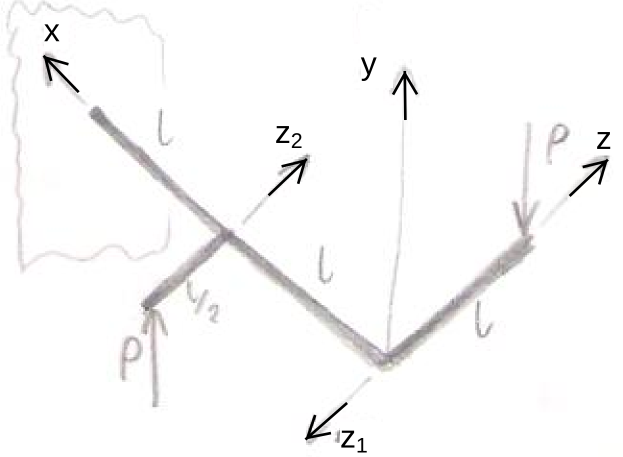
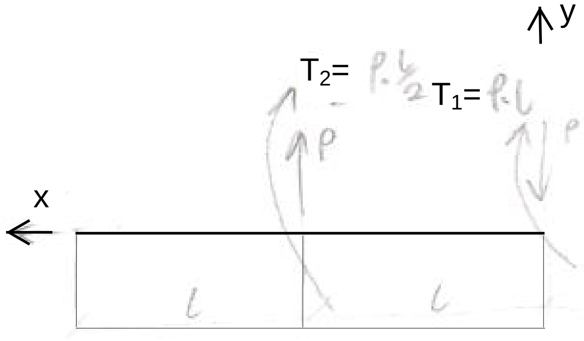




$0 < x < l$

$T_b = -P \cdot x$

for $x = 0$

$T_b = 0$

for $x = l$

$T_b = -P \cdot l$

$T_t = T_1$

$T_t = P \cdot l$

$l < x < 2l$

$T_b = -P \cdot x + P \cdot (x - l)$

for $x = l$

$T_b = -P \cdot l + 0$

$T_b = -P \cdot l$

for $x = 2l$

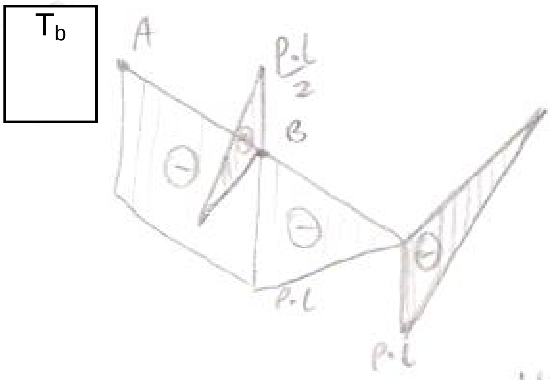
$T_b = -P \cdot 2l + P \cdot l$

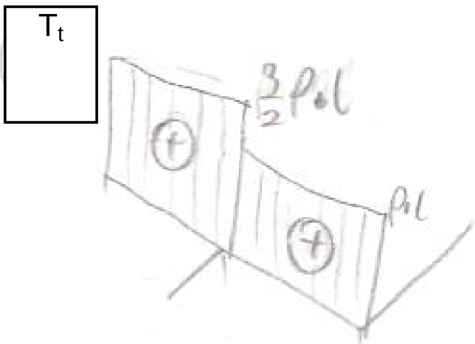
$T_b = -P \cdot l$

$T_t = T_1 + T_2$

$T_t = P \cdot l + \frac{P \cdot l}{2}$

$T_t = 1\frac{1}{2} P \cdot l$





$W = \frac{J_{zc}}{y_{max}}$

$W = \frac{\pi d^4}{64} \cdot \frac{2}{d}$

for axis z_1

$0 < z_1 < l$

$T_b = -P \cdot z_1$

for $z_1 = 0$

$T_b = 0$

for $z_1 = l$

$T_b = -P \cdot l$

for axis z_2

$0 < z_2 < l/2$

$T_b = P \cdot z_2$

for $z_2 = 0$

$T_b = 0$

for $z_2 = l/2$

$T_b = P \cdot \frac{l}{2}$

T_{r_v} − *reduced vicarious torque*

$$T_{r\_v} = \sqrt{{T_b}^2 + 0{,}75 \cdot {T_t}^2}$$

σ_{r_v} − *reduced vicarious stress*

$$\sigma_{r\_v} = \frac{T_{r\_v}}{w} \leq k_r$$

$$\sigma_{r\_v} = \frac{32}{\pi \cdot d^3} \cdot \sqrt{{T_b}^2 + 0{,}75 \cdot {T_t}^2} \leq k_r$$

Known:
P=4[kN] - force
l=0,2[m] - length
k_r =120[MPa] - maximum stress

Find:
d=?
beam has circle section
d - beam section diameter

$$W = \frac{J_{zc}}{y_{max}}$$

$$W = \frac{\pi d^4}{64} \cdot \frac{2}{d}$$

$$W = \frac{\pi d^3}{32}$$

$$T_{r\_v}{}^{B} = T_{r\_v}{}^{A}$$

$$T_{r\_v}{}^{B} = \sqrt{(-P \cdot l)^2 + 0{,}75\left(\frac{3}{2} P \cdot l\right)^2}$$

$$T_{r\_v}{}^{B} = P^2 \cdot l^2 + 0{,}75 \cdot \frac{9}{4} P^2 \cdot l^2$$

$$T_{r\_v}{}^{B} = P \cdot l \cdot \sqrt{1 + \frac{3}{4} \cdot \frac{9}{4}}$$

$$T_{r\_v} = P \cdot l \cdot \sqrt{\frac{16}{16} + \frac{27}{16}}$$

$$T_{r\_v} = P \cdot l \cdot \sqrt{\frac{43}{16}}$$

$$\sigma_{r\_v} = \frac{T_{r\_v}}{W} \leq k_r$$

$$\frac{P \cdot l \cdot \sqrt{\frac{43}{16}}}{\frac{\pi d^3}{32}} \leq k_r$$

$$P \cdot l \cdot \sqrt{\frac{43}{16}} \cdot \frac{32}{\pi d^3} \leq k_r$$

$$d^3 \cdot k_r \geq P \cdot l \cdot \sqrt{\frac{43}{16}} \cdot \frac{32}{\pi}$$

$$d^3 \geq \frac{32 \cdot P \cdot l \sqrt{\frac{43}{16}}}{\pi \cdot k_r}$$

$$d \geq \left(\frac{32 \cdot P \cdot l \sqrt{\frac{43}{16}}}{\pi \cdot k_r}\right)^{1/3}$$

$$d \geq \left(\frac{32 \cdot 4 \cdot 10^3 \cdot 0{,}2 \cdot \sqrt{\frac{43}{16}}}{\pi \cdot 120 \cdot 10^6}\right)^{1/3}$$

$$d \geq 48\,mm$$