MET 4501 Spring 2025: In-Class Quiz 1 Name: SOLUTION

INSTRUCTIONS:

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

Please answer all questions on your individual papers and submit to me by the end of today's class period.

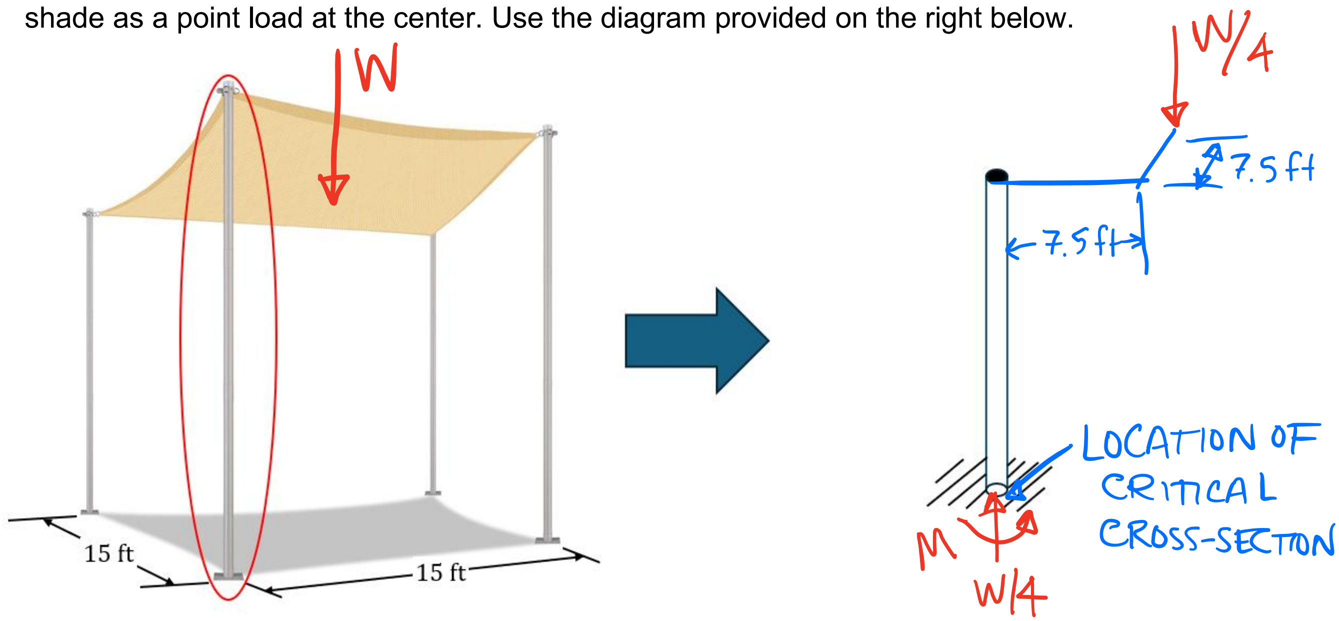
GIVEN:

Evaluate the design of the shelter shown below. The supports poles are solid cylinders, each 2 inches in diameter.

The shade is 15' x 15' in size, weighs 50 lbf, and the weight is evenly distributed to all four supports.

FIND:

1) (20 points) Draw a Free-Body Diagram (FBD) of one pole, simplifying the weight of the shade as a point load at the center. Use the diagram provided on the right below.

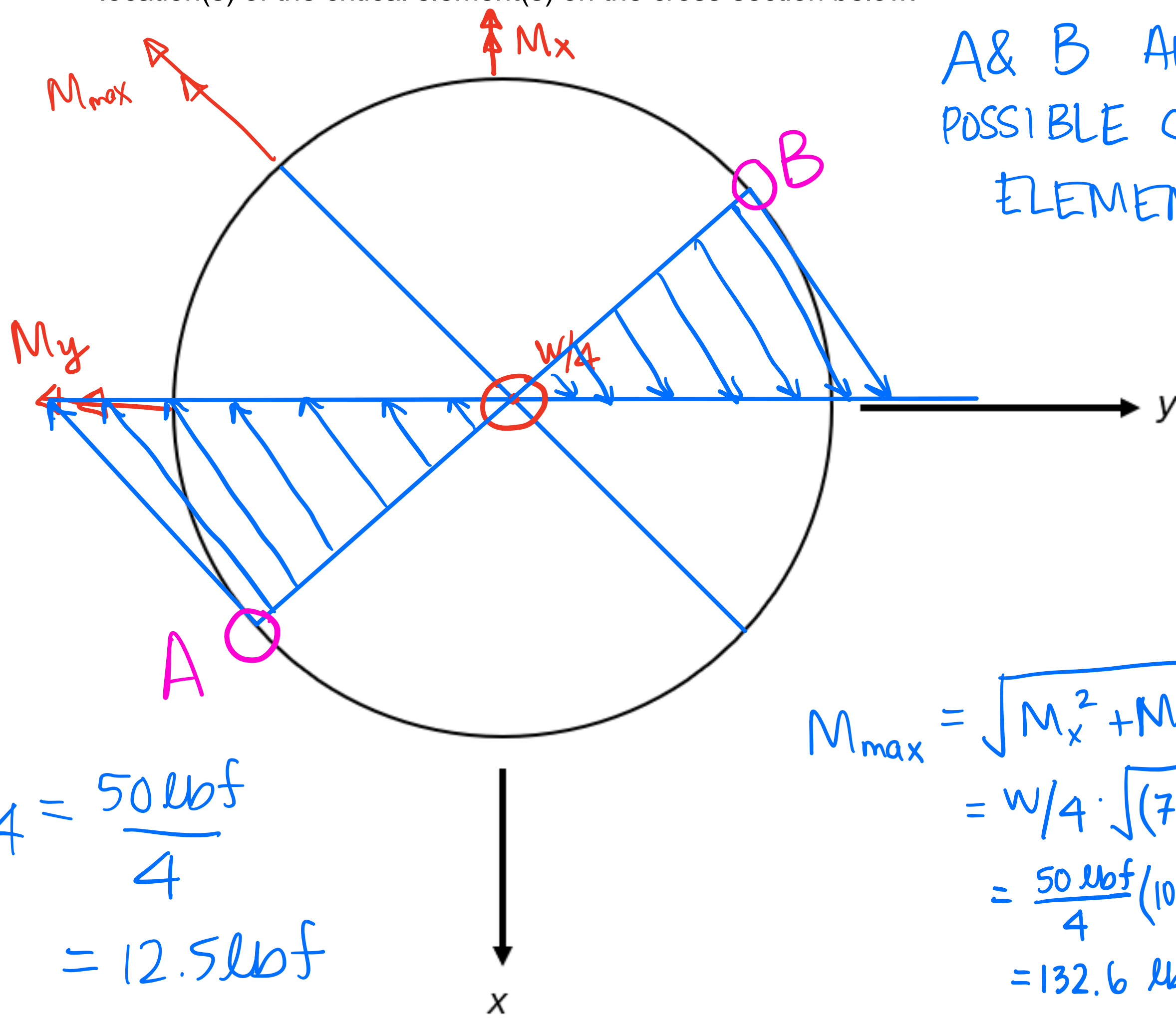


2) (20 points) The internal loads acting in the pole are (select all that apply):
   - ● Axial
   - O Torsion
   - ● Bending
   - O Transverse shear

3) (20 points) Identify the location of the critical cross section of the pole.

AT THE BASE

4) (20 points) For the critical cross-section, identify the critical element(s). Show the location(s) of the critical element(s) on the cross-section below.



A & B ARE TWO POSSIBLE CRITICAL ELEMENTS

$W/4 = \frac{50 \text{ lbf}}{4} = 12.5 \text{ lbf}$

$M_{max} = \sqrt{M_x^2 + M_y^2}$
$= W/4 \cdot \sqrt{(7.5 \text{ ft})^2 + (7.5 \text{ ft})^2}$
$= \frac{50 \text{ lbf}}{4} (10.6 \text{ ft})$
$= 132.6 \text{ lbf-ft}$

5) (20 points) For each critical element identified above, calculate the numerical values of each stress acting and show the stress state on a stress element.

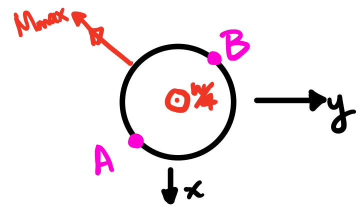
<u>BONUS</u>: (10 points) Where might an additional support bar be placed to most effectively reduce the maximum stress on the existing poles? Explain your reasoning.

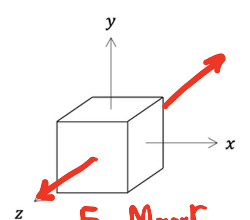
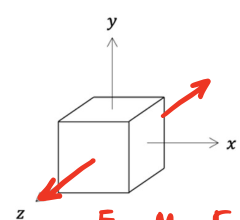
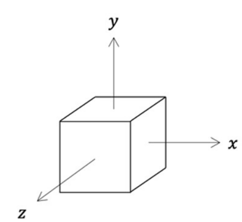
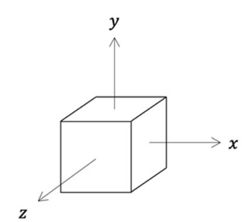
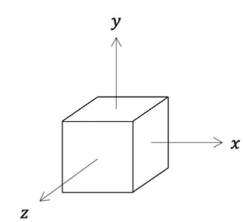
THE BENDING STRESS IS THE BIGGEST COMPONENT OF THE INTERNAL LOAD, SO ANY ADDITIONAL SUPPORT SHOULD BE USED TO REDUCE THE BENDING STRESS.

IF WE PLACE AN ADDITIONAL SUPPORT BAR AT THE CENTER OF THE SHELTER, THE MOMENT ARM LENGTH WILL BE REDUCED FROM 10.6 ft TO 5.3 ft, REDUCING THE MAXIMUM MOMENT BY 50%.

In this box,

- Draw the critical cross-section
- Identify and label the potential locations for the critical element(s) (e.g. top, bottom, left, right, and center)



Potential location of critical element		A	B			
Internal load	Axial	$\sigma_a = \frac{F}{A} = \frac{12.5\ lbf}{\pi(1\ in)^2} = 3.98\ psi$	$\sigma_a = \frac{F}{A} = 3.98\ psi$			
	Torsion	NONE →	→			
	Transverse shear	NONE →	→			
	Bending	$\sigma_b = \frac{+M_{max} r}{I} = \frac{(132.6\ lbf\text{-}ft)(1\ in)}{\pi(1\ in)^4/4}$ $= 2026\ psi$	$\sigma_b = \frac{-M_{max} r}{I} = -2026\ psi$			
Stress element		 $\sigma_z = \frac{F}{A} + \frac{M_{max} r}{I}$	 $\sigma_z = \frac{F}{A} - \frac{M_{max} r}{I}$			

AT A: $\sigma_z = 2030\ psi$ AT B: $\sigma_z = -2022\ psi$

A IS THE CRITICAL ELEMENT!