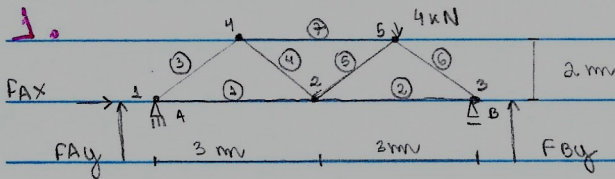


EAN



$$\sum F_{y_j} = 0$$

$$F_{B_y} + F_{A_y} = 4 \text{ kN}$$

$$\sum M_A = 0$$

$$(-4 \cdot 4,5) + (F_{B_y} \cdot 6) = 0$$

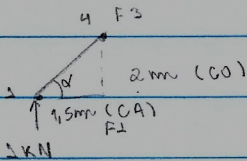
$$F_{B_y} = 3 \text{ kN}$$

$$F_{A_y} = 1 \text{ kN}$$

$$\sum F_x = 0$$

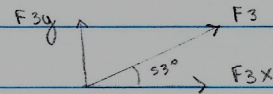
$$F_{A_x} = 0$$

mó 1



$$\tan \alpha = \frac{CB}{CA} = \frac{2}{1,5} = 1,33$$

$$\alpha = 53^\circ$$



$$F_{3x} = F_3 \cos 53^\circ$$

$$F_{3y} = F_3 \sin 53^\circ$$

$$\sum F_x = 0$$

$$F_1 + F_3 \cos 53^\circ = 0$$

$$F_1 + 0,60 F_3 = 0$$

$$\sum F_{y_j} = 0$$

$$1 \text{ kN} + F_3 \sin 53^\circ = 0$$

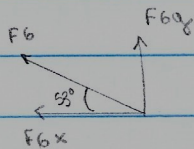
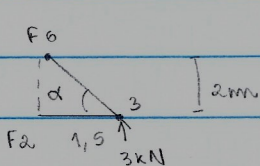
$$F_3 = -1,25 \text{ kN (C)}$$

$$F_1 = -0,6 F_3$$

$$F_1 = -0,6 (-1,25)$$

$$F_1 = 0,75 \text{ kN (T)}$$

mó 2



$$F_{6x} = F_6 \cos 53^\circ$$

$$F_{6y} = F_6 \sin 53^\circ$$

$$\sum F_x = 0$$

$$-F_2 - F_6 \cos 53^\circ = 0$$

$$-F_2 - 0,6 F_6 = 0$$

$$\sum F_{y_j} = 0$$

$$3 \text{ kN} + F_6 \sin 53^\circ = 0$$

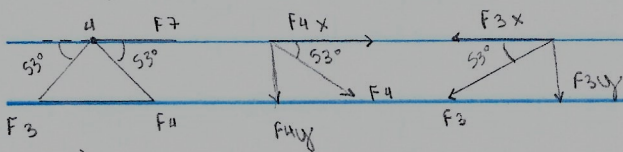
$$F_6 = -2,75 \text{ kN (C)}$$

$$F_2 = -0,6 F_6$$

$$F_2 = -0,6 (-2,75)$$

$$F_2 = 1,65 \text{ kN (T)}$$

mó 4



$$F_{4x} = F_4 \cos 53^\circ$$

$$F_{4y} = F_4 \sin 53^\circ$$

$$F_{3x} = -F_3 \cos 53^\circ$$

$$F_{3y} = -F_3 \sin 53^\circ$$

$$(-1,25 \text{ kN})$$

$$\sum F_x = 0$$

$$F_7 + F_4 \cos 53^\circ - (-1,25 \cos 53^\circ) = 0$$

$$F_7 + 0,6 F_4 + 0,75 = 0$$

$$F_7 = -0,6(1,25) - 0,75$$

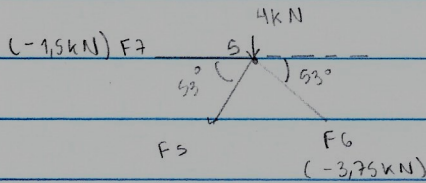
$$F_7 = -1,5 \text{ kN (C)}$$

$$\sum F_y = 0$$

$$-F_4 \sin 53^\circ - (-1,25 \sin 53^\circ) = 0$$

$$F_4 = 1,25 \text{ kN (T)}$$

• m'g's

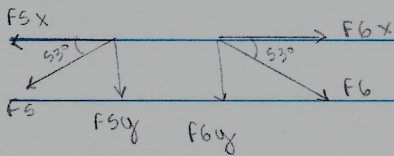


$$\sum F_y = 0$$

$$-4 - (-3,75 \sin 53^\circ) - F_5 \sin 53^\circ$$

$$-1,009 - F_5 \sin 53^\circ = 0$$

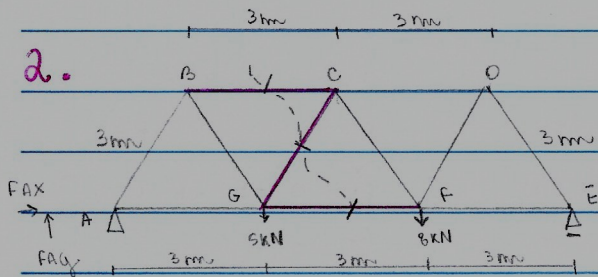
$$F_5 = -1,25 \text{ kN (C)}$$



$$F_{5x} = -F_5 \cos 53^\circ \quad F_{6x} = F_6 \cos 53^\circ$$

$$F_{5y} = -F_5 \sin 53^\circ \quad F_{6y} = -F_6 \sin 53^\circ$$

2.



$$F_{BC} = ?$$

$$F_{CG} = ?$$

$$F_{GF} = ?$$

1º - cálculo das forças de reação dos apoios

$$\sum F_x = 0$$

$$F_{Ax} = 0$$

$$\sum F_y = 0$$

$$F_{Ay} + F_{Ey} - 5 - 8 = 0$$

$$F_{Ay} + F_{Ey} = 13 \text{ kN}$$

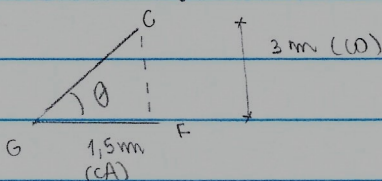
$$\sum M_A = 0$$

$$(-5 \cdot 3) + (-8 \cdot 6) + (F_{Ey} \cdot 9) = 0$$

$$F_{Ey} = 7 \text{ kN}$$

$$F_{Ay} = 6 \text{ kN}$$

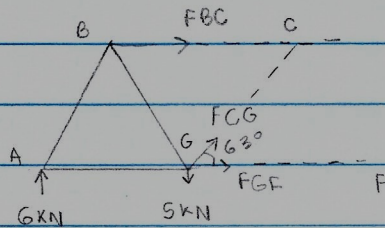
2º - cálculo do ângulo



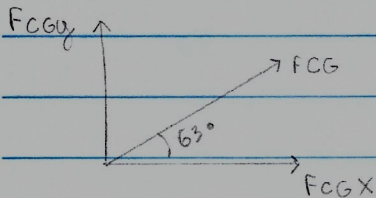
$$\operatorname{tg} \theta = \frac{CG}{CA} = \frac{3}{1,5} = 2$$

$$\theta \approx 63^\circ$$

3º - corte (em até 3 barras)



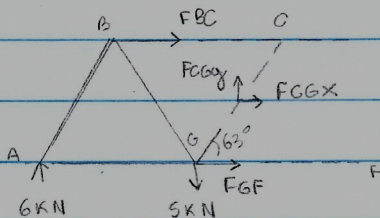
4º - decomposição de vetores



$$FCGX = FCG \cos 63^\circ$$

$$FCGY = FCG \sin 63^\circ$$

5º - somatória das forças



$$\sum F_x = 0$$

$$FBC + FGF + FCG \cos 63^\circ = 0$$

$$FBC + FGF + 0,45 FCG = 0$$

$$FBC + FGF + 0,45(-1,12) = 0$$

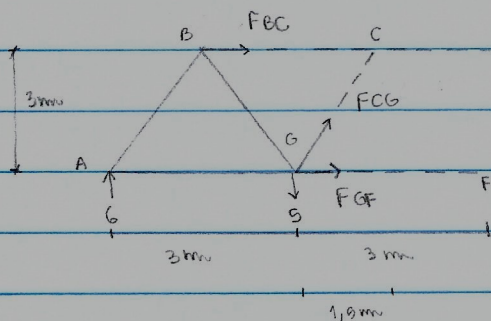
$$FBC + FGF = 0,504 \text{ kN}$$

$$\sum F_y = 0$$

$$6 - 5 + FCG \sin 63^\circ = 0$$

$$FCG = -1,12 \text{ kN (C)}$$

6º - momento



$$\sum M_G = 0$$

$$(-6 \cdot 4,5) + (5 \cdot 1,5) + (FGF \cdot 3) = 0$$

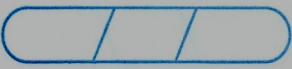
$$FGF = 6,5 \text{ kN (T)}$$

$$FBC + FGF = 0,504 \text{ kN}$$

$$FBC + 6,5 = 0,504 \text{ kN}$$

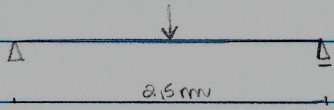
$$FBC = 0,504 - 6,5$$

$$FBC = -6 \text{ kN (C)}$$



3.

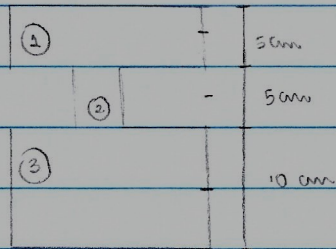
500 kg F

 $E = 20.000 \text{ kN/cm}^2$ 

$$A_1 = 20 \cdot 5 = 100 \text{ cm}^2$$

$$A_2 = 4 \cdot 5 = 20 \text{ cm}^2$$

$$A_3 = 20 \cdot 10 = 200 \text{ cm}^2$$



| Fig. | x | y | A | x A | y A |
|------|----|------|--------------|------|------|
| 1 | 10 | 17,5 | 100 | 1000 | 1750 |
| 2 | 10 | 12,5 | 20 | 200 | 250 |
| 3 | 10 | 5 | 200 | 2000 | 1000 |
| | | | Σ 320 | 3200 | 3000 |

8 4 8 cm

20 10 cm

$$\bar{x} = \frac{\Sigma x A}{\Sigma A} = \frac{3200}{320} = 10 \text{ cm}$$

$$\bar{y} = \frac{\Sigma y A}{\Sigma A} = \frac{3000}{320} = 9,375 \text{ cm}$$

$$I_x = \frac{b \cdot h^3}{12} + A (y - \bar{y})^2$$

$$I_x = I_{x1} + I_{x2} + I_{x3} = \left[\frac{20 \cdot 5^3}{12} + 100 (17,5 - 9,375)^2 \right] + \left[\frac{4 \cdot 5^3}{12} + 20 (12,5 - 9,375)^2 \right] + \left[\frac{20 \cdot 10^3}{12} + 200 (5 - 9,375)^2 \right] = 11.551,72 \text{ cm}^4$$

$$F = \frac{P \cdot l^3}{48 E I}$$

$$F = \frac{500 \cdot 250^3}{48 \cdot 20.000 \cdot 11.551,72} = 0,56 \text{ cm}$$

$$F = 0,56 \text{ cm}$$