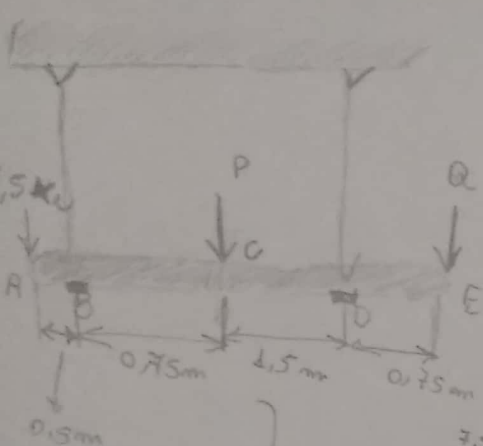


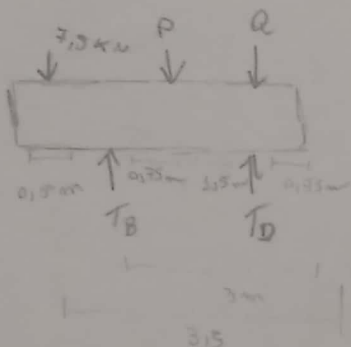
6



$$\begin{cases} P = 5 \text{ kN} \\ \text{em A: } 2,5 \text{ kN} \\ Q = ? \\ \text{max. } T_{\text{roçô}} = 12 \text{ kN} \end{cases}$$

↑ positivo
↓ negativo

$$\left(\sum M_a = 0 \right) \left\{ \sum (V + F) = 0 \right.$$



$$\sum M_a = 0$$

$$\text{Com } T_D \text{ max} = 12 \text{ kN}$$

$$(V \cdot T_D) + (V \cdot T_B) + (V \cdot T_P) + (V \cdot T_A) = 0$$

$$(0,75 \cdot 12 \text{ kN}) + (3 \cdot T_B) - (2,25 \cdot 5 \text{ kN}) - (3,5 \cdot 7,5 \text{ kN}) = 0$$

$$3T_B = (-0,75 \cdot 12 \text{ kN} + 2,25 \cdot 5 \text{ kN} + 3,5 \cdot 7,5 \text{ kN})$$

$$T_B = \left[\frac{28500}{3} \right]$$

$$T_B = 9500 \text{ N}$$

$$\sum M_a = 0$$

$$\text{Com } T_B \text{ max} = 12 \text{ kN}$$

$$(0,75 \cdot T_D) + (3 \cdot 12 \text{ kN}) - (2,25 \cdot 5 \text{ kN}) - (3,5 \cdot 7,5 \text{ kN}) = 0$$

$$(0,75 \cdot T_D) = [-3 \cdot 12 \text{ kN} + 2,25 \cdot 5 \text{ kN} + 3,5 \cdot 7,5 \text{ kN}]$$

$$T_D = \left[\frac{1500}{0,75} \right]$$

$$T_D = 2000 \text{ N}$$

$$\text{* } Q \text{ quando } T_B = 12 \text{ kN e } T_D = 2 \text{ kN}$$

$$\sum F = 0$$

$$(F_A + F_P + F_B + F_D + Q) = 0$$

$$(7,5 \text{ kN} + 5 \text{ kN} - 12 \text{ kN} - 2 \text{ kN} + Q) = 0$$

$$-1,5 \text{ kN} + Q = 0$$

$$Q = 1,5 \text{ kN}$$

$$L_{\text{q}} =$$

$$1,5 \text{ kN} \leq Q \leq 9 \text{ kN}$$

↓ positivo
↑ negativo

$$\text{* } \text{Quando } T_B = 9,5 \text{ kN e } T_D = 12 \text{ kN}$$

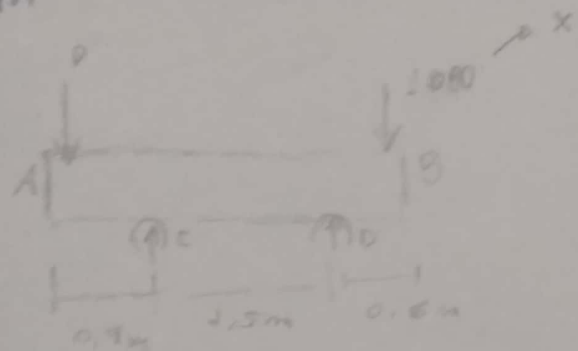
$$\sum F = 0$$

$$(7,5 \text{ kN} + 5 \text{ kN} - 9,5 \text{ kN} - 12 \text{ kN} + Q) = 0$$

$$-9 \text{ kN} + Q = 0$$

$$Q = 9 \text{ kN}$$

4.7

Intervalo de P

→ Força em Y

↑ positivo

↓ negativo

$$\sum M_C = 0 \rightarrow (-P) \cdot 0$$

$$(x, P) + (x, D) + (x, B) = 0$$

$$+ (0,9 \cdot P) + (1,5 \cdot D) - (2,1 \cdot 1080) = 0$$

$$D = \frac{2268 + (0,9 \cdot P)}{1,5}$$

$$D = 1512 + 0,6P$$

$$\sum F_y = 0$$

$$C + D + P + Y = 0$$

$$+C + D - P - X = 0$$

$$+C + (1512 + 0,6P) - P - 1080 = 0$$

$$C = +0,6P + P + 1080 - 1512$$

$$C = 1,6P + 432$$

* Para permanecer em equilíbrio:

$$C \geq 0 \rightarrow 1,6P + 432 \geq 0$$

$$P \geq \frac{432}{1,6}$$

$$P \geq 270$$

$$D \geq 0 \rightarrow 1512 + 0,6P \geq 0$$

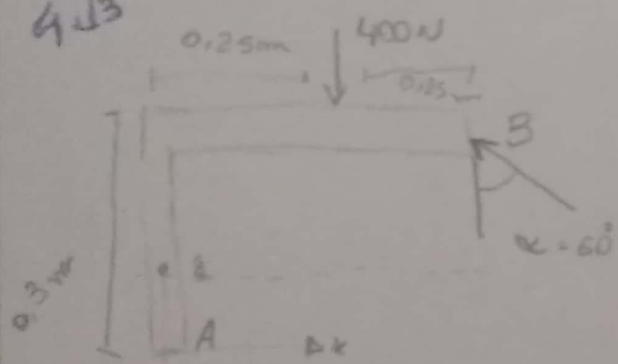
$$P \geq \frac{-1512}{-0,6}$$

$$P \geq 2520$$

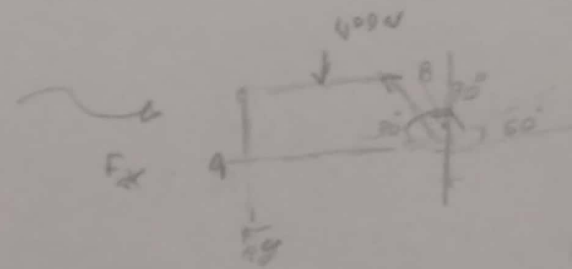
Logo:

$$270 \text{ N} \leq P \leq 2520 \text{ N}$$

4.3



Reações em A e B



FORÇAS

$$\sum F_x = 0 \quad \text{e} \quad \sum F_y = 0$$

$$A + B = 0$$

$$F_{Ax} - \cos 30^\circ \cdot B = 0$$

$$A + B = 0$$

$$F_{Ax} = \cos 30^\circ \cdot 196,09$$

$$F_{Ay} = 400 + \sin 30^\circ \cdot B =$$

$$F_{Ax} = 166,35 \text{ N}$$

$$F_{Ay} = 1301,96 \text{ N}$$

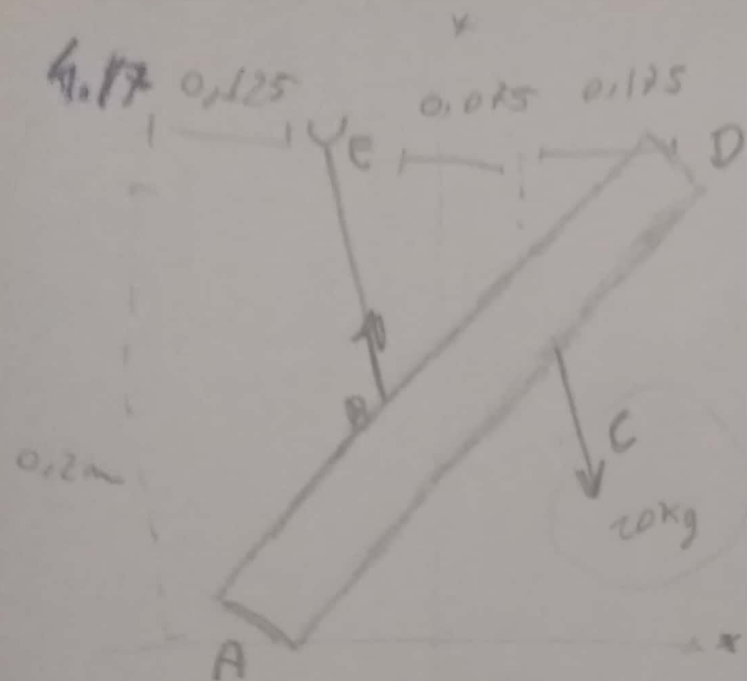
MOMENTO

$$\sum M_A = 0$$

$$-(0,25 \cdot 400) + (0,5 \cdot \cos 60^\circ \cdot F_B) + (0,3 \cdot \sin 60^\circ \cdot F_B) = 0$$

$$F_B (0,25 + 0,26) = 100$$

$$F_B = 196,09 \text{ N}$$



$T_{BE}?$

$F_A = ?$

$F_D = ?$

$$\begin{array}{l} m \cdot g \\ 20 \cdot 9,8 \\ 196 \text{ N} \end{array}$$

como $A = D$

$$D = 73,5$$

em x

$$\sum F_x = 0$$

$$A - D = 0$$

$$A = D$$

em y

$$\sum F_y = 0$$

$$T_{BE} - C = 0$$

$$T_{BE} = C$$

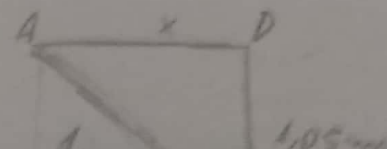
$$\downarrow + M = 0$$

$$(0,2 \cdot A) - (T_{BE} \cdot 0,075) = 0$$

$$A = \frac{196 \cdot 0,075}{0,2}$$

$$A = 73,5 \text{ N}$$

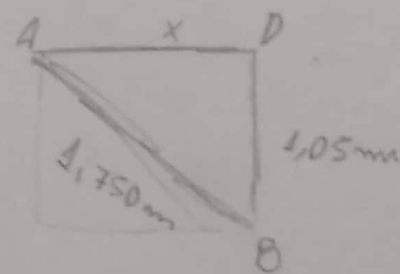
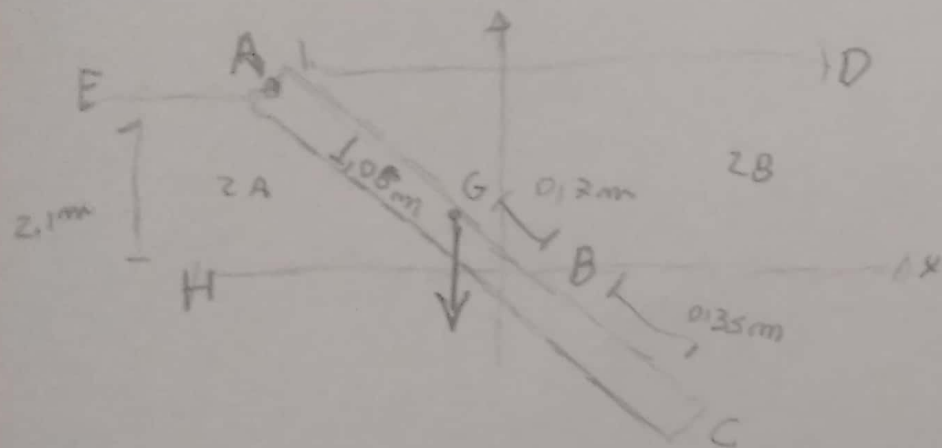
4.19



$$A^2 = B^2 + C^2$$

$$x^2 = 1,05^2 + 1,05^2$$

4.19



$$A^2 = B^2 + C^2$$

$$x^2 = 1.750^2 - 1.05^2$$

$$x = \sqrt{1.750^2 - 1.05^2}$$

$$x = 1.41 \text{ m}$$

a) Tensão no cabo AE

$$\sum M_A = 0$$

$$2B(BD) - 720 \cdot d = 0$$

$$2B \cdot 1.050 - 720 \cdot 0.846 = 0$$

$$B = \frac{720 \cdot 0.846}{2 \cdot 1.050}$$

$$B = 292.61$$

$$\sum F_x = 0$$

$$-T_{AE} + 2B = 0$$

$$T_{AE} = 2 \cdot 292.61$$

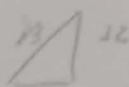
$$T_{AE} = 585.22 \text{ N}$$

$$\sum F_y = 0$$

$$2A - 720 = 0$$

$$A = 360 \text{ N}$$

4024



$$\sum M_B = 0$$

$$A = \sqrt{12^2 + 5^2}$$

$$A = 13$$

$$\frac{5}{13} = 0,38$$

$$\frac{12}{13} = 0,92$$

Support A

$$A_x(7,2m) - (900N)(2,1m) = 0$$

$$A_x = 262,5 N$$

$$A_y - T = 6900$$

$$\sum F_x = 0$$

$$0 - T + 4900 = 0$$

$$0,38T + 262,5 = 0$$

$$T = 690,79$$

$$\sum F_y = 0$$

$$A_y - 0,92 \cdot 690,79 - 4900 = 0$$

$$A_y = 5535$$

$$T \sin \alpha = 5535$$

$$\frac{5535}{262,5}$$

$$A = \frac{262,5}{\cos \alpha}$$

$$\alpha = 87,28^\circ$$

$$A = 5531,54 N$$

Support B

$$\sum M_A = 0$$

$$M_A - (900N)(2,1) = 0$$

$$M_A = 1890 N \cdot m$$

$$\sum F_x = 0$$

$$A_x = 0$$

$$\sum F_y = 0$$

$$A_y \neq 0$$

$$A_y - 900 - 4000 = 0$$

$$A_y = 4900 N$$

$$\sum M_A = 0$$

$$M_A + (0,38 \cdot 1950) \cdot (7,2) - (900 \cdot 2,1) = 0$$

$$M_A = -3445,2 N \cdot m$$

$$M_A = 3445,2 N \cdot m$$

Support C

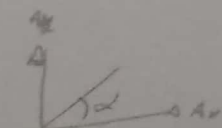
$$\sum F_y = 0$$

$$A_x - 0,38 \cdot 1950 = 0$$

$$A_x = 741 N$$

$$A_y - 0,92(1950) - 4900 = 0$$

$$A_y = 6694$$



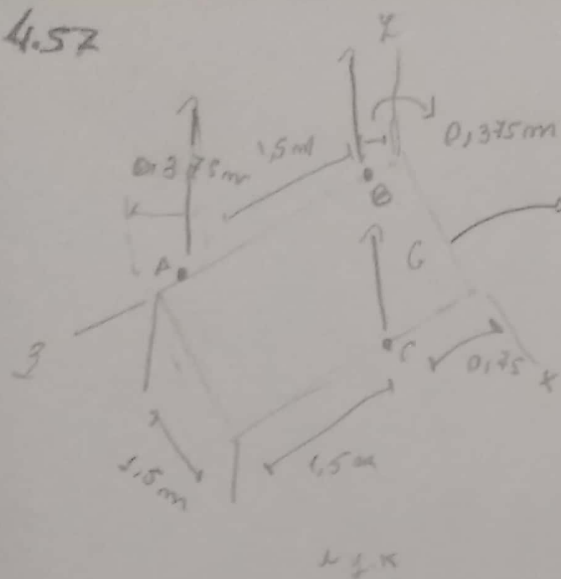
$$T \sin \alpha = \frac{49}{\frac{A_x}{\cos \alpha}}$$

$$\alpha = 83,68^\circ$$

$$A = \frac{A_x}{\cos \alpha}$$

$$A = 6731 N$$

4.52



$$r_{AB} = 1,5 \text{ m}$$

$$r_{CB} = 0,375 \text{ m}$$

$$\sum M_B = 0$$

$$r_{AB} \cdot T_A + r_{CB} \cdot T_C + r_{GB} \cdot T_G = 0$$

$$r_{AB} T_A \hat{j} + r_{CB} T_C \hat{j} + r_{GB} (-360 \hat{j}) = 0$$

$$0 = 1,5 \hat{k} \times T_A \hat{j} + (1,5 \hat{i} + 0,375 \hat{k}) \times T_C \hat{j} + (0,375 \hat{i} + 0,375 \hat{k}) \times (-360 \hat{j})$$

$$-1,5 T_A \hat{i} + 1,5 T_C \hat{i} - 0,375 T_C \hat{i} (-0,375 \hat{k} + 0,375 \hat{k}) \times 360$$

$$(-1,5 T_A - 0,375 T_C + 270) \hat{i} + (1,5 T_C - 270) \hat{k} = 0$$

o tração ocorre em y

$$\sum F_y = 0$$

$$T_A + T_B + T_C - 360 = 0$$

$$135 + T_B + 180 - 360 = 0$$

$$T_B = 360 - 135 - 180$$

$$T_B = 45$$

$$\boxed{\text{em N}}$$

$$1,5 T_C - 270 = 0$$

$$T_C = \frac{270}{1,5}$$

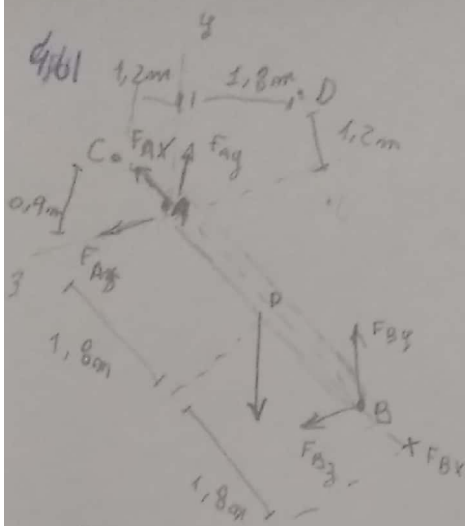
$$T_C = 180 \text{ N}$$

$$\boxed{\text{em N}}$$

$$-1,5 T_A - 0,375 T_C + 270 = 0$$

$$\frac{270 - 0,375 \cdot 180}{1,5} = T_A$$

$$T_A = 135$$



Respostas

$$A = 0\hat{i} + 0\hat{j} + 0\hat{k}$$

$$B = +3,6\hat{i} + 0\hat{j} + 0\hat{k}$$

$$C = 0\hat{i} + 0,9\hat{j} + 1,2\hat{k}$$

$$D = 0\hat{i} + 1,2\hat{j} - 1,8\hat{k}$$

$$P = 1,8\hat{i} + 0\hat{j} + 0\hat{k}$$

colocado
as respostas
na resposta

$$T_{BC} = \frac{BC}{|BC|}$$

C-B

$$T_{BC} = \frac{-3,6\hat{i} + 0,9\hat{j} + 1,2\hat{k}}{\sqrt{3,6^2 + 0,9^2 + 1,2^2}} = -0,92\hat{i} + 0,23\hat{j} + 0,3\hat{k}$$

$$T_{BD} = \frac{-3,6\hat{i} + 1,2\hat{j} - 1,8\hat{k}}{\sqrt{3,6^2 + 1,2^2 + 1,8^2}} = -0,86\hat{i} + 0,29\hat{j} - 0,43\hat{k}$$

$$\sum M_A = 0$$

$$1,8\hat{i} \times (3825 - \hat{j}) + 3,6\hat{i} \times (T_{BD}(-0,86\hat{i} + 0,29\hat{j} - 0,43\hat{k}) + T_{BC}(-0,92\hat{i} + 0,23\hat{j} + 0,3\hat{k})) = 0$$

$$(6885 - x)(3,6 \cdot 0,29)T_{BD}\hat{k} + (3,6 \cdot 0,43)T_{BD}\hat{j} + (3,6 \cdot 0,23)T_{BC}\hat{k} + (3,6 \cdot -0,3)T_{BC}\hat{j} = 0$$

$$(6885 + 1,04T_{BD} + 0,83T_{BC})\hat{k} + (1,55T_{BD} - 1,08T_{BC})\hat{j} = 0$$

$$\begin{cases} 1,54T_{BD} - 1,08T_{BC} = 0 \\ -6885 + 1,04T_{BD} + 0,83T_{BC} = 0 \end{cases}$$

$$T_{BD} = \frac{1,08T_{BC}}{1,54}$$

$$T_{BD} = 0,71T_{BC}$$

$$= 0,7 \cdot 4387,46$$

$$\approx 3150 \text{ N}$$

$$T_{BC} = 4387$$

$$(-4050\hat{i} + 1012,5\hat{j} + 1350\hat{k}) \text{ N}$$

$$T_{BD} = 3150$$

$$(-2700\hat{i} + 900\hat{j} - 1350\hat{k}) \text{ N}$$

$$\sum F = 0$$

$$-2700 - 4050 + F_{Ax} = 0$$

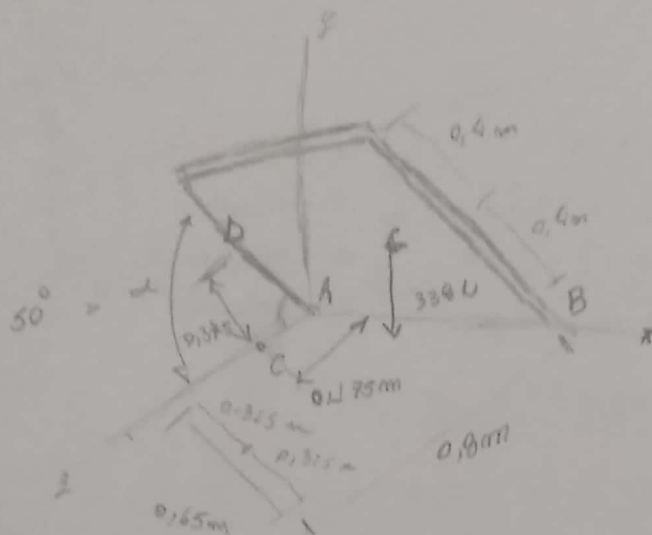
$$900 + 1012,5 - 3825 + F_{Ay} = 0$$

$$-1350 + 1350 + F_{Az} = 0$$

$$F_R = (6750\hat{i} + 1912,5\hat{j}) \text{ N}$$

$$\begin{cases} F_{Az} = 0 \\ F_{Ax} = 6750 \text{ N} \\ F_{Ay} = 1912,5 \text{ N} \end{cases}$$

4.60



$$D = ?$$

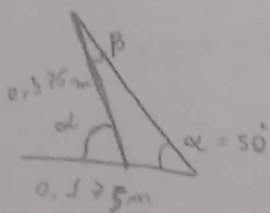
$$A_x = ?$$

$$A_y = ?$$

$$A_z = ?$$

$$B_x = ?$$

$$B_y = ?$$



Là des sinus

$$\frac{\sin \beta}{0.375} = \frac{\sin 50^\circ}{0.325}$$

$$\gamma = 50^\circ + 20.94^\circ$$

$$\gamma = 70.94^\circ$$

$$\sin \beta = \frac{\sin 50^\circ \cdot 0.375}{0.325}$$

$$\beta = 20.94^\circ$$

$$A = (-119.38)\hat{j} + (-17.14)\hat{k}$$

$$\sum M_A = 0$$

$$r_{C,D} + r_D \times 6\hat{j} + r_B \times (B_y\hat{j} + B_z\hat{k}) = 0$$

$$[1.75\hat{k} \times (0.5\sin\gamma\hat{j} + \cos\gamma\hat{k})] + [(0.325\hat{i} + 0.4\cos\gamma\hat{k}) \times (-338\hat{j})] + [0.65\hat{i} \times (B_y\hat{j} + B_z\hat{k})] = 0$$

$$-1.75 \cdot 0.5 \sin\gamma \hat{k} - 0.325 \cdot 338 \hat{k} + 0.4 \cos\gamma \hat{k} \cdot 338 = 0.65 B_z \hat{j} + 0.65 B_y \hat{k}$$

$$(-1.75 \cdot 0.5 \sin\gamma + 0.4 \cos\gamma \cdot 338)\hat{k} - (0.65 B_z)\hat{j} + (-0.325 \cdot 338 + 0.65 B_y)\hat{k} = 0$$

$$\hat{i}: -1.75 \cdot 0.5 \sin 70.94^\circ + 338 \cdot 0.4 \cos 50.94^\circ = 0$$

$$\sum F_x = 0 \rightarrow A_x = 0$$

$$D = \frac{338 \cdot 0.4 \cdot \cos 50.94^\circ}{1.75 \cdot 0.5 \sin 70.94^\circ} = 52.5$$

$$\sum F_y = A_y + 0.5 \sin\gamma + 338 + B_y = 0$$

$$= A_y + 52.5 \sin 70.94^\circ - 338 - 169 = 0$$

$$A_y = -119.38$$

$$\hat{j}: 0.65 B_z = 0$$

$$B_z = 0$$

$$\hat{k}: -0.325 \cdot 338 + 0.65 B_y = 0$$

$$\sum F_z = A_z + 52.5 \cos 70.94^\circ$$

$$B_y = \frac{0.325 \cdot 338}{0.65} = 169$$

$$A_z = -17.14$$

470

$$T = (15000)(9.8) = 147N //$$

$$T_x = (147)(-\cos 45^\circ + \sin 45^\circ)$$

$$T_x = -(104,05)\hat{i} + (104,05)\hat{j}$$

$$W = -(20000)(9.8)\hat{j} = -196,2N //$$

$$\sum M_O = 0$$

$$15\hat{j} \times (A_x\hat{i} + A_y\hat{j}) + 0,61 \times (-196,2\hat{j})$$

$$+ (4,2\hat{i} + 1,75\hat{j}) \times (-104,05\hat{i} + 104,05\hat{j})$$

$$+ (1,05\hat{i} + 0,65\hat{j}) \times (P_x\hat{i}) = 0$$

$$-1,5A_x\hat{k} + 1,5A_y\hat{i} - 117,72\hat{i} - 124,9\hat{j} + 182,1\hat{k} + 182,1\hat{i} + 1,05P\hat{j} - 0,65P\hat{i} = 0$$

$$a) 1,5A_y + 182,1 - 0,65(118,9) = 0$$

$$b) -124,9 + 1,05P = 0$$

$$c) -1,5A_x - 117,7 + 182,1 = 0$$

$$P = 118,9N$$

$$A_x = 42,9N$$

$$A_y = -69,9N$$

$$\left. \begin{array}{l} P = 118,9N \\ A_x = 42,9N \\ A_y = -69,9N \end{array} \right\} A = [(42,9\hat{i}) - (69,9)\hat{j}]N$$

$$\sum F_x \rightarrow A_x + B_x - T \cos 45^\circ - P = 0$$

$$\sum F_y \rightarrow B_y + W = 0$$

$$\sum F_z \rightarrow A_z + B_z + 104,05 - 118,9 = 0$$

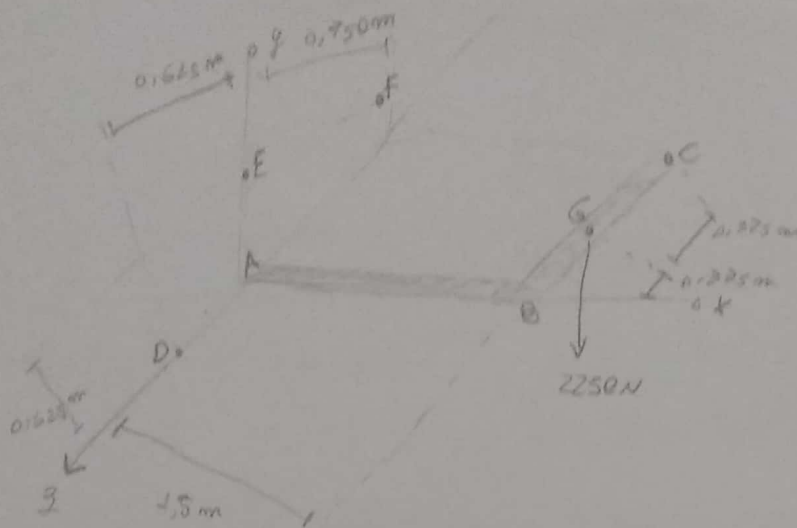
$$B_x = +61,1N$$

$$B_y = W = 196,2N$$

$$B_z = +84,7N$$

$$B = [61,1\hat{i} + 196,2\hat{j} + 84,7\hat{k}]N$$

4.73



$$T_{BD} = \frac{\vec{BD}}{|\vec{BD}|} = \frac{-1.5\hat{i} + 0.625\hat{j}}{1.625}$$

$$T_{BE} = \frac{\vec{BE}}{|\vec{BE}|} = \frac{-1.5\hat{i} + 0.625\hat{j}}{1.625}$$

$$T_{CF} = \frac{\vec{CF}}{|\vec{CF}|} = \frac{-1.5\hat{i} + 0.625\hat{j}}{1.625}$$

$$\sum M_A = 0$$

$$\hat{i} \quad \hat{j} \quad \hat{k} \quad \hat{i} \quad \hat{j}$$

$$r_B \times (-2250\hat{j}) + r_B \times T_{BD} + r_E \times T_{BE} + r_C \times T_{CF} = 0$$

$$[(1.5\hat{i} - 0.375\hat{k}) \times (-2250\hat{j})] + [1.5\hat{i} \times T_{BD}] + [-1.5\hat{i} + 0.625\hat{j}] \times \frac{-1.5\hat{i} + 0.625\hat{j}}{1.625} + [1.5\hat{i} \times T_{BE} + (-1.5\hat{i} + 0.625\hat{j}) \times \frac{-1.5\hat{i} + 0.625\hat{j}}{1.625}] + [1.5\hat{i} \times T_{CF} + (-1.5\hat{i} + 0.625\hat{j}) \times \frac{-1.5\hat{i} + 0.625\hat{j}}{1.625}] = 0$$

$$-3375\hat{k} - 843.75\hat{i} - 0.577\hat{j} \times T_{BD} + 0.577\hat{i} \times T_{BE} + 0.577\hat{k} + 0.69\hat{j} \times T_{CF} + 0.29\hat{i} \times T_{CF} = 0$$

$$(843.75 + 0.29 T_{CF})\hat{i} + (-0.577 T_{BD} + 0.69 T_{CF})\hat{j} + (-3375 + 0.577 T_{BE} + 0.577 T_{CF})\hat{k} = 0$$

$$1.843,75 + 0.29 T_{CF}$$

$$T_{CF} = \frac{843,75}{0,29} = 2909,48$$

$$-0.577 T_{BD} + 0.69 T_{CF} = 0$$

$$T_{BD} = \frac{0,69 \cdot 2909,48}{0,577} = 3479,27$$

$$K = -3375 + 0.577 T_{BE} + 0.577 T_{CF}$$

$$T_{BE} = \frac{-3375 + 0.577 \cdot 2909,48}{0,577}$$

$$T_{BE} = 2936,17$$

$$\sum F_x = 0 \rightarrow A_x = \frac{1.5}{1.625} \cdot (2909,48 + 3479,27 + 2936,17)$$

$$\sum F_y = 0$$

$$A_y = 2250 + \frac{0.625}{1.625} \cdot (2936,17 + 2909,48)$$

$$\sum F_z = 0$$

$$A_z = 0$$

$$A_z = 1338,18$$

$$A = (8607,64)\hat{i} + (1338,18)\hat{j}$$