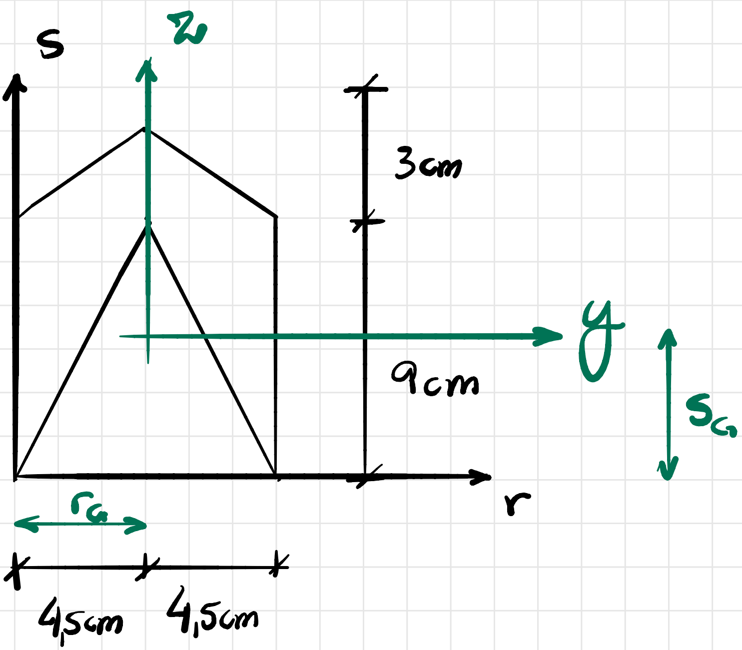
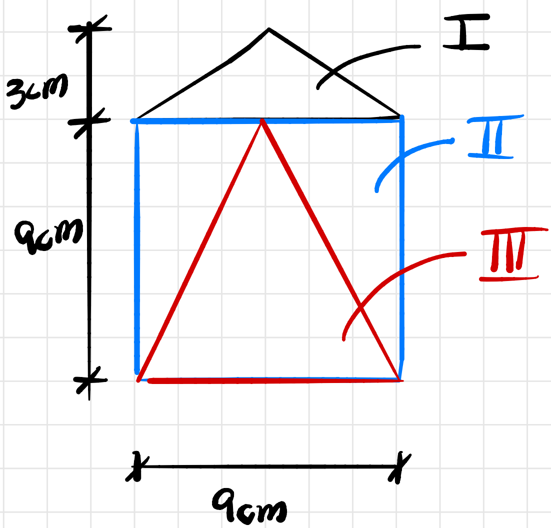
Q1



Para resolver, vamos usar as seguintes áreas:



I + II − III

	r_G	s_G	A	d_s	$d_s^2 A$	I_y
I	4,5	10	13,5	3	121,5	6,75
II	4,5	4,5	81	2,5	506,25	546,75
III	4,5	3	40,5	4	648	182,25

$$r_G = \frac{4{,}5 \cdot 13{,}5 + 4{,}5 \cdot 81 - 4{,}5 \cdot 40{,}5}{13{,}5 + 81 - 40{,}5} = 4{,}5\ \text{cm}$$

(por simetria é directo)

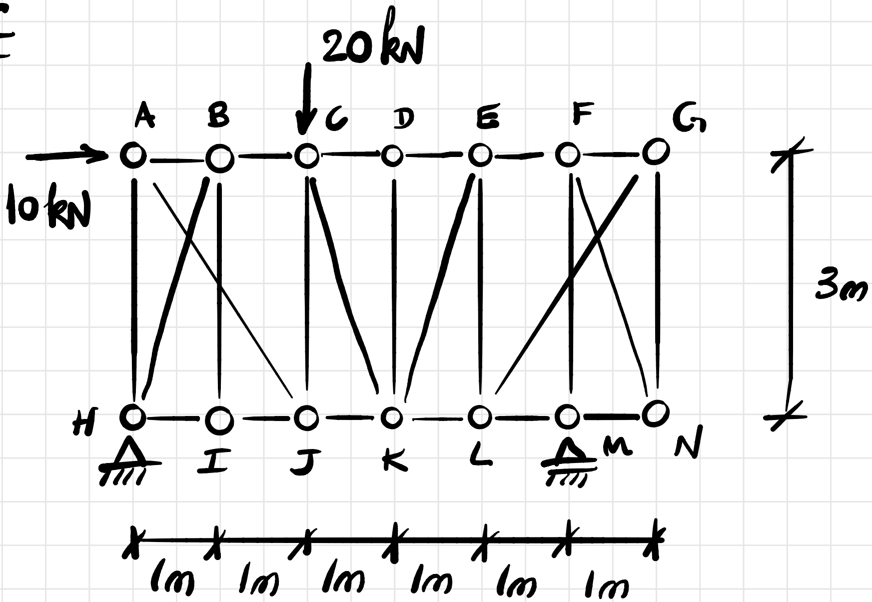
$$s_G = \frac{10 \cdot 13{,}5 + 4{,}5 \cdot 81 - 3 \cdot 40{,}5}{54} = 7\text{cm}$$

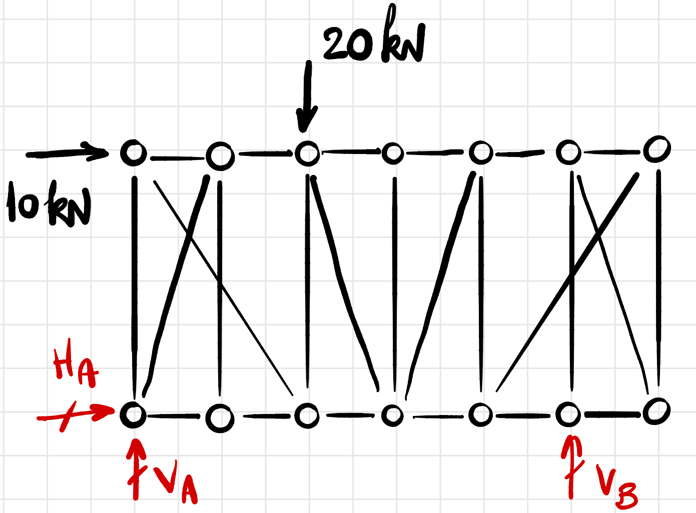
a) O baricentro da figura é $(4{,}5;7)$

$$I_y = (6{,}75 + 121{,}5) + (546{,}75 + 506{,}25) - (182{,}25 + 648) = 351\ \text{cm}^4$$

b) $I_y = 351\ \text{cm}^4$.

Q2

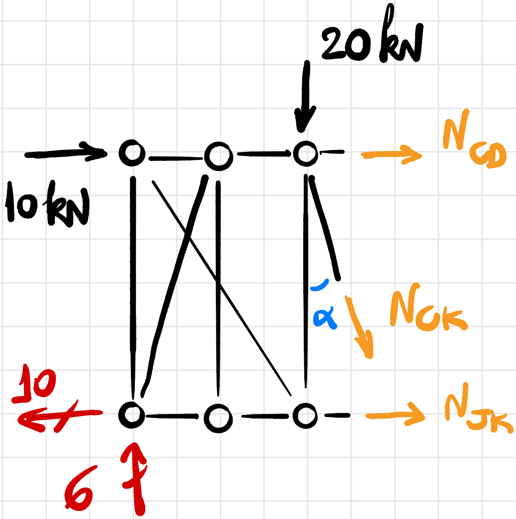


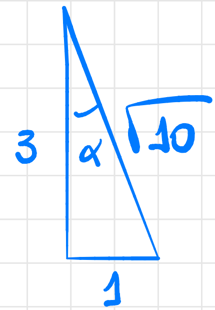


$\sum F_H = 0: H_A + 10 = 0 \Rightarrow \boxed{H_A = -10\,kN}$

$\sum F_V = 0: V_A + V_B = 20$

$(+)\ \sum M_A = 0: -10.3 - 20.2 + V_B.5 = 0 \Rightarrow \boxed{V_B = 14\,kN}\ \boxed{V_A = 6\,kN}$





$$\operatorname{sen}\alpha = 1/\sqrt{10}$$

$$\cos\alpha = 3/\sqrt{10}$$

$$\sum F_H = 0: \; 10 + N_{CD} - 10 + N_{CK}\operatorname{sen}\alpha + N_{JK} = 0$$

$$N_{CD} + \frac{N_{CK}}{\sqrt{10}} + N_{JK} = 0$$

$$\sum F_V = 0: \; 6 - 20 - N_{CK}\cos\alpha = 0$$

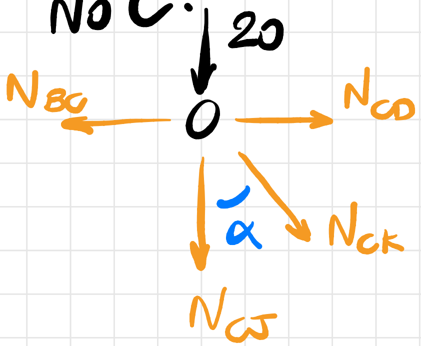
$$\frac{3N_{CK}}{\sqrt{10}} = -14 \Rightarrow \boxed{N_{CK} = -\frac{14}{3}\sqrt{10}\ \text{kN}}$$

$$\circlearrowleft(+)\ \sum M_C = 0: \; N_{JK}\cdot 3 - 6\cdot 2 - 10\cdot 3 = 0$$

$$N_{JK} = 14\ \text{kN}$$

$$\boxed{N_{CD} = -28/3\ \text{kN}}$$

Nó C:

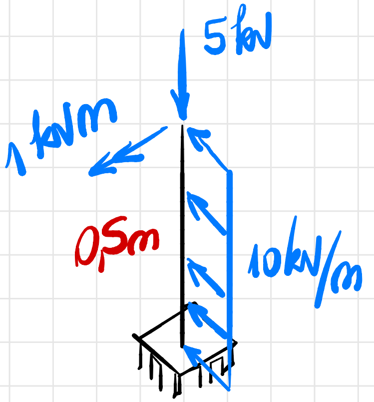


$$\sum F_H = 0: \; -N_{BC} + N_{CD} + N_{CK}\,\mathrm{sen}\,\alpha = 0$$

$$N_{BC} = -\frac{28}{3} - \frac{14\sqrt{10}}{3} \cdot \frac{1}{\sqrt{10}} \Rightarrow \boxed{N_{BC} = -14\ kN}$$

Q3

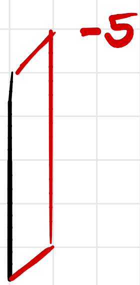
Transportando os esforços:



$M_y = -5\,kN \cdot 0{,}2\,m = -1\,kNm$

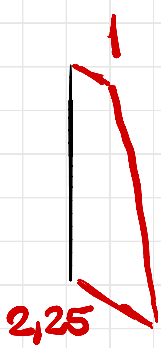
Diagramas:

N[kN]



V[kN]

M[kNm]



T[kNm]

a) Assim, os esforços no engastamento são:

$N = -5\,kN;\ V_z = 5\,kN;\ M_{fy} = 2{,}25\,kNm$

$V_y = M_{fz} = T = 0.$ $(225\,kNcm)$

b) A equação geral da flexão é:

$$\sigma = \frac{N}{A} - \frac{M_z}{I_z}y + \frac{M_y}{I_y}z$$

Precisamos das propriedades da seção:

$A = 0{,}4 \cdot 0{,}2 = 0{,}08\,m^2$ $(800\,cm^2)$

$I_y = \frac{0{,}2 \cdot 0{,}4^3}{12} = \frac{32}{3} \cdot 10^{-4}\,m^4$ $\left(\frac{32}{3} \cdot 10^4\,cm^4\right)$

$I_z = \frac{0{,}4 \cdot 0{,}2^3}{12} = \frac{8}{3} \cdot 10^{-4}\,m^4$ $\left(\frac{8}{3} \cdot 10^4\,cm^4\right)$

Logo:

$$\sigma = \frac{-5}{800} - \frac{0}{I_z} y + \frac{225}{32/3 \cdot 10^4} z$$

$$\boxed{\sigma = -0{,}00625 + 0{,}00211\ z} \quad \left[kN/cm^2 \right]$$

c) Linha neutra:

$$\sigma = 0 \Rightarrow z = +\frac{0{,}00625}{0{,}00211}$$

$$\boxed{z = +2{,}96\,cm}$$

d) Tensões máximas em $z = \pm 20\,cm$:

$$\sigma_T = -0{,}00625 + 0{,}00211 \cdot (20) = \underline{0{,}036\ kN/cm^2}$$

$$\sigma_C = -0{,}00625 + 0{,}00211(-20) = \underline{-0{,}048\ kN/cm^2}$$