ME 323: Mechanics of Materials **Homework 10**

Spring 2024 **Due: April 12, 2024**

Problem 1 (10 points):

A cylindrical vessel (shown in *Figure 1*) has an internal radius of r = 2.5 m, and a wall thickness of t = 15 mm. The internal pressure in the vessel is P = 1.5 MPa and the maximum allowable stress in the walls of the vessel is 400 MPa. Determine:

a) Axial stress σ_a and hoop stress σ_h in the cylindrical part of the vessel.
b) Principal stresses σ_{p1} and σ_{p2}
c) Maximum in-plane shear stress τ_{max}
d) Maximum allowable pressure P_{allow} such that σ_{p1} doesn't exceed σ_{allow}.

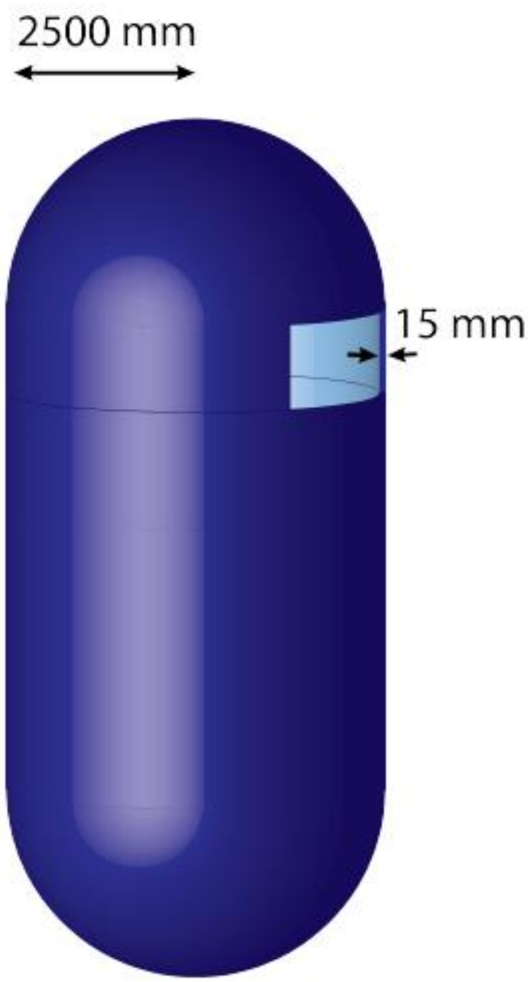


Figure 1: Cylindrical vessel for Problem 1.

Problem 2 (10 points):

The stress element shown below represents the state of stress measured along the x'y' axis in a component loaded under plane stress. No information is known about the stress α except that it is compressive.

(a) Determine the magnitude of the maximum compressive normal stress that can be applied, if the component is made of a material which can withstand a maximum in-plane shear stress of 100 MPa.

(b) Determine the stress components when the element is oriented along the x-y axes using values from part a.

(c) Draw a stress element oriented along the maximum in-plane shear stress directions. (Show the angle of this rotated element with respect to the axis x')

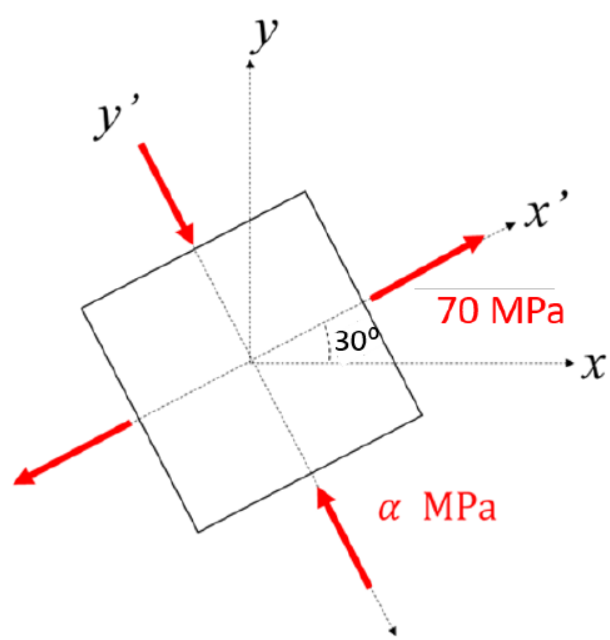


Figure 2: Stress element for Problem 2

Problem 3 (10 points):

For the following state of plane stress:
σ_x=22 MPa; σ_y=10 MPa; τ_{xy}=8 MPa; with other stresses zero

(a) Sketch the stresses on a stress element.
(b) Draw the Mohr's circle for this loading condition. Determine value of σ_{p1}, σ_{p2}, and in-plane τ_{max}.
(c) Find the value of the maximum absolute shear stress $\tau_{max,abs}$.
(d) Determine the value of the stresses if the element is rotated counterclockwise by 45°.

Problem 4 (2.5 + 2.5 points):

I. A moment M (about positive z) and torque T (about positive x) are applied to a circular rod as shown in *Figure 4.1*. Choose the correct in plane Mohr's circle, from the given options, for the stress states at Point a and Point b. (Note that **location of Point a is at (L/2, 0, -R)** where R is the radius of the cross section.)

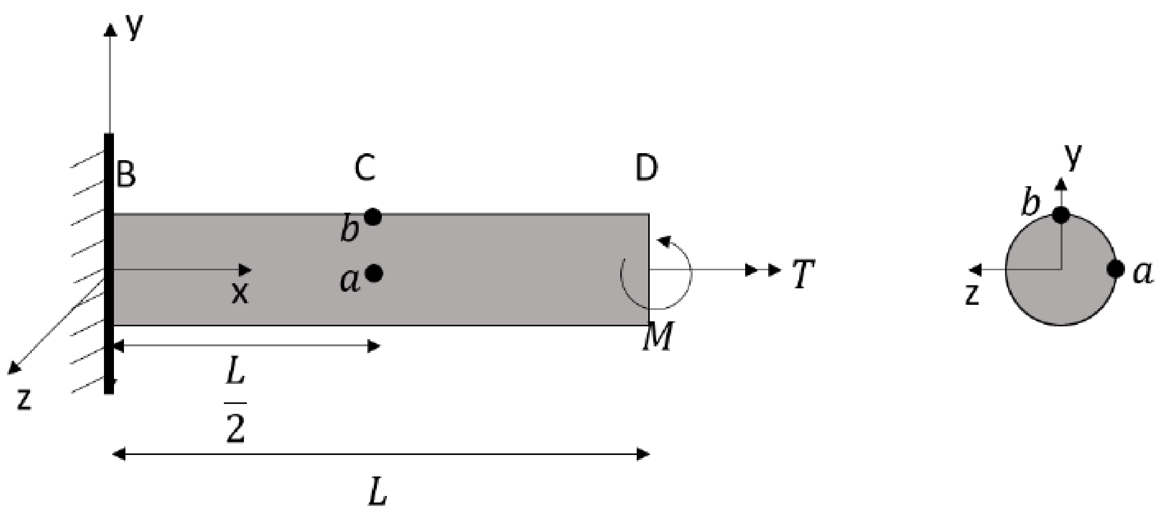
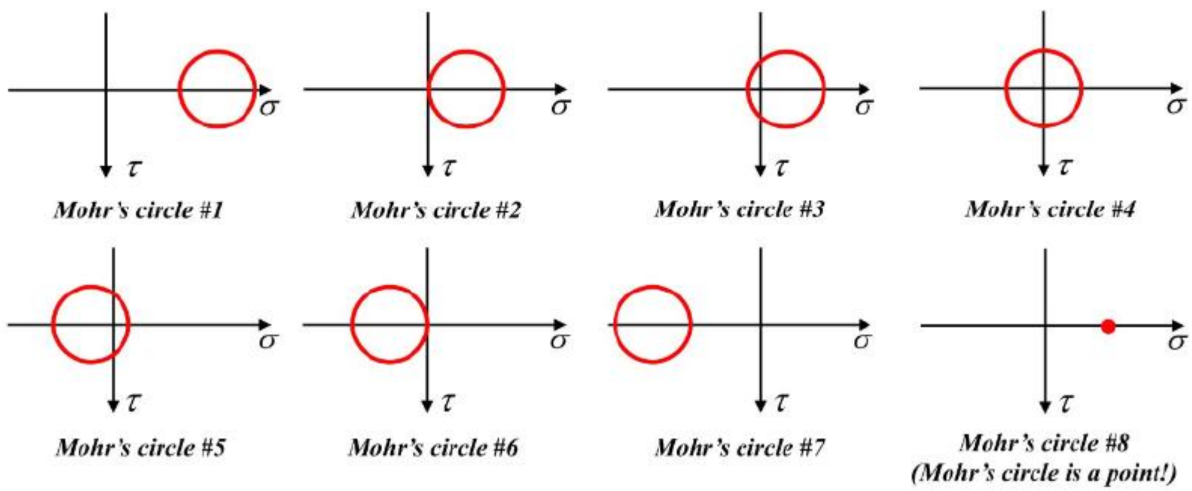


Figure 4.1: Loading of circular rod for Problem 4.I



II. Consider stress states (a) and (b) shown in *Figure 4.2*, with $|\sigma_1| > |\sigma_2|$. Let $\left(|\tau|_{max,abs}\right)_a$ and $\left(|\tau|_{max,abs}\right)_b$ represent the absolute maximum shear stress corresponding to stress states (a) and (b), respectively. Choose the response below that describes the relative sizes of these stresses.

$$a)\ \left(|\tau|_{max,abs}\right)_a > \left(|\tau|_{max,abs}\right)_b$$

$$b)\ \left(|\tau|_{max,abs}\right)_a = \left(|\tau|_{max,abs}\right)_b$$

$$c)\ \left(|\tau|_{max,abs}\right)_a < \left(|\tau|_{max,abs}\right)_b$$

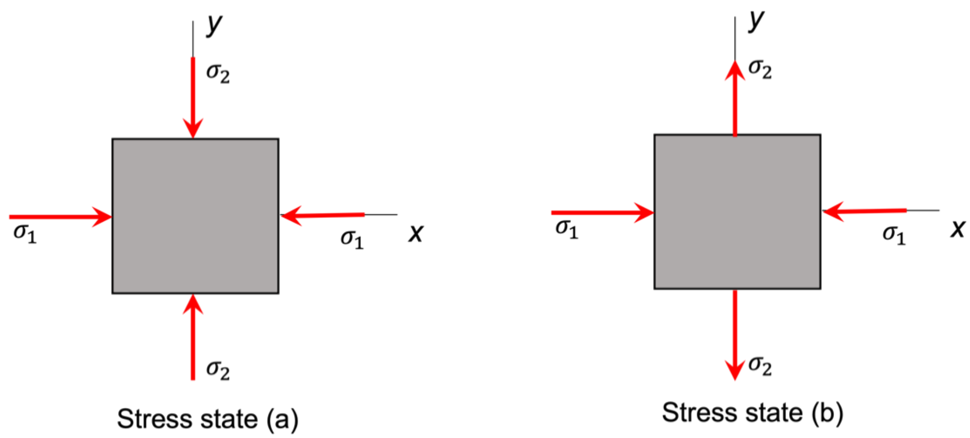


Figure 4.2: Stress states for Problem 4.II