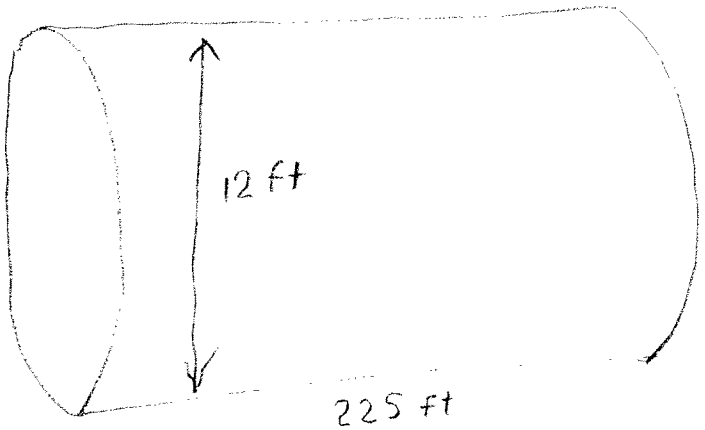
4.55 Not to scale



$\epsilon = \alpha \Delta T$

$$\epsilon_{long.} = \frac{\Delta L}{L} \Rightarrow \Delta L = \alpha \Delta T L$$

$$= \left(\frac{6.5 \times 10^{-6}}{^\circ F}\right)(250^\circ F)(225\,ft)$$

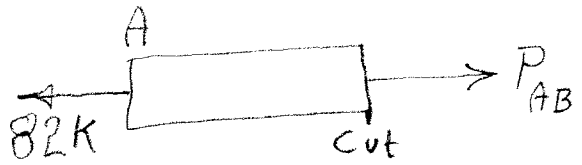
$$= 0.3656\,ft = \boxed{4.39\,in}$$

$$\epsilon_{trans} = \frac{\Delta D}{D} \Rightarrow \Delta D = \alpha \Delta T D$$

$$= \left(\frac{6.5 \times 10^{-6}}{^\circ F}\right)(250^\circ F)(12\,ft)$$

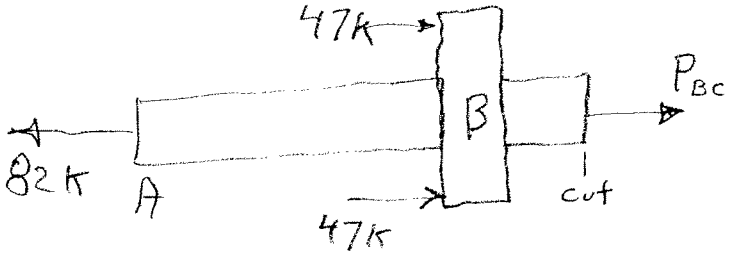
$$= 0.0195\,ft = \boxed{0.234\,in}$$

4.61



$\Sigma F_x = 0$

$P_{AB} = 82K \ (T)$



$\Sigma F_x = 0$

$P_{BC} = -12K \ (C)$

$\Sigma F_x = 0$

$P_{CD} = 45K \ T$

AB: $\sigma_{AB} = \frac{P_{AB}}{A} = \frac{82\,K}{4\,in^2} = 20.5 ksi$

$\delta_{AB} = \frac{P_{AB} L_{AB}}{A E} = 20.5 ksi \left(\frac{96 in}{30{,}000 ksi}\right) = 0.0656 in$

BC: $\sigma_{BC} = \frac{P_{BC}}{A} = \frac{-12K}{4 in^2} = -3.0 ksi$

$\delta_{BC} = \frac{P_{BC} L_{BC}}{A E} = -3.0 ksi \left(\frac{60 in}{30000 ksi}\right) = -0.006 in$

CD: $\sigma_{CD} = \frac{P_{CD}}{A} = \frac{45K}{4.0 in^2} = 11.25 ksi$

$\delta_{CD} = \frac{P_{CD} L_{CD}}{A E} = (11.25 ksi)\left(\frac{48 in}{30000 ksi}\right) = 0.018 in$

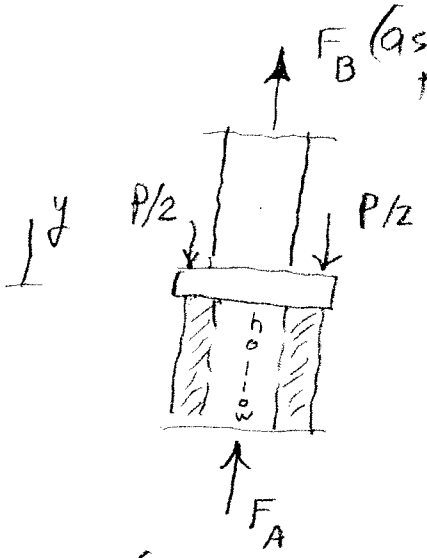
Total $\delta = \delta_{AB} + \delta_{BC} + \delta_{CD} = 0.0776$

a) **20.5 ksi** b) **0.0656 in** c) **-0.006 in**

d) **0.018 in**

4.72 $E_b = 100{,}000\ N/mm^2$ $\quad A_b = \frac{\pi}{4}(100^2 - 50^2)\ mm^2 = 5890\ mm^2$

$E_s = 200{,}000\ N/mm^2$ $\quad A_s = \frac{\pi}{4}(50\ mm)^2 = 1963\ mm^2$



$$\Sigma F_y = 0$$

$$F_A + F_B - P = 0$$

$$\sigma_A = \frac{F_A}{A_b} \qquad \sigma_B = \frac{F_B}{A_s}$$

$$\sigma_A A_b + \sigma_B A_s = P \quad (1)$$

$$5890\,\sigma_A + 1963\,\sigma_B = 500{,}000$$

$$\delta_{collar} = \delta_B = -\delta_A$$

$$\frac{F_B L_B}{E_s A_s} = -\frac{(-F_A L_A)}{E_b A_b}$$

$$\sigma_B \frac{L_B}{E_s} = \sigma_A \frac{L_A}{E_b} \quad (2)$$

$$\sigma_B \left(\frac{2060\ mm}{200{,}000\ N/mm^2}\right) = \sigma_A \left(\frac{1500\ mm}{100{,}000\ N/mm^2}\right)$$

Solving, $\boxed{\sigma_A = 56.6\ MPa\ Comp.}$ $\quad \boxed{\sigma_B = 84.9\ MPa\ Tens.}$

$$\delta = \sigma_B \frac{L_B}{E_s} = \boxed{0.849\ mm \downarrow}$$

4.83

$$\delta = \frac{PL}{AE} + \alpha \Delta T L$$

$\delta = 0$ in this case

$$\sigma\left(\frac{L}{E}\right) = -\alpha \Delta T L$$

$$\sigma = -\alpha \Delta T E$$

$$= -\left(\frac{12.5 \times 10^{-6}}{^\circ F}\right)\left(-100^\circ F\right)\left(10{,}500 \text{ Ksi}\right)$$

$$\boxed{\sigma = 13.25 \text{ Ksi. (T)}}$$

4-86

Assume the overall length constant, thermal strain changes, $\Rightarrow$ mech strain changes $\Rightarrow$ stress changes. $\delta = \frac{PL}{AE} + \alpha \Delta T$

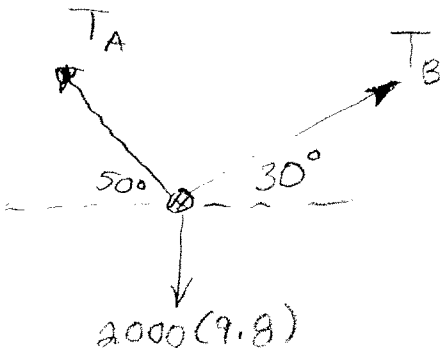
$$\sigma_{summer} \frac{L}{E} = \sigma_{winter} \frac{L}{E} + \alpha \Delta T L$$

$$\sigma_{winter} = \sigma_{summer} - \alpha \Delta T E$$

$$= 15\,MPa - \frac{11.9 \times 10^{-6}}{^\circ C} (-10 - 30)\,^\circ C \left(\frac{200000}{MPa}\right)$$

$$= 110.2\,MPa$$

4.96



$$\Sigma F_x = 0$$

$$-T_A \cos(50°) + T_B \cos(30°) = 0$$

$$\Sigma F_y = 0$$

$$T_A \sin(50°) + T_B \sin(30) - 2000(9.8) = 0$$

$T_A = 17236\ N$ $\quad T_B = 12793\ N$

From table $\sigma_y = 250\ MPa$

$$FS = 1.75 = \frac{\sigma_y}{\sigma_{all}} \Rightarrow \sigma_{all} = 142.9\ MPa$$

$$\sigma_{all} = \frac{T_A}{A_A} = \frac{17236\ N}{\frac{\pi}{4} d_A^2} = 142.9\ \frac{N}{mm^2}$$

$$d_A = 12.39\ mm$$

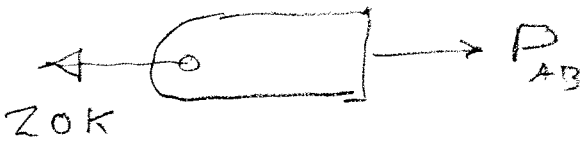
$$\sigma_{all} = \frac{T_B}{A_B} = \frac{12793\ N}{\frac{\pi}{4} d_B^2} = 142.9\ \frac{N}{mm^2}$$

$$d_B = 10.68\ mm$$

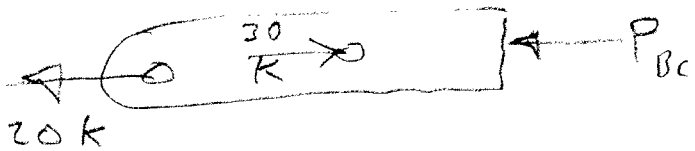
$d_A = 13\ mm$ ← Use

$d_B = 11\ mm$

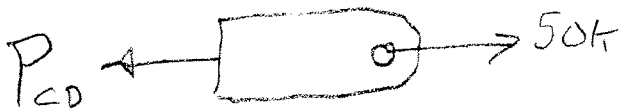
4.99



$\Sigma F_x = 0 \quad P_{AB} = 20K \ (T)$



$\Sigma F_x = 0 \quad P_{BC} = 10K \ (C)$



$\Sigma F_x = 0 \quad P_{CD} = 50K \ (T)$

The 50K load governs!

Table $\Rightarrow \quad \sigma_{ys} = 53 \text{ ksi}$

$$\frac{\sigma_{ys}}{\sigma_{all}} = 1.75 \qquad \sigma_{all} = 30.29 \text{ ksi}$$

$$\sigma_{all} = \frac{P_{CD}}{(1in)w} \qquad 30.29 \text{ ksi} = \frac{50K}{(1in)w}$$

$$\boxed{w = 1.651 \text{ in}}$$