 Name: Solution

INSTRUCTIONS:

This quiz is open-book, open-note, and you may work with your classmates.

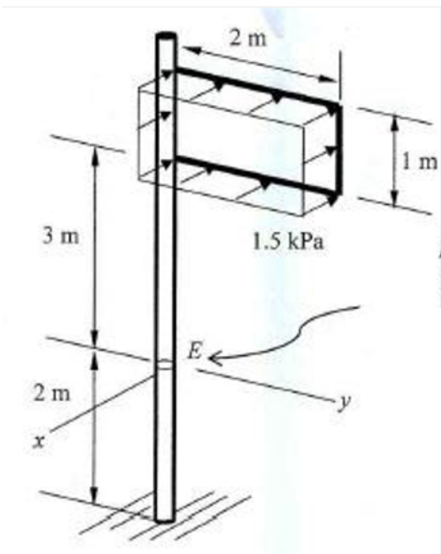
Submit your quiz on Gradescope by the end of today's class period.

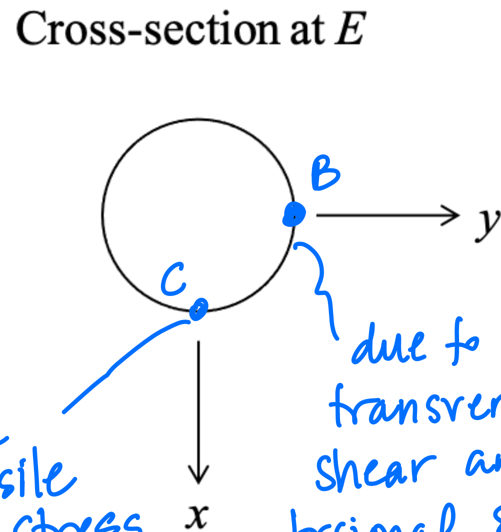
GIVEN:

The sign shown is subjected to a uniform wind load of 1.5 kPa. The wind acts in the negative x-direction.

The sign is supported by a 0.1 m diameter pole.

The weights of the sign and the pole are negligible compared to the wind load.





due to tensile bending stress and torsional shear stress.

due to transverse shear and torsional shear stresses acting in the same direction

FIND:

a) The internal loads acting in the pole are (select all that apply):

- ○ Axial
- ● Torsion
- ● Bending
- ● Transverse shear

b) Identify the location of the critical cross-section of the pole. see next page

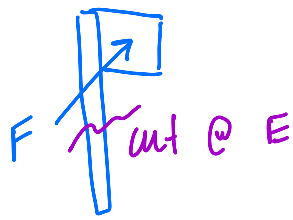
c) For the cross-section at location E, identify the critical element(s). Show the location(s) of the critical element(s) on the cross-section above. see worksheet + above

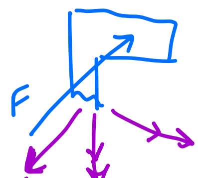
d) For each critical element identified in part (c), calculate the numerical values of each stress acting and show the stress state on a stress element.

e) How would your answers to parts (a), (b), and (c) change if the weights of the sign and pole were not neglected? You do not need to perform any calculations, just briefly discuss.

a) the distributed load can be represented by a point load acting @ the middle of the sign.

$$F = 1500\,\frac{N}{m^2}\cdot(1\,m)\cdot(2\,m) = 3000\ N$$





bending

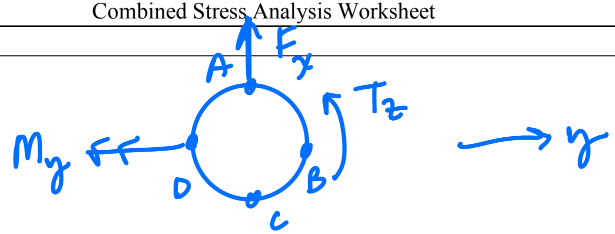
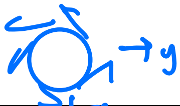
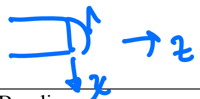
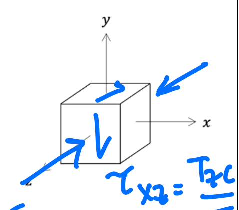
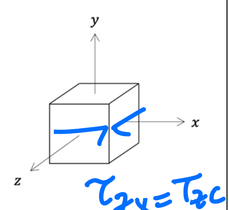
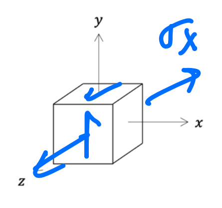
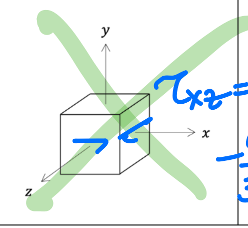
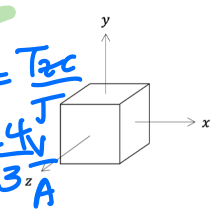
$$M_y = (2.5\,m)(3000\,N) = 7500\ N\text{-}m$$

$$F_x = 3000\ N \qquad T_z = (1\,m)(3000\,N) = 3000\ N\text{-}m$$

transverse shear

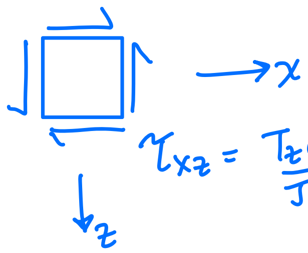
torsion

b) the critical cross-section will be at the base of the pole because the bending moment will be highest.

• Draw the machine component's critical cross-section. • Identify and label the potential locations for the critical element(s) (e.g., top, bottom, right, left, and center)					
Potential location of critical element	A	B	C	D	
Internal load: Axial	none →	→	→	→	→
Internal load: Torsion 	$\tau_{zy} = -\frac{T_z c}{J}$	$\tau_{zx} = -\frac{T_z c}{J}$	$\tau_{zy} = +\frac{T_z c}{J}$	$\tau_{zx} = +\frac{T_z c}{J}$	
Internal load: Transverse shear 	0	$\tau_{zx} = -\frac{4V}{3A}$	0	$\tau_{zx} = -\frac{4V}{3A}$	
Internal load: Bending	$\sigma_z = -\frac{M_y c}{I}$	0	$\sigma_z = +\frac{M_y c}{I}$	0	
Stress element	 $\tau_{xz} = \frac{T_z c}{J}$ $\sigma_z = \frac{M_y c}{I}$	 $\tau_{zx} = \frac{T_z c}{J} - \frac{4V}{3A}$	 σ_x	 ~~$\tau_{xz} = \frac{T_z c}{J} - \frac{4V}{3A}$~~	

never worse than B

@ location B

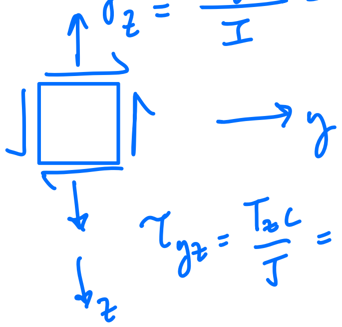


$$\tau_{xz} = \frac{T_z c}{J} + \frac{4}{3}\frac{V}{A}$$

$$= \frac{3000\ \text{N-m} \cdot (0.05\ \text{m})}{\frac{\pi}{32}(0.1\text{m})^4} + \frac{4}{3} \cdot \frac{3000\ \text{N}}{\frac{\pi}{2}(0.1\text{m})^2} = 15.8\ \text{MPa}$$

@ location C

$$\sigma_z = \frac{M_y c}{I} = \frac{7500\ \text{N}\cdot\text{m} \cdot (0.05\text{m})}{\frac{\pi}{64}(0.1\text{m})^4} = 76.4\ \text{MPa}$$



$$\tau_{yz} = \frac{T_z c}{J} = \frac{3000\ \text{N-m} \cdot (0.05\ \text{m})}{\frac{\pi}{32}(0.1\text{m})^4} = 15.3\ \text{MPa}$$

e) if the weight is not neglected, now an
axial (compressive) internal load acts at cross
section E, as well as a bending moment about
the x-direction. The critical cross-section would
not change but the critical element would now
reflect the magnitude of the bending moment
from $\sqrt{M_x^2 + M_y^2}$ and be rotated around the circumference.