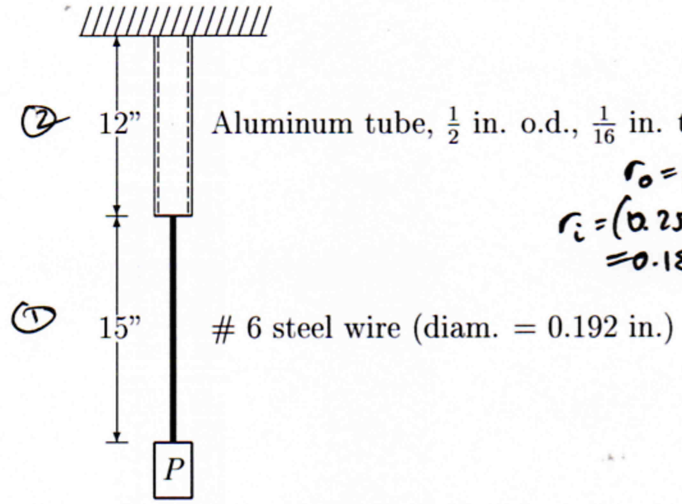
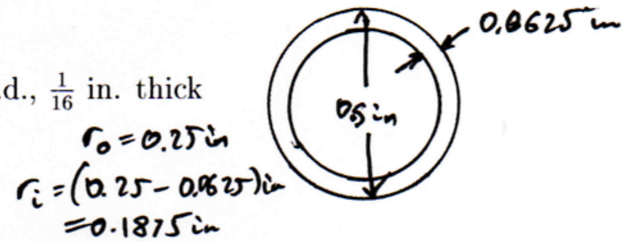
1.





$$E_{\text{steel}} = 30 \times 10^6 \text{ psi}, \qquad E_{\text{Al}} = 10 \times 10^6 \text{ psi}$$

(a) Find the magnitude of the force P that will produce a total elongation of 0.020 in., and find the resulting stresses in the steel and aluminum.

(b) If the tensile yield stresses are 15 ksi in aluminum and 36 ksi in steel, find the ultimate tensile load P_u for the system, and compute the safety factor under which it is working as in (a).

(a) $\Delta = P\left(\frac{L_1}{E_1 A_1} + \frac{L_2}{E_2 A_2}\right)$

$A_1 = \frac{1}{4}\pi(0.192 \text{ in})^2 = 0.0290 \text{ in}^2$; $A_2 = \pi(r_o^2 - r_i^2) = 0.0859 \text{ in}^2$

$0.02 \text{ in} = P\left(\frac{15 \text{ in}}{30 \times 10^6 \times 0.029 \text{ lb}} + \frac{12 \text{ in}}{10 \times 10^6 \times 0.0859 \text{ lb}}\right) = 31.2 \times 10^{-6} \frac{\text{in}}{\text{lb}} \cdot P$

$\rightarrow P = 641 \text{ lb}$

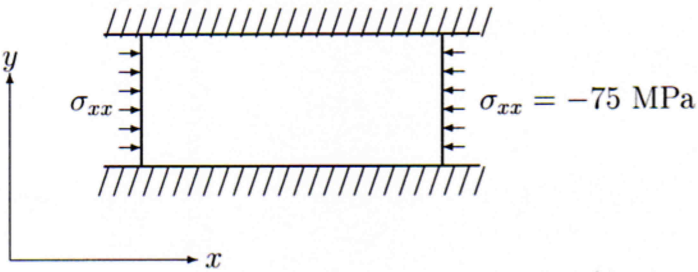
$\sigma_1 = \frac{641 \text{ lb}}{0.0290 \text{ in}^2} = 22.1 \text{ ksi}$, $\sigma_2 = 7.46 \text{ ksi}$

(b) $P_u = \min(\sigma_{Y1} A_1, \sigma_{Y2} A_2) = \min(1044, 1289) \text{ lb}$

$= 1044 \text{ lb}$

Safety factor $= \frac{P_u}{P} = \frac{1044 \text{ lb}}{641 \text{ lb}} = 1.63$

2. The steel plate shown is restrained from expanding or contracting in the y-direction, and, in addition to the stress σ_{xx}, it experiences a temperature drop of 20°C. Determine the stress σ_{yy} and the strain ε_{zz} if $E = 208$ GPa, $G = 80$ GPa and $\alpha = 11.7 \times 10^{-6}/°C$.



$$G = \frac{E}{2(1+\nu)} \rightarrow \nu = \frac{E}{2G} - 1 = \frac{208}{2(80)} - 1 = 0.3 \ ; \quad \Delta T = -20°C$$

$\sigma_{zz} = 0$ (plate)

$$\varepsilon_{yy} = 0 = \frac{1}{E}\left(\sigma_{yy} - \nu\sigma_{xx} - \nu\sigma_{zz}\right) + \alpha\Delta T \quad (\sigma_{zz} = 0)$$

$$\Rightarrow \sigma_{yy} = \nu\sigma_{xx} - E\alpha\Delta T$$
$$= 0.3 \times (-75 \text{ MPa}) - 208 \times 10^3 \text{ MPa} \times 11.7 \times 10^{-6} \times (-20)$$
$$= (-22.5 + 48.7) \text{ MPa} = 26.2 \text{ MPa}$$

$$\varepsilon_{zz} = \frac{1}{E}\left(\sigma_{zz} - \nu\sigma_{xx} - \nu\sigma_{yy}\right) + \alpha\Delta T \quad (\sigma_{zz} = 0)$$
$$= \frac{0.3}{208 \times 10^3 \text{ MPa}}\left(+75 \text{ MPa} - 26.2 \text{ MPa}\right) + 11.7 \times 10^{-6} \times (-20)$$
$$= (70.4 - 234) \times 10^{-6} = 163.6 \times 10^{-6}$$
$$\approx 164 \ \mu\text{strain}$$