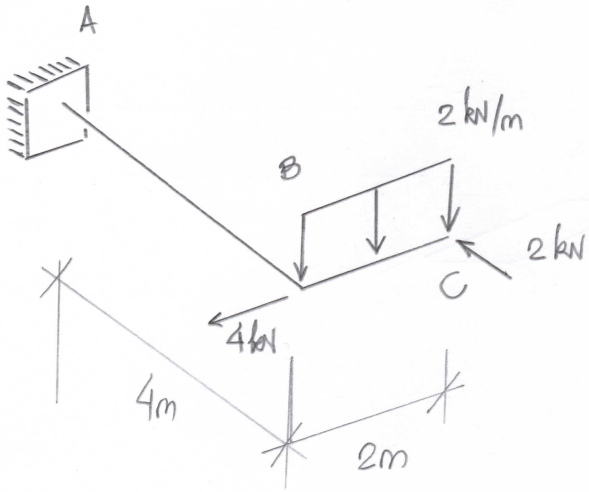
Diagramas:



- normal e momento torçor: qualquer quadrante
- cortante: no plano da cortante (ex. cortante  $x$  e torque no  $z \rightarrow$  desenhos no  $xz$ )
- momento: lado traçado.



Exemplo 1:



T [kNm]

Transporte para B:

