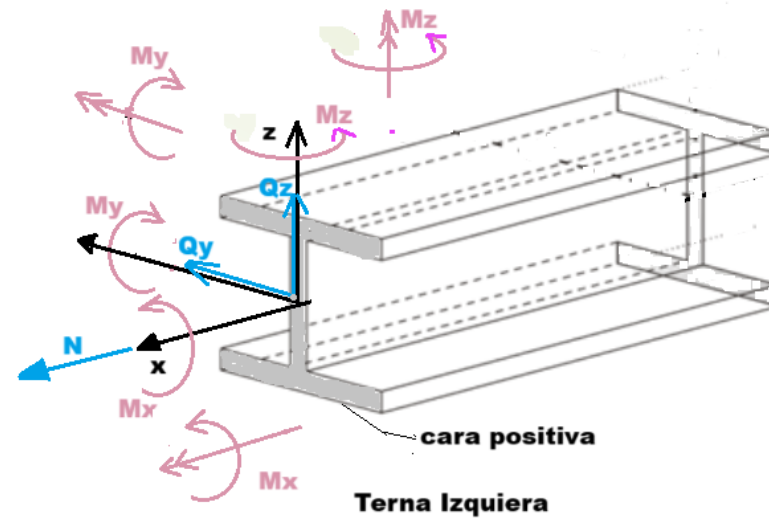
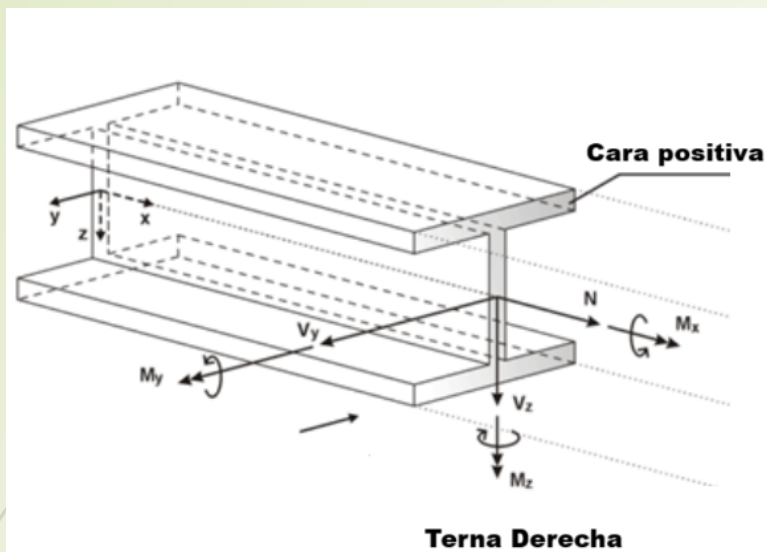


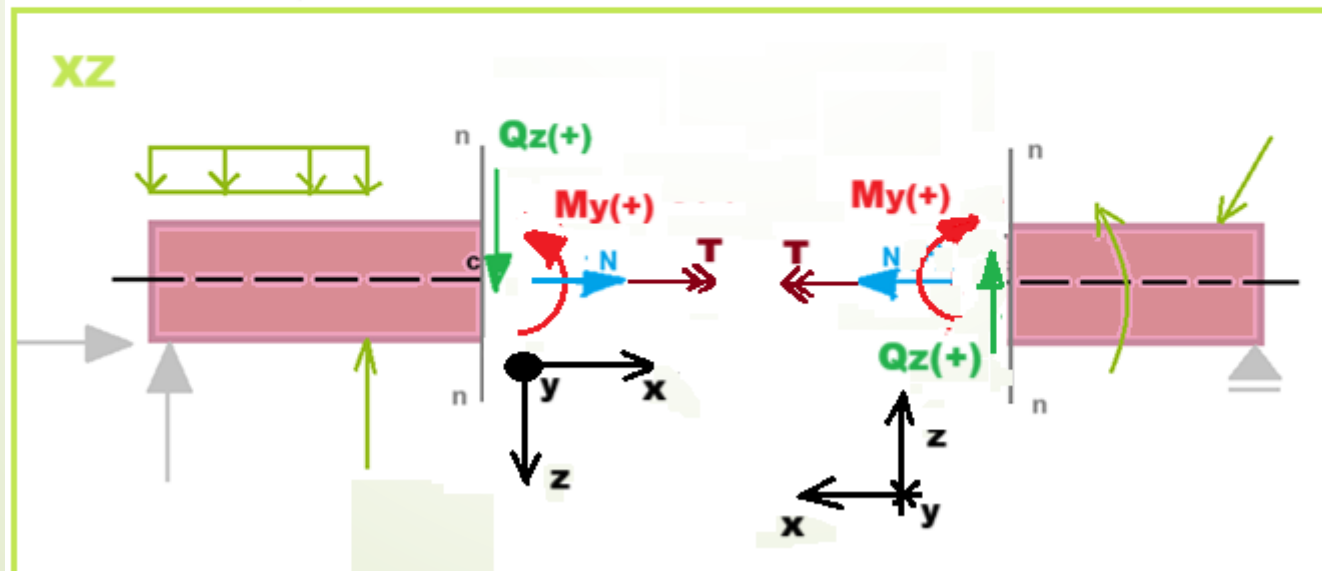
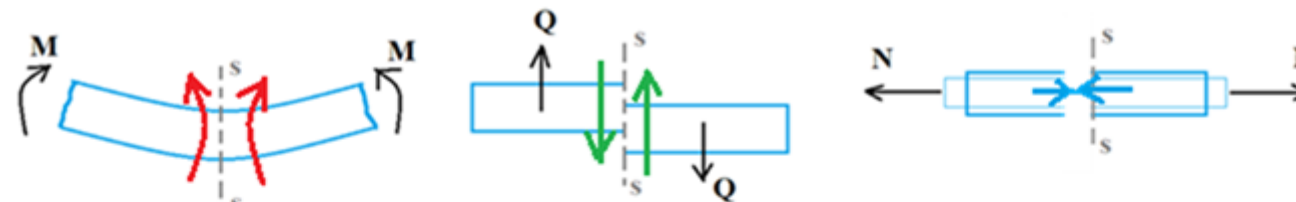
ESFUERZOS INTERNOS EN EL ESPACIO





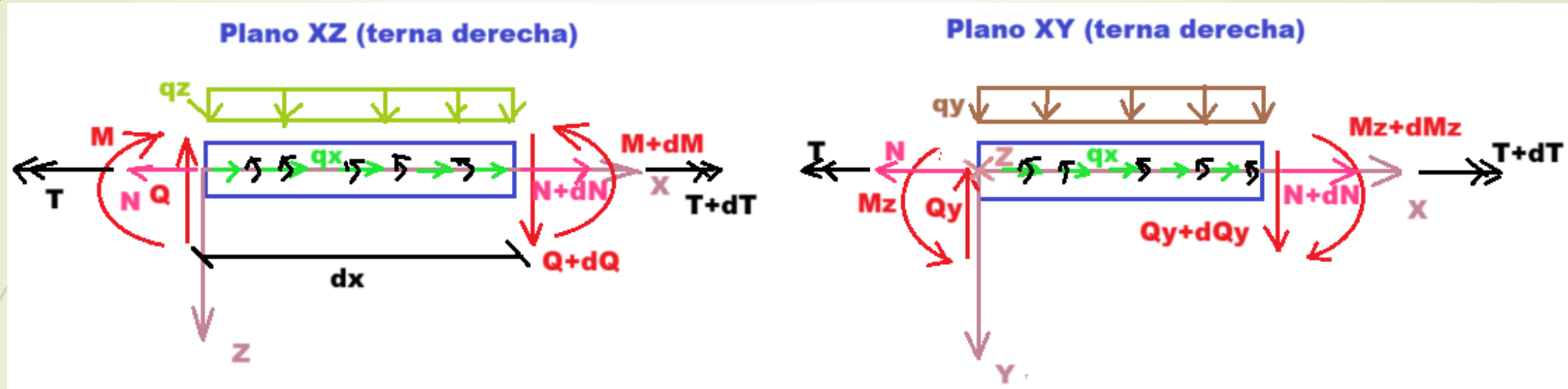
$$R = \begin{bmatrix} N \\ Q_y \\ Q_z \end{bmatrix}$$

$$M = \begin{bmatrix} M_T \\ M_z \\ M_y \end{bmatrix}$$



Convención de
signos plano XZ

Relaciones diferenciales



$$\sum F_x = 0$$

$$-N + q_x dx + N + dN = 0$$

$$\sum F_y = 0$$

$$-Q_y + q_y dx + Q_y + dQ_y = 0$$

$$\sum M_x = 0$$

$$T + m_x dx - T - dT = 0$$

$$\sum M_y = 0$$

$$M_y + Q_z dx - q_z \frac{dx^2}{2} - M_y - dM_y = 0$$

$$\sum M_z = 0$$

$$-M_z + Q_y dx - q_y \frac{dx^2}{2} + M_z + dM_z = 0$$

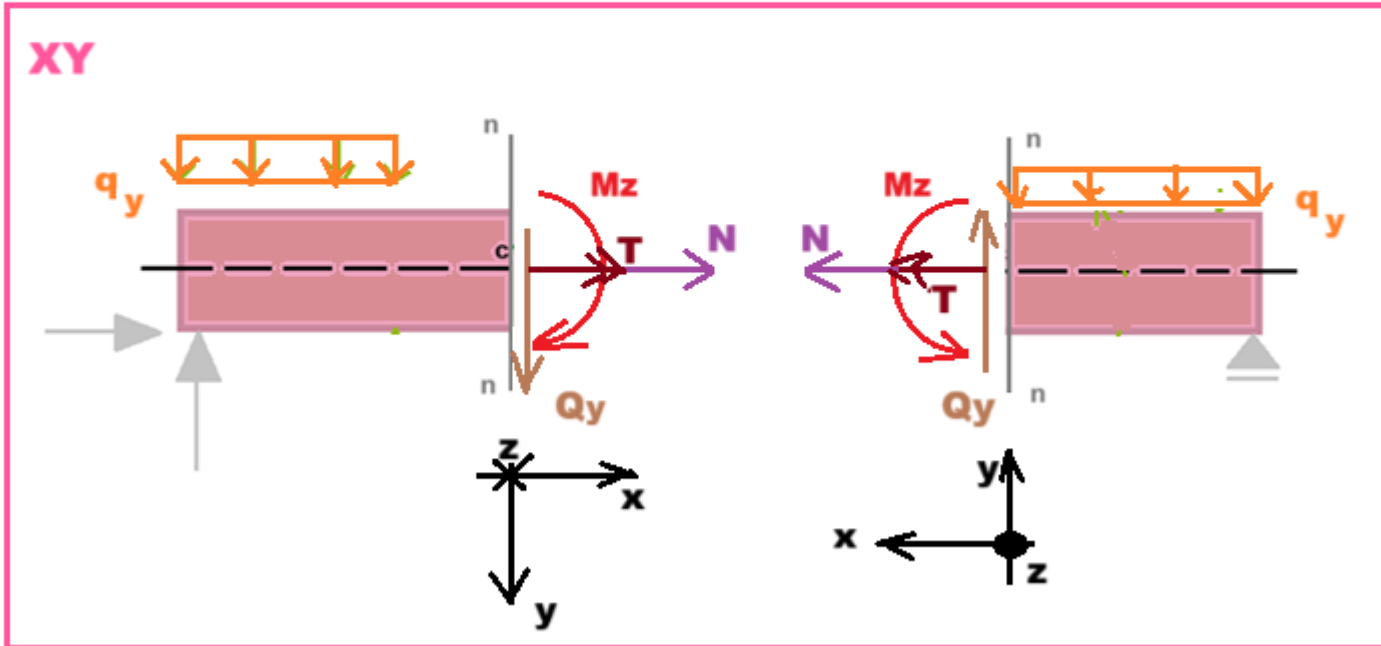
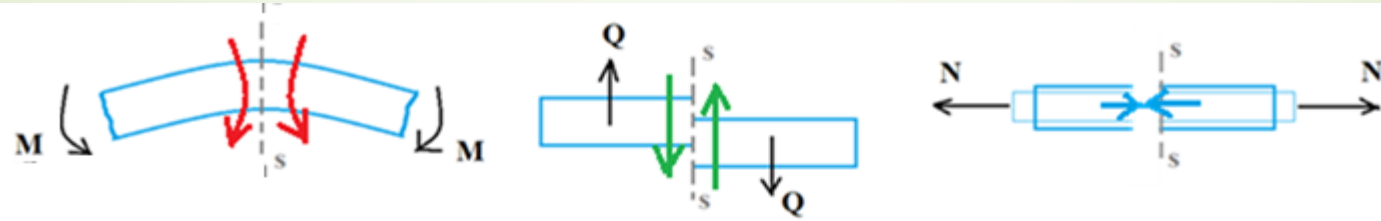
$$-q_x = \frac{dN}{dx}$$

$$-q_y = \frac{dQ_y}{dx}$$

$$m_x = \frac{dT}{dx}$$

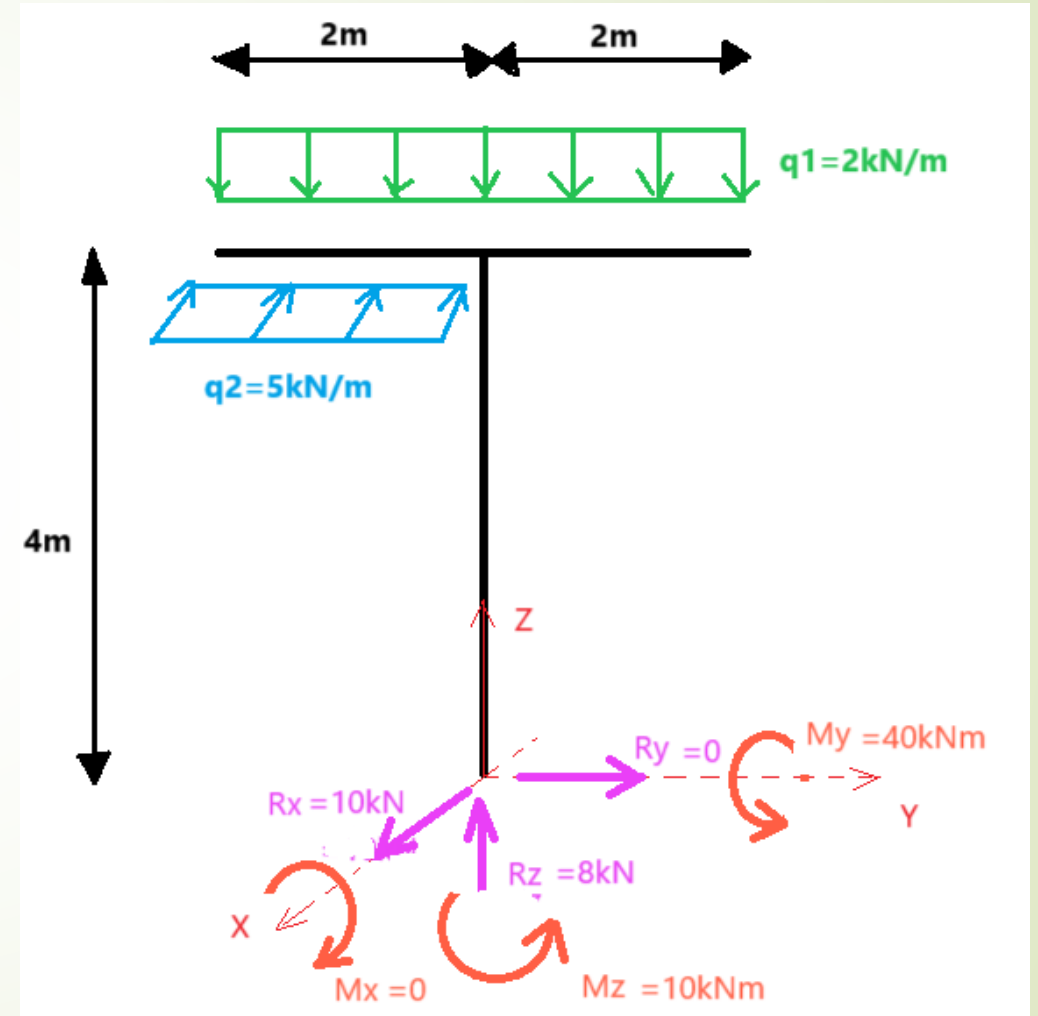
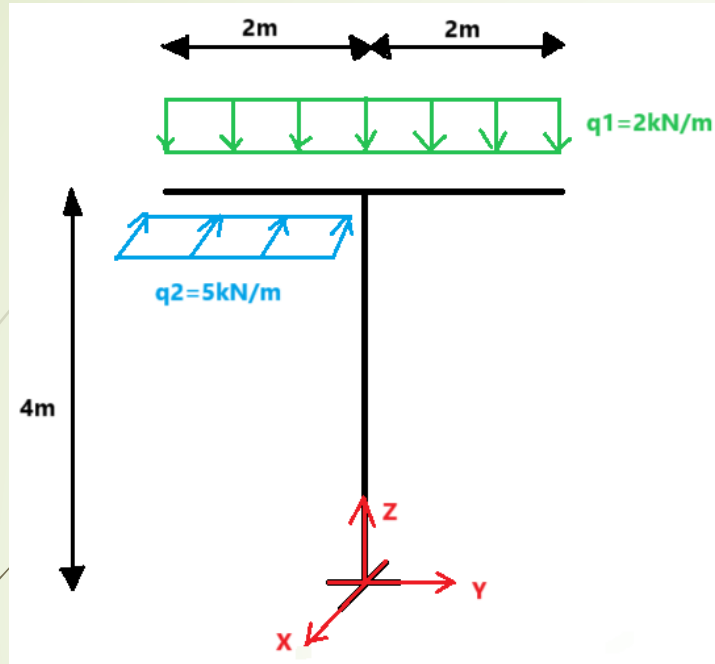
$$Q_z = \frac{dM_y}{dx}$$

$$-Q_y = \frac{dM_z}{dx}$$



Convención de
signos plano XY

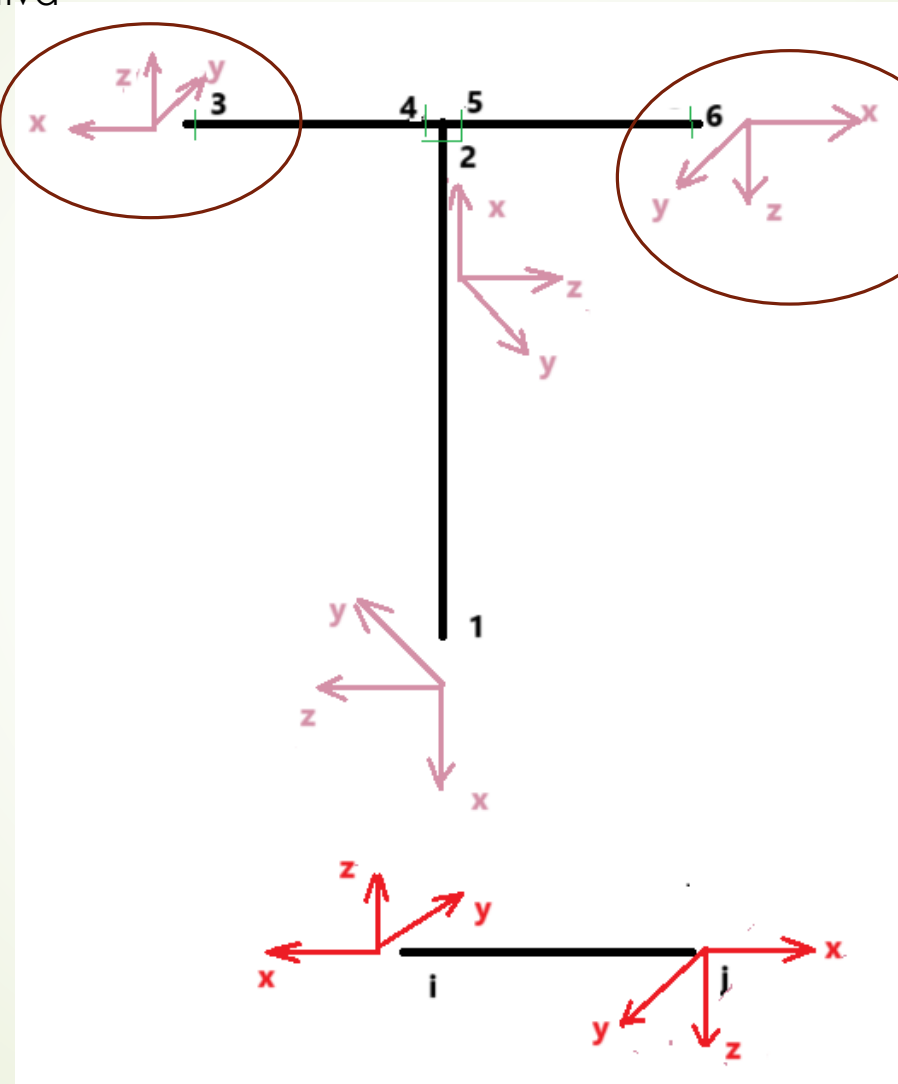
Se definen los ejes globales para determinar reacciones.



Se definen los ejes locales y secciones para determinar esfuerzos internos.

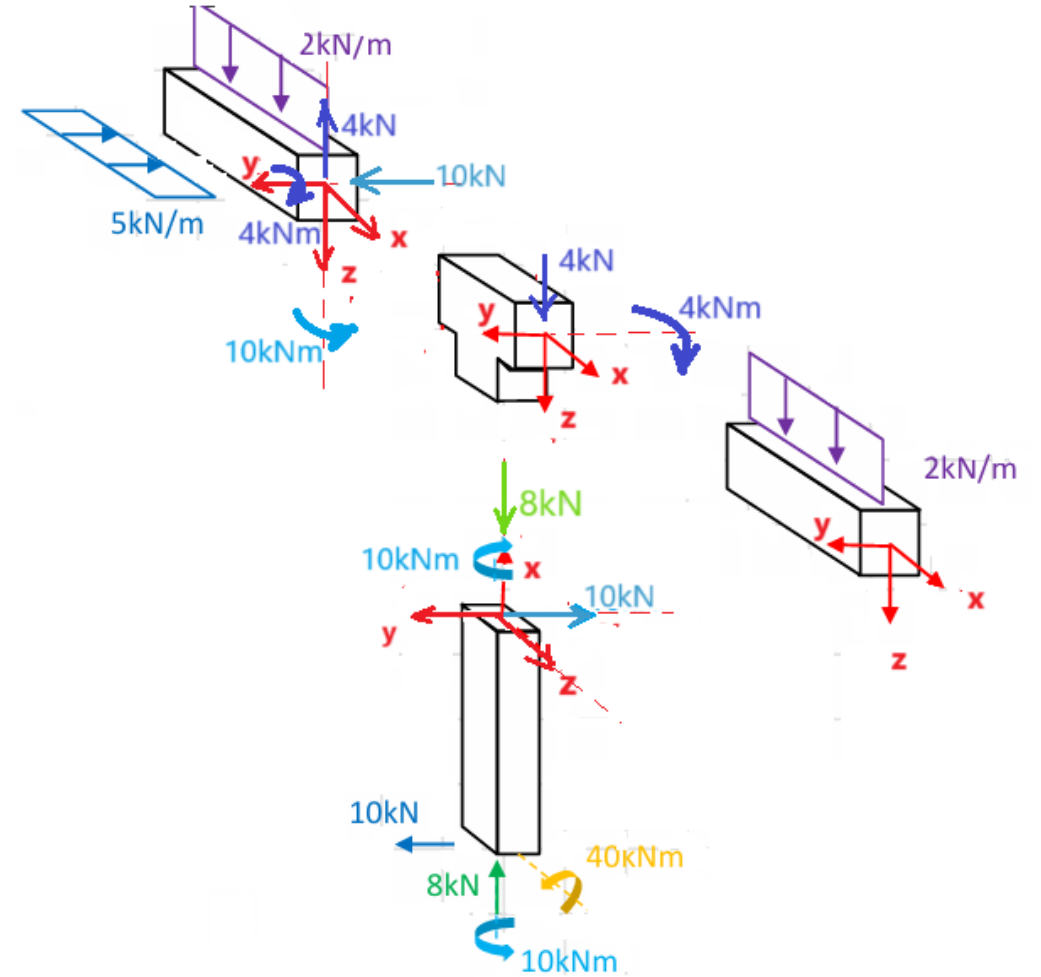
Convención cara negativa

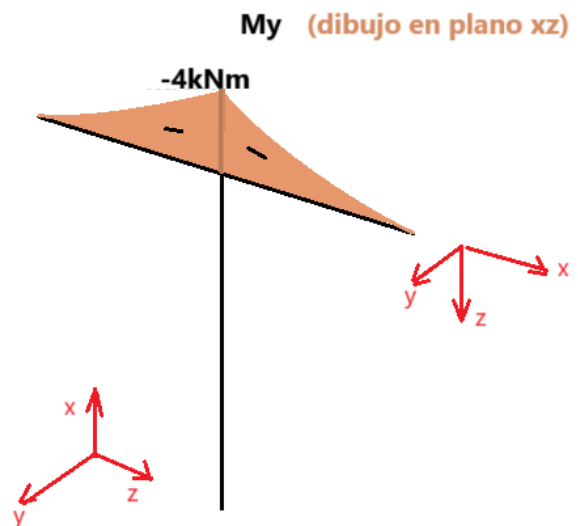
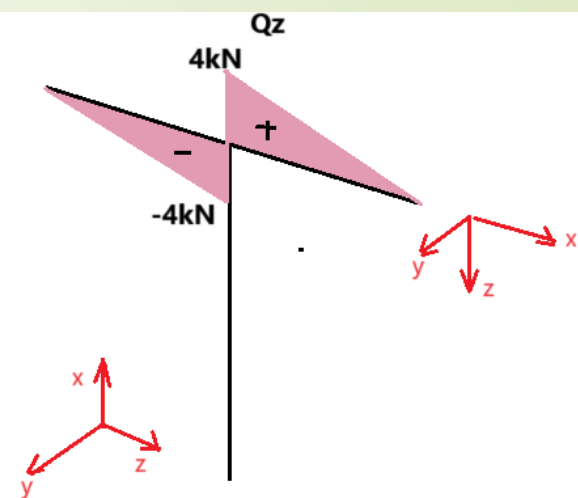
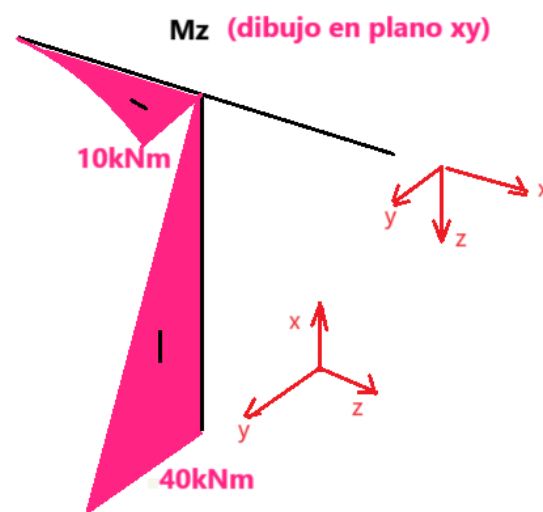
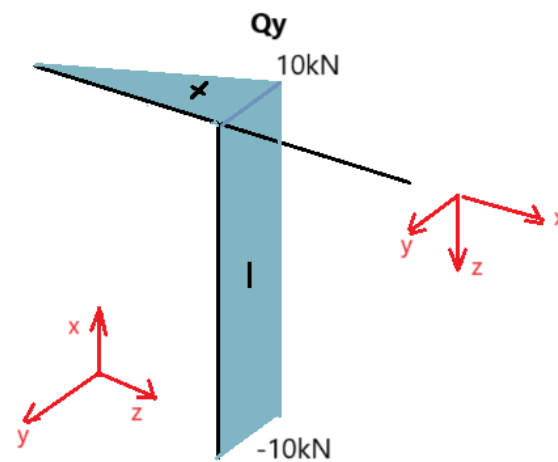
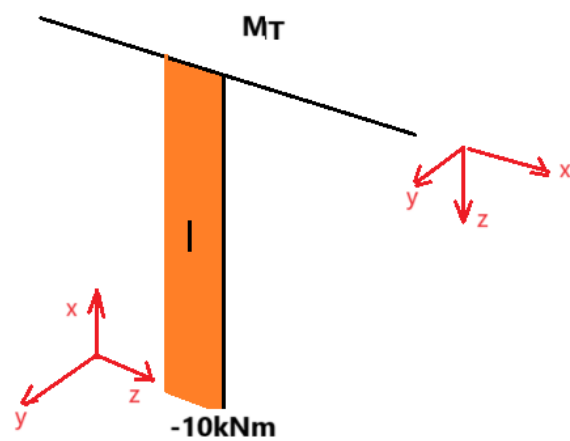
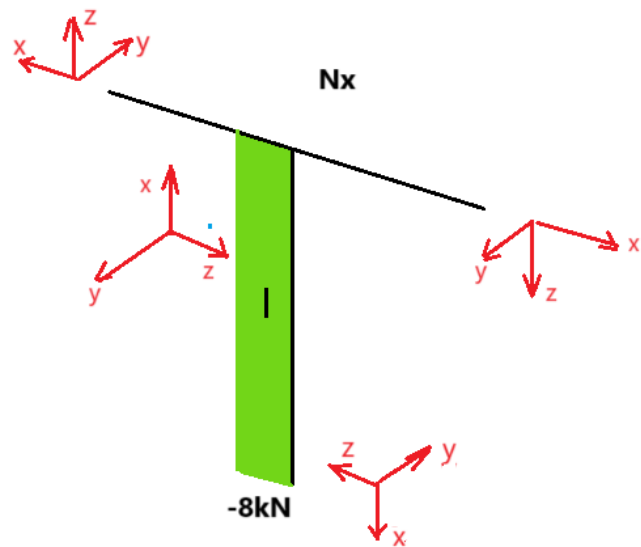
Convención cara positiva



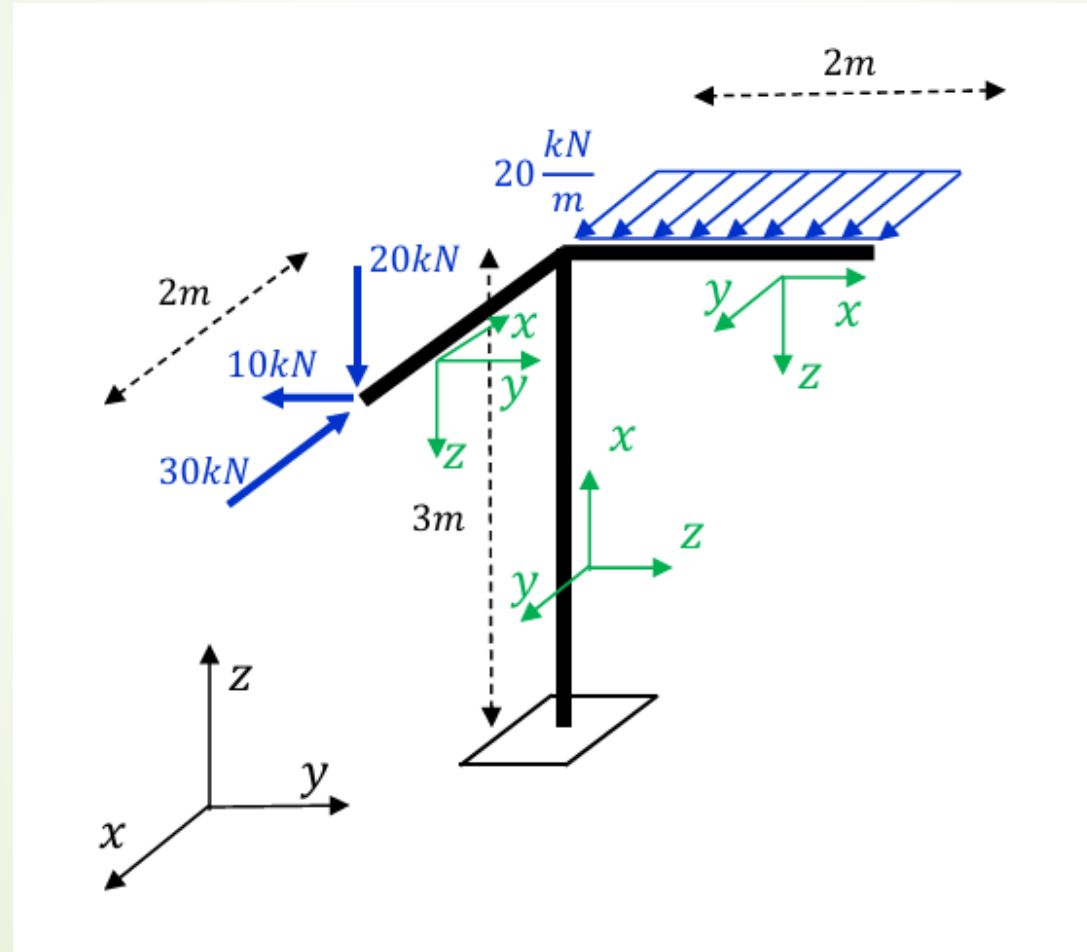
Esfuerzos característicos

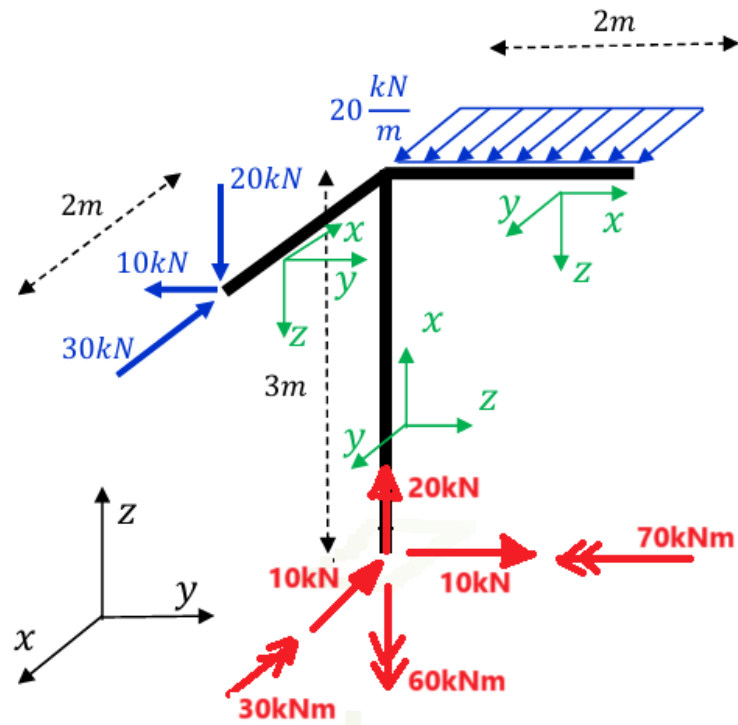
	1	2	3	4	5	6
N_x	-8kN	-8kN	0	0	0	0
Q_y	-10kN	-10kN	0	10kN	0	0
Q_z	0	0	0	-4kN	4kN	0
M_x	-10kNm	-10kNm	0	0	0	0
M_y	0	0	0	-4kNm	-4kNm	0
M_z	-40kNm		0	-10kNm	0	0



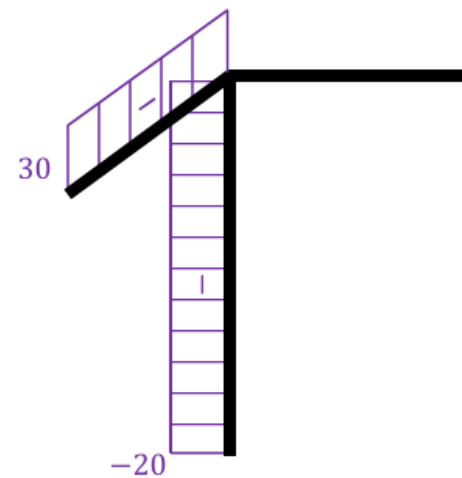


Ejemplo: Determinar los esfuerzos internos en la estructura 3D.



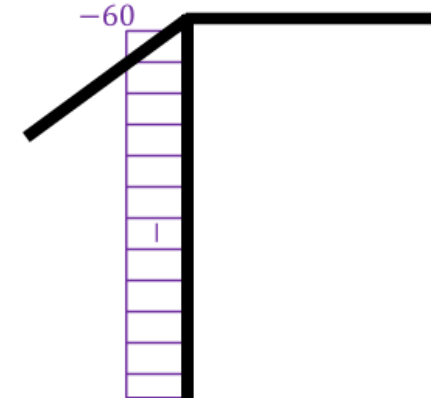


$$\frac{dN(x)}{dx} = -q_x(x)$$



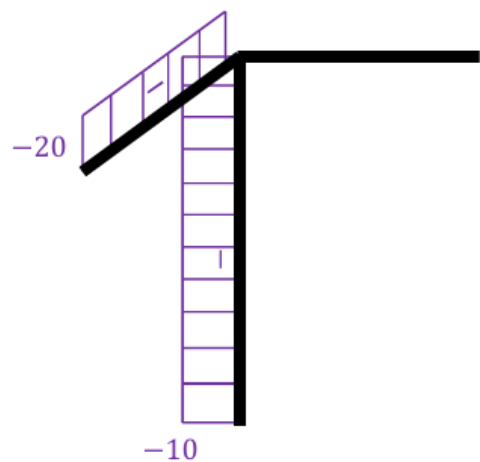
N [kN]
(cualquier plano)

$$\frac{dM_t(x)}{dx} = -m_t(x)$$



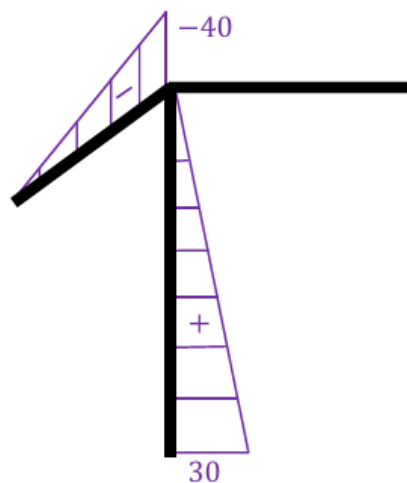
M_t [kNm]
(cualquier plano)

$$\frac{dQ_z(x)}{dx} = -q_z(x)$$



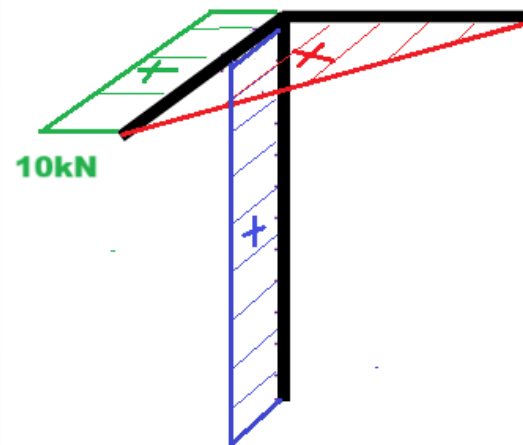
Q_z [kN]
(plano xz)

$$\frac{dM_y(x)}{dx} = Q_z(x)$$



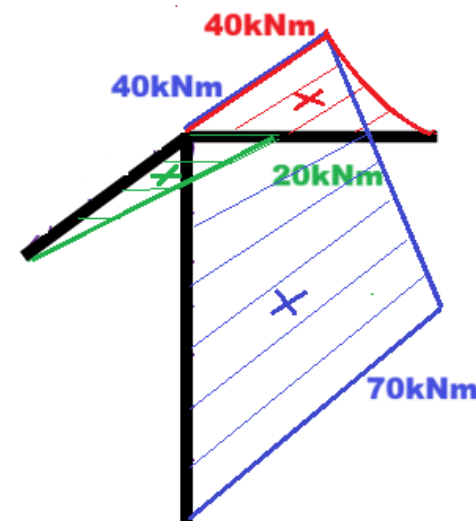
M_y [kNm]
(plano xz)

$$\frac{dQ_y(x)}{dx} = -q_y(x)$$



Q_y [kN]
(plano xy)

$$\frac{dM_z(x)}{dx} = -Q_y(x)$$



M_z [kNm]
(plano xy)

