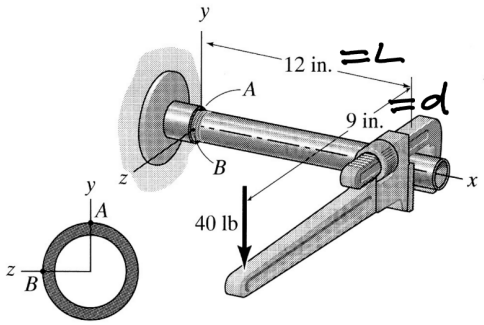
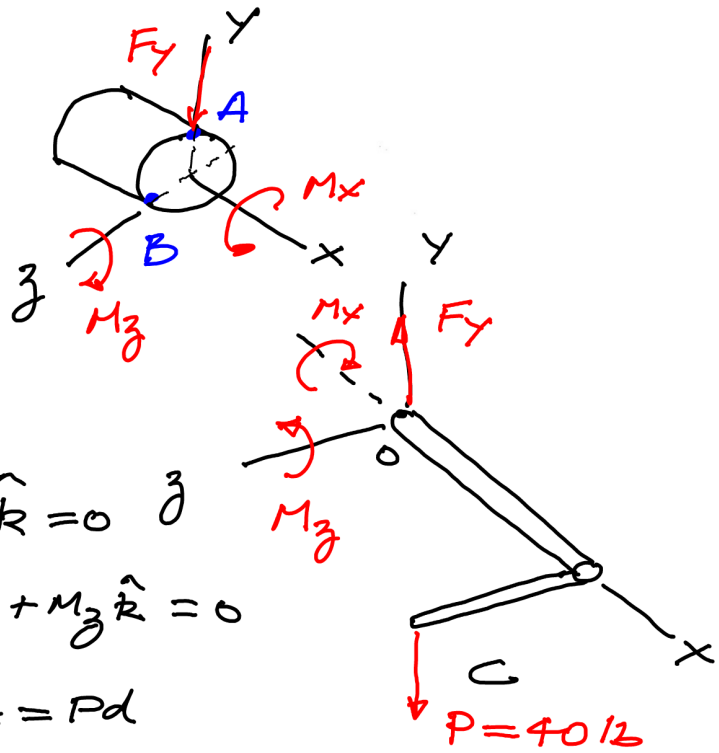
Example 16.4

A vertical force of $P = 40lb$ is applied to the end of a pipe wrench, whose handle is parallel to the z-axis. Determine the principal stresses at points A and B on the cross section of the pipe when the pipe threads start. The pipe has an outer diameter of 1 in and a wall thickness of 0.1 in.





Equilibrium

- $\sum \vec{M}_O = \vec{r}_{C/O} \times \vec{P} - M_x \hat{i} + M_z \hat{k} = 0$

↳ $(L\hat{i} + d\hat{k}) \times (-P\hat{j}) - M_x \hat{i} + M_z \hat{k} = 0$

↳ $\hat{i}$: $Pd - M_x = 0 \Rightarrow M_x = Pd$

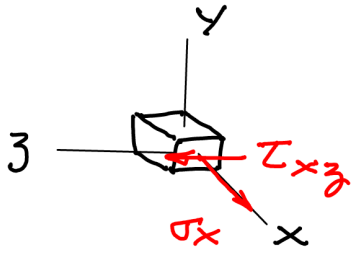
$\hat{k}$: $-PL + M_z = 0 \Rightarrow M_z = PL$

- $\sum F_y = -P + F_y = 0 \Rightarrow F_y = P$

Point A

$$\tau_{xz} = \frac{M_x r_o}{J}$$

$$\sigma_x = \frac{M_z r_o}{I}$$

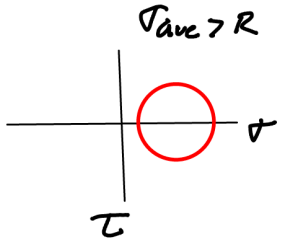


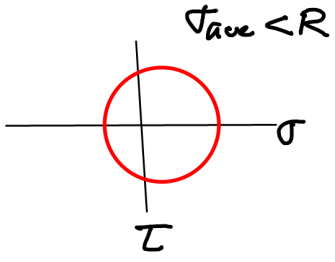
w/ $r_o = 0.5in$

$$J = \frac{\pi}{2}(0.5)^4 - \frac{\pi}{2}(0.4)^2$$

$$I = \frac{\pi}{4}(0.5)^4 - \frac{\pi}{4}(0.4)^2$$

$$\left.\begin{aligned} \sigma_{ave} &= \frac{\sigma_x}{2} \\ R &= \sqrt{\left(\frac{\sigma_x}{2}\right)^2 + \tau_{xz}^2} \end{aligned}\right\} \quad \begin{aligned} \sigma_1 &= \sigma_{ave} + R \\ \sigma_2 &= \sigma_{ave} - R \end{aligned}$$





Point B

$$\tau_{xy} = \frac{M_x r_o}{J} + \frac{3}{2}\frac{F_y}{A}$$

w/ $A = \pi(0.5)^2 - \pi(0.4)^2$

$\sigma_{ave} = 0$

$R = \tau_{xy}$

$\sigma_1 = \sigma_{ave} + R$

$\sigma_2 = \sigma_{ave} - R$