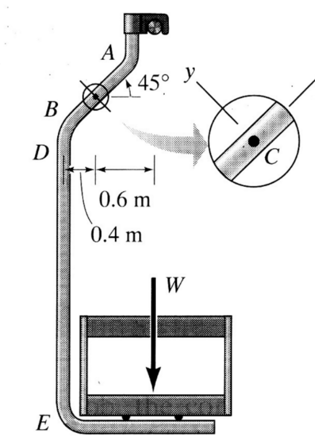
Example 16.6

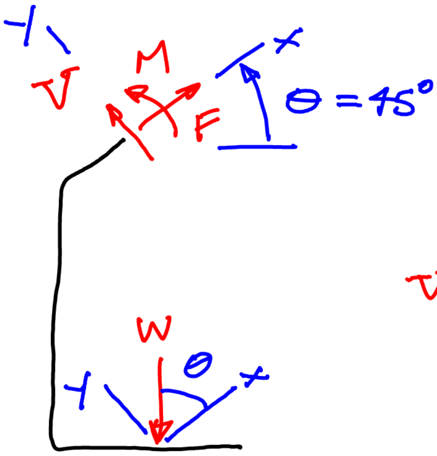
A chair on a ski lift is supported by a steel pipe with outer and inner diameters of $d_o = 60\ mm$ and $d_i = 52\ mm$, respectively. The weight of the pipe may be neglected as compared to the weight $W = 2\ kN$ of the chair and occupants.

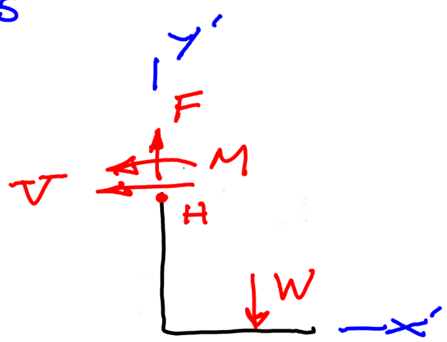
a) Determine the stresses at point C on the front section of the pipe at the location shown. The x-axis is parallel to the angled section of the pipe.

b) Determine the principal stresses and the maximum in-plane shear stress at point C.

c) Determine the maximum tensile stress in the straight section DE of the pipe.







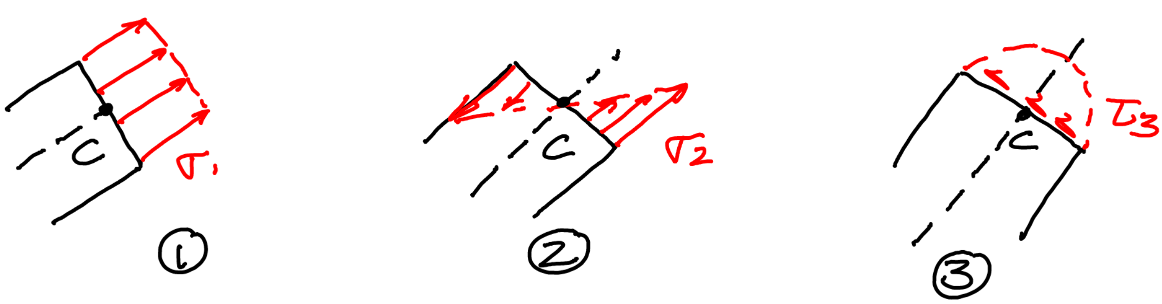
From FBD of cut at C:

$\Sigma M_c = -0.6W + M = 0 \quad \Rightarrow \mathbf{M = 0.6W}$

$\Sigma F_x = F - W\cos\theta = 0 \Rightarrow F = W\cos\theta$

$\Sigma F_y = V - W\sin\theta = 0 \Rightarrow V = W\sin\theta$

<u>Stresses at C</u>



At C we have:

$$\sigma = \sigma_1 = \frac{F}{A}$$

$$\tau = \tau_3\Big|_{max} = \frac{V A^* \bar{y}^*}{I t}$$

w/ $A = \pi\left(\frac{d_o}{2}\right)^2 - \pi\left(\frac{d_i}{2}\right)^2$

$$I = \frac{\pi}{4}\left(\frac{d_o}{2}\right)^4 - \frac{\pi}{4}\left(\frac{d_i}{2}\right)^4$$

$$A^* \bar{y}^* = \frac{\pi}{2}\left(\frac{d_o}{2}\right)^2 \frac{4}{3\pi}\left(\frac{d_o}{2}\right) - \frac{\pi}{2}\left(\frac{d_i}{2}\right)^2 \frac{4}{3\pi}\left(\frac{d_i}{2}\right)$$

$$t = d_o - d_i$$

$\therefore$

$$\begin{cases} \sigma_{ave} = \frac{\sigma}{2} \\ R = \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2} \end{cases}$$

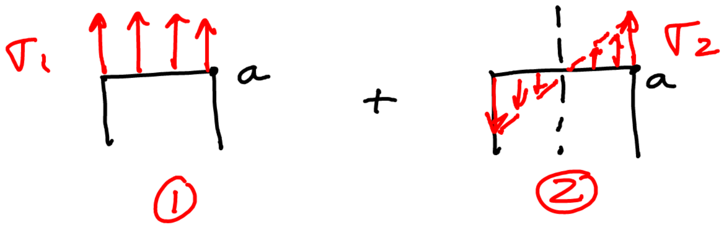
$$\begin{cases} \sigma_1 = \sigma_{ave} + R \\ \sigma_2 = \sigma_{ave} - R \\ (\tau_{max})_{in\text{-}plane} = R \end{cases}$$

(c) Make cut through section DE

$$\Sigma F_{y'} = F - W = 0 \Rightarrow F = W$$

$$\Sigma M_H = -W(1) + M = 0 \Rightarrow M = W$$

Stresses at cut



Make tensile stress occurs at "a":

$$\sigma = \sigma_1 + \sigma_2|_{max}$$

$$= \frac{F}{A} + \frac{My}{I} \quad ; \; y = \frac{d_o}{2}$$