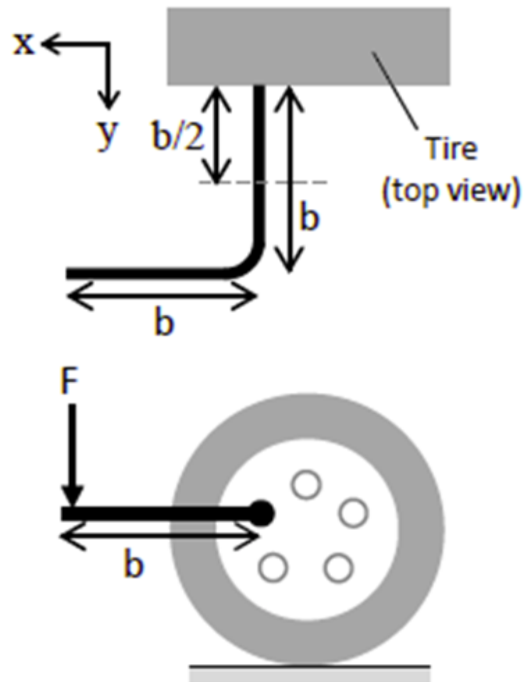
Let's start with an example



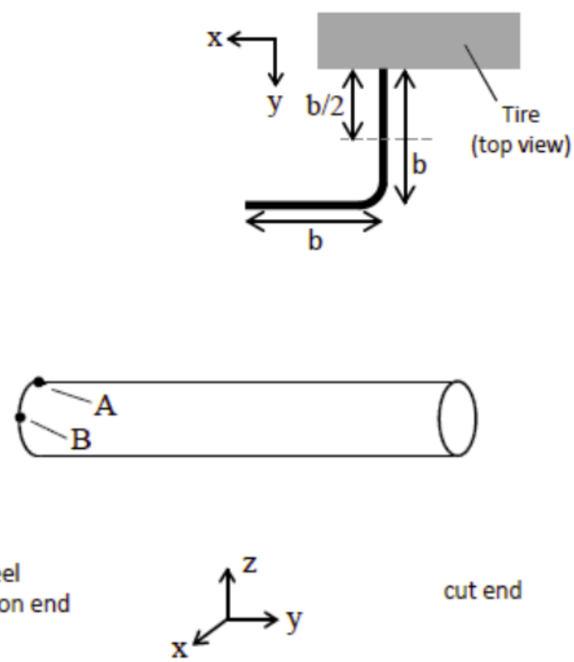
Top and front views of lug wrench loading

In order to remove a vehicle wheel, a steel lug wrench is used to loosen the lug nuts. In the case shown, the force F is applied at the end of the wrench arm while it is in a horizontal position. Both segments of the wrench have length b and radius r.

(a1) Draw the free body diagram for the section of the wrench between the dashed line shown in the diagram (above right) and the wheel.

(a2) Determine all forces and moments in the free body diagram in terms of applied loads and dimensions.

Example



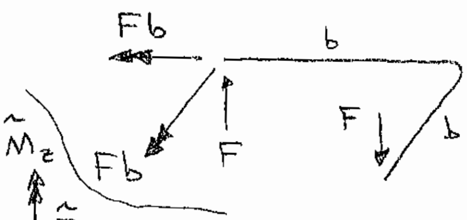
(b) Draw the state of stress for the element located at Point A (located on the top surface of the rod). Find the values of each of the non-zero stresses in terms of the applied loads and dimensions.

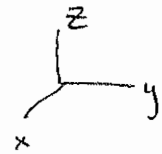
(c) Repeat for Point B

* Could continue to find principal stresses, evaluate failure, etc

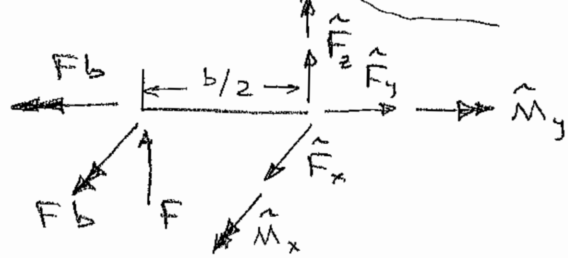
Example Problem

a) Find boundary loads



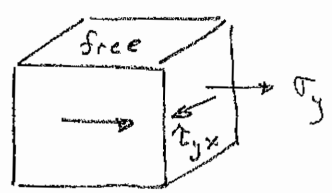


Now cut:



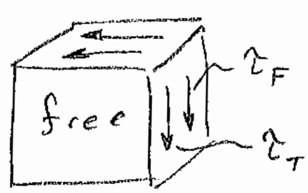
- $\Sigma F_x = 0 \Rightarrow \hat{F}_x = \underline{0}$
- $\Sigma F_y = 0 \Rightarrow \hat{F}_y = \underline{0}$
- $\Sigma F_z = 0 \Rightarrow \tilde{F}_z = \underline{-F}$
- $\Sigma M_x = 0 \Rightarrow Fb + \tilde{M}_x - F\frac{b}{2} = 0 \Rightarrow \tilde{M}_x = F\frac{b}{2} - Fb = \underline{-F\frac{b}{2}}$
- $\Sigma M_y = 0 \Rightarrow \tilde{M}_y - Fb = 0 \Rightarrow \hat{M}_y = \underline{Fb}$
- $\Sigma M_z = 0 \Rightarrow \hat{M}_z = \underline{0}$

b)



- Stress due to F
  - $\tau_{yz} \approx F/A$, but  $\Rightarrow \tau_{yz} = 0$
- Stress due to $\hat{M}_x$ (note M @ A = Fb)
  - $\sigma_y = \frac{My}{I} = \frac{Fbr}{I} = \frac{Fb\cancel{r}}{\frac{\pi r^{\cancel{4}3}}{4}} = \frac{4Fb}{\pi r^3}$
- Stress due to $\hat{M}_y$: $\tau_{yx} = \frac{Tr}{J} = \frac{Fbr}{2I} = \frac{Fb\cancel{r}}{\frac{\pi r^{\cancel{4}3}}{2}} = \frac{2Fb}{\pi r^3}$

c)



- $\tau_F = \frac{4V}{3A}$
- $\tau_T = \frac{Tr}{J} = \frac{2Fb}{\pi r^3}$