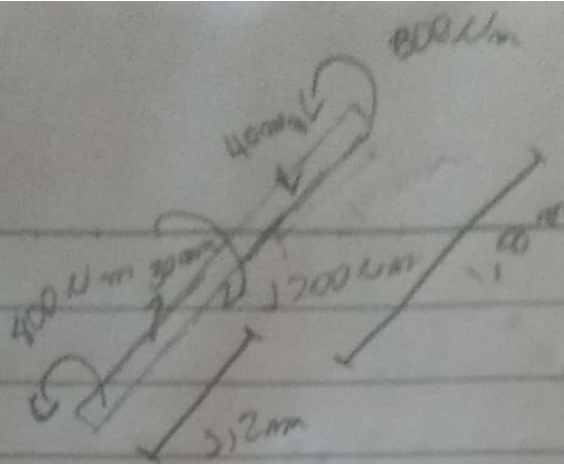


10.7



a) dados $T = 400 \text{ N·m}$ $J = \frac{\pi C^4}{2}$
 $C = \frac{1}{2} d \Rightarrow 0,015 \text{ m}$
 $d = 0,030 \rightarrow 0,020 \text{ m}$

• $\tau_{medio} = \frac{T_C}{J} = \frac{2T}{\pi C^3} = \frac{2 \cdot 400}{\pi \cdot (0,015)^3} = 7,5 \cdot 10^6 \text{ PA}$

b) $\frac{2T}{\pi C^3} = \frac{2 \cdot 800}{\pi (0,020)^3} = 63,7 \cdot 10^6 \text{ PA}$

10.8 (continua anterior)

a) $T = 400 \text{ N·m}$

$\tau_{max} = 60 \text{ MPa}$

$J = \frac{\pi C^4}{2}$

$\tau = \frac{T_C}{J} = \frac{2T}{\pi C^3}$

(AB)

$C = \sqrt[3]{\frac{2T}{\pi \tau_{mat}}}$

$C = \sqrt[3]{\frac{2 \cdot 400}{\pi (60 \cdot 10^6)}}$

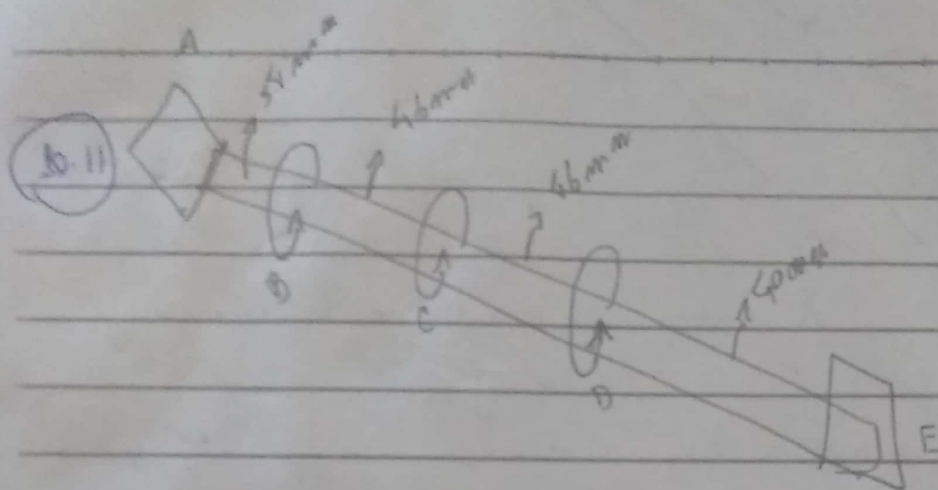
$C = 16,19 \cdot 10^{-3} \text{ m}$

(BC)

b) $T = 800 \text{ N·m}$

$\tau_{max} = 60 \text{ MPa}$

$\therefore C = \sqrt[3]{\frac{2 \cdot 800}{\pi (60 \cdot 10^6)}} = 20,40 \text{ m}$



a) $T_{AB} = 2,4 \cdot 10^3$

(AB)

$c = \frac{1}{2} L = 0,027 \text{ m}$

$\tau_{AB} = \frac{T_c}{\gamma} = \frac{2T}{\pi c^3} = \frac{2 \cdot 2,4 \cdot 10^3}{\pi \cdot (0,027)^3} = 77,625 \cdot 10^6 \text{ Pa}$

b) $T_{BC} = 2,4 \text{ kNm} - 1,2 \text{ kNm}$
 $= 1,2 \text{ kNm}$

(BC)

$c = \frac{1}{2} L = 0,025 \text{ m}$

$\tau_{BC} = \frac{2T}{\pi c^3} = \frac{2T}{\pi c^3} = \frac{2 \cdot (1,2 \cdot 10^3)}{\pi \cdot (0,023)^3} = 62,788 \cdot 10^6 \text{ Pa}$

c) $T_{CD} = 0,4 \cdot 10^3 \text{ kNm}$

$c = \frac{1}{2} L = 0,023 \text{ m}$

(CD)

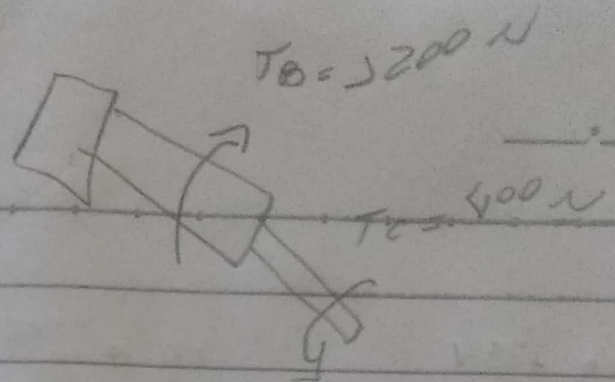
$\tau_{CD} = \frac{T_c}{\gamma} = \frac{2T}{\pi c^3} = \frac{2 \cdot 0,4 \cdot 10^3}{\pi \cdot (0,023)^3} = 20,929 \cdot 10^6 \text{ Pa}$

10.17

$$\tau_{max} = 55 \text{ MPa}$$

$$\tau_{max} \cdot \frac{I_C}{\tau} = \frac{2T}{\pi C^3}$$

$$C = \sqrt[3]{\frac{2T}{\pi \tau_{max}}}$$



AB

$$T_{AB} = 1200 - 400 = 800 \text{ N}$$

$$C = \sqrt[3]{\frac{2 \cdot 800}{\pi \cdot 55 \cdot 10^6}} = 21 \cdot 10^{-3} \text{ m}$$

$$\bullet \text{minimo} \Rightarrow 2 \cdot C \rightarrow 2 \cdot 21 \cdot 10^{-3} = 42 \cdot 10^{-3}$$

BC

$$C = \sqrt[3]{\frac{2 \cdot 400}{\pi \cdot 55 \cdot 10^6}} = 16,667 \cdot 10^{-3}$$

$$\bullet \text{minimo } 2BC \rightarrow 2 \cdot C = 33,3 \cdot 10^{-3} \text{ m}$$

10.19

$$T_F = 135 \text{ N}$$

$$r_D = 200 \text{ mm} = 0,2 \text{ m}$$

$$\gamma_{\text{CSO}} = 72 \cdot 10^6 \text{ Pa}$$

$$r_g = 75 \text{ mm} = 0,075 \text{ m}$$

$$T_e = \frac{r_D}{r_g} \cdot T_F \rightarrow \frac{0,2}{0,075} \cdot 135 = 360$$

$$a) c^3 = \frac{2T}{\pi \tau} \rightarrow c = \sqrt[3]{\frac{2 \cdot 360}{\pi \cdot 72 \cdot 10^6}} = 0,0147 \text{ m}^3$$

$$J_{DE} = 2 \cdot c$$

$$= 2 \cdot 1,45 \cdot 10^{-3}$$

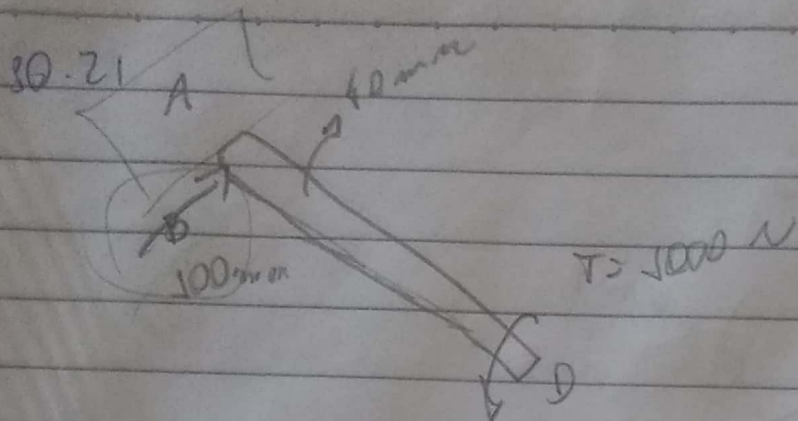
$$= 0,0294$$

$$b) c = \sqrt[3]{\frac{2 \cdot 135}{\pi \cdot 72 \cdot 10^6}} = 0,0106$$

$$J_{FG} = 2 \cdot c$$

$$= 2 \cdot 0,0106$$

$$= 0,0212$$



$$T_{CD} = 1000 \text{ Nmm}$$

$$T_{AB} = \frac{x_B}{r_c} = \frac{100}{40} \cdot 1000 = 2500 \text{ Nmm}$$

a)

(AB)

$$c = \frac{1}{2} d = 0,028 \text{ m}$$

$$\tau = \frac{T_c}{J} = \frac{2T}{\pi c^3} = \frac{2 \cdot 1000}{\pi \cdot 0,028^3} = 72,50 \cdot 10^6 \text{ Pa}$$

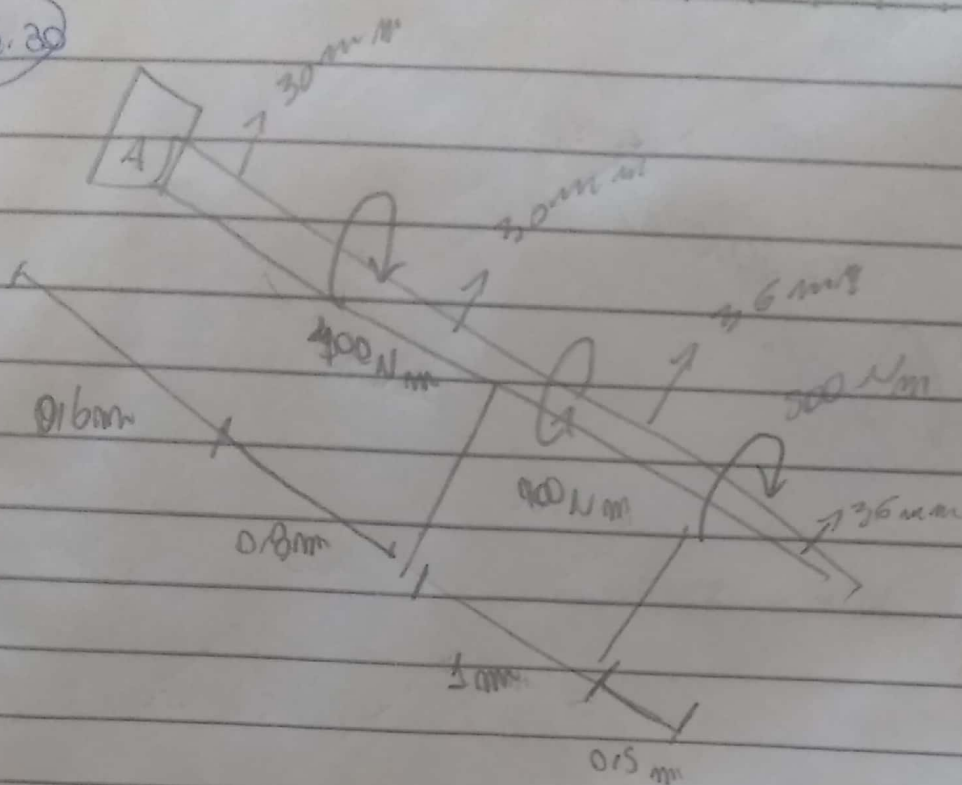
b)

(BC)

$$c = \frac{1}{2} d = 0,020$$

$$\tau = \frac{T_c}{J} = \frac{2T}{\pi c^3} = \frac{2 \cdot 1000}{\pi \cdot 0,020^3} = 68,7 \cdot 10^6 \text{ Pa}$$

40.30



$$a) c = \frac{1}{2} d = 0.015 \text{ mm}$$

$$J_{BC} = \frac{\pi}{4} c^4 = 79.522 \cdot 10^{-9} \text{ mm}^4$$

$$L_{BC} = 0.08 \text{ mm}$$

$$G = 27 \cdot 10^9 \text{ Pa}$$

$$P_{BC} = \frac{T L}{G J} = \frac{500 \cdot 0.08}{27 \cdot 10^9 \cdot 79.522 \cdot 10^{-9}}$$

$$= 0.149904 \text{ rad}$$

$$c = \frac{1}{2} d = 0.015 \text{ mm}$$

$$b) L_{CD} = 1 \text{ mm}$$

$$T_{CD} = 400 - 900 = -500$$

$$P_{CD} = \frac{T L}{G J} = \frac{-500 \cdot 1}{27 \cdot 10^9 \cdot 79.522 \cdot 10^{-9}}$$

$$= -0.11230 \text{ rad}$$

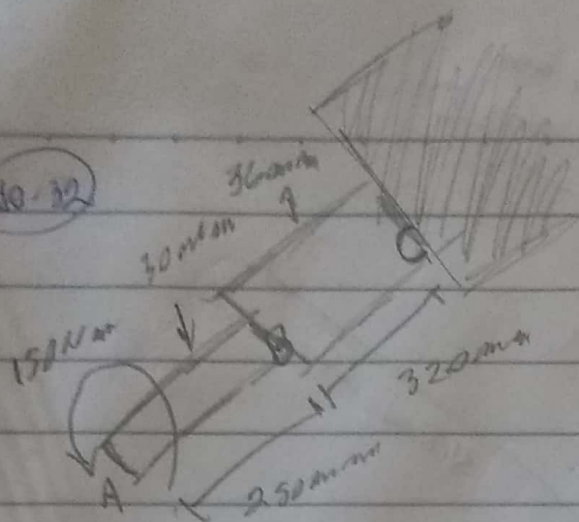
$$P_{BD} = P_{BC} + P_{CD}$$

$$= 0.149904 - 0.11230$$

$$= 0.037604 \text{ rad}$$

$$\approx 2.11^\circ$$

10-22



(in rad)

a) $\rightarrow B$?

in AB

$$P_{AB} = \frac{TL}{GJ} = \frac{180 \cdot 250}{(39 \cdot 10^9) \cdot (79,522 \cdot 10^{-9})}$$

$$C = \frac{1}{2} L = 0,125 \text{ m}$$

$$L = 0,250 \text{ m}$$

$$G = 39 \cdot 10^9$$

$$J = \frac{\pi C^4}{2} = 79,522 \cdot 10^{-9} \text{ m}^4$$

$$T = 180 \text{ N m}$$

$$= 14,510 \cdot 10^{-3} \text{ rad}$$

in BC

$$C = \frac{1}{2} L = 0,16 \text{ m}$$

$$L = 0,320 \text{ m}$$

$$G = 27 \cdot 10^9 \text{ Pa}$$

$$J = \frac{\pi C^4}{2} = 164,896 \cdot 10^{-9} \text{ m}^4$$

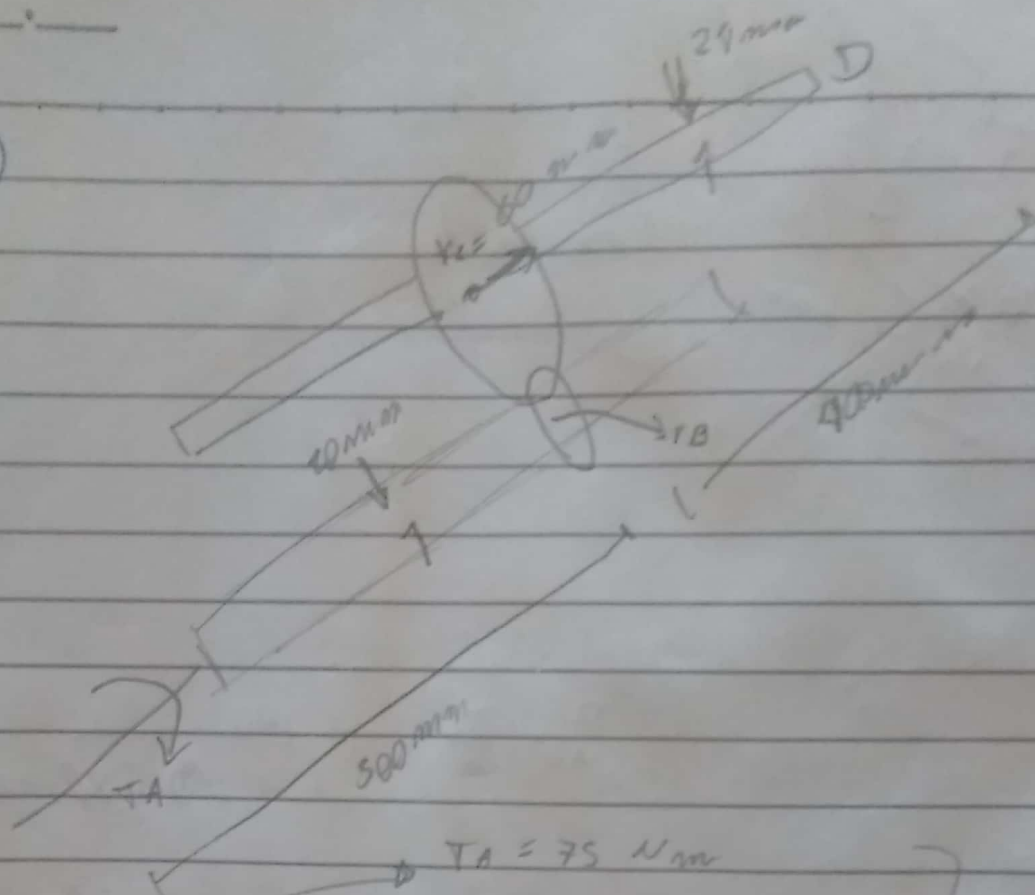
$$P_{BC} = \frac{180 \cdot 0,320}{27 \cdot 10^9 \cdot 164,896 \cdot 10^{-9}}$$

$$= 12,937 \cdot 10^{-3}$$

$$\rightarrow P_{BC} = P_{BC} = 12,937 \cdot 10^{-3} \text{ rad}$$

$$\rightarrow P_A = P_{BC} + P_{AB} = 27,447 \cdot 10^{-3} \text{ rad}$$

10.33



$$T_A = 75 \text{ N}\cdot\text{m}$$

TORQUES

$$T = \frac{T_{AB}}{r_B} = \frac{T_{CD}}{r_C} \Rightarrow T_{CD} = \frac{r_C}{r_B} \cdot T_{AB}$$

$$T_{CD} = \frac{0,060(75)}{0,020} = 225 \text{ N}\cdot\text{m}$$

CD

$$\gamma = \frac{\pi}{2} \cdot C_{CD}^4 = \frac{\pi}{2} \cdot (0,02)^4 = 32,542 \cdot 10^{-9} \text{ m}$$

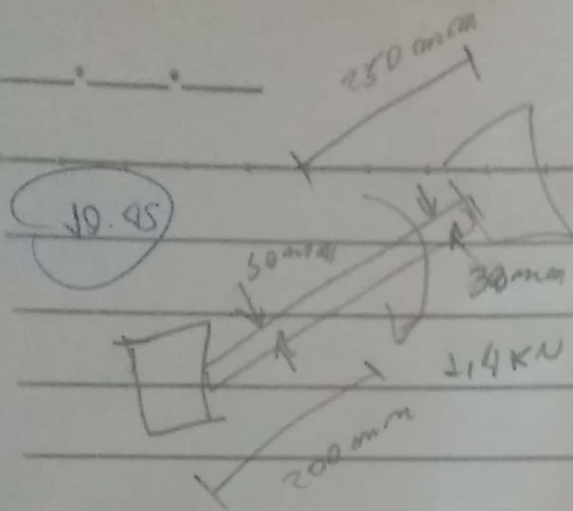
$$L_{CD} = 0,400 \text{ m} \quad P_{CD} = \frac{TL}{GJ} = \frac{225 \cdot 0,400}{77 \cdot 10^9 \cdot 32,542 \cdot 10^{-9}} = 35,885 \cdot 10^{-3} \text{ rad}$$

ângulo B

$$\gamma_{AB} = \frac{\pi}{2} \cdot C_{AB}^4 = \frac{\pi}{2} \cdot (0,020)^4 = 15,708 \cdot 10^{-9}$$

$$L_{AB} = 0,500 \text{ m} \quad P_{AB} = \frac{TL}{GJ} = \frac{75 \cdot 0,500}{77 \cdot 10^9 \cdot 15,708 \cdot 10^{-9}} = 31,04 \cdot 10^{-3} \text{ rad}$$

$$\Rightarrow \text{logo} \Rightarrow P_A = P_{CD} + P_{AB} = 138,70 \cdot 10^{-3} \text{ rad}$$



(A0)

$$J_{AB} = J$$

$$C = \frac{1}{2} d = 25 \cdot 10^{-3} \text{ m}$$

$$L_{AB} = 0,200 \text{ m}$$

$$J = \frac{\pi}{2} C^4 = \frac{\pi}{2} \cdot (0,025)^4 = 613,59 \cdot 10^{-9}$$

$$P_0 = \frac{T_{AB} L_{AB}}{G J_{AB}} \Rightarrow T_{AB} = \frac{G J_{AB}}{L_{AB}} \cdot P_0$$

$$= \frac{77,2 \cdot 10^9 \cdot 613,59 \cdot 10^{-9}}{0,200} \cdot P_0$$

$$= 236,857 \cdot 10^3 \text{ PA}$$

(BC)

$$J = J_{BC} \quad L = 0,250 \text{ m}, \quad C = \frac{1}{2} d = 0,019 \text{ m}$$

$$J = \frac{\pi}{2} \cdot C^4 = \frac{\pi}{2} \cdot (0,019)^4 = 204,71 \cdot 10^{-9}$$

$$T_{BC} = \frac{G J_{BC}}{L_{BC}} \cdot P_0 = \frac{77,2 \cdot 10^9 \cdot 204,71 \cdot 10^{-9}}{0,250} \cdot P_0$$

$$= 63219 \cdot 10^3 \text{ PA}$$

• equilíbrio no disco

$$1,4 \cdot 10^3 = 236,847 \cdot 10^3 P_0 + 63,214 \cdot 10^3 P_0$$
$$P_0 = 4,6657 \cdot 10^{-3} \text{ rad}$$

$$T_B = (236,847 \cdot 10^3) (4,6657 \cdot 10^{-3}) = 1,10506 \cdot 10 \text{ N m}$$

$$T_{BC} = (63,214 \cdot 10^3) (4,6657 \cdot 10^{-3}) = 294,94 \text{ N m}$$

a)

• Relação de superfície

$$T_A = T_{AB} = 1105 \text{ N m}$$

$$T_C = T_{BC} = 295 \text{ N m}$$

b) máxima tensão AB

$$\gamma_{AB} = \frac{T_{AB}}{J_{AB}} = \frac{(1,10506 \cdot 10^3) (0,019)}{(204,71 \cdot 10^{-9})} = 45,1 \cdot 10^9 \text{ Pa}$$

c) máxima tensão em BC

$$\gamma_{BC} = \frac{T_{BC} \cdot c}{J_{BC}} = \frac{(294,94) (0,019)}{204,71 \cdot 10^{-9}} = 27,4 \cdot 10^9 \text{ Pa}$$