32/50

CEE 220

Midterm I

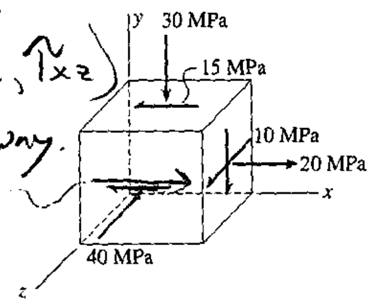
April 29, 2003

Name: ______________________________
Closed Book; 1 page of notes.

Part I: Short Answer (3 points each)

1. What is wrong with the picture below?

One of the 10 MPa shear stresses (τ_{zx}, τ_{xz}) is pointing the wrong way. Should be (possibly)



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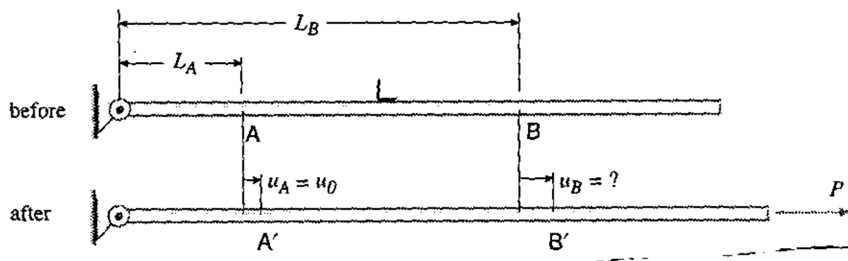
2. A rod is elongated by an end load as indicated below. The displacement at point A is measured to be $u_A = u_0$. What is the displacement at point B?



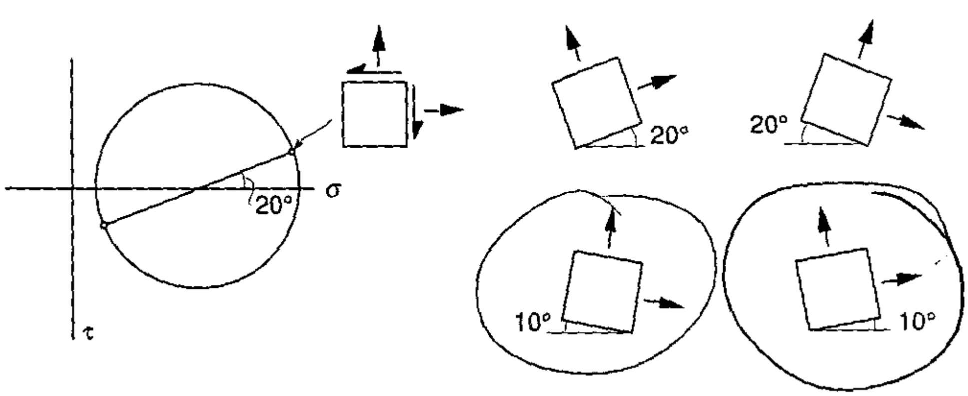
$L =$ dist A to B

$L_B - L_A = AB$

$$\boxed{\frac{u_B - u_0}{L_B - L_A} = \epsilon_B}$$

1

3. Circle the correct principal orientation corresponding to the stress state shown.

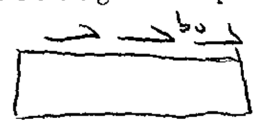


1

5

4. Determine whether the following displacement expression satisfies equilibrium for a 1-D rod loaded axially by a distributed load $b(x) = b_0$. Assume E, A, etc. have their usual meanings for 1-D problems.

$$u(x) = -\frac{b_0 x^2}{2AE}$$



$\boxed{\text{NO BOUNDS}}$

$$\frac{d}{dx}\left[EA\left(\frac{du}{dx}\right) + b(x)\right] = 0$$

3

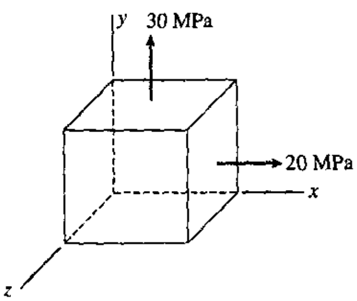
$$EA\frac{d^2u}{dx^2} + \frac{d\,b(x)}{dx} = 0 \qquad -\cancel{\frac{d}{dx}}\,b(x) = EA\,\cancel{\frac{d^2u}{dx^2}} \qquad \frac{-b(x)}{EA} = \frac{du}{dx} \Rightarrow \int \frac{-b_0\,dx}{EA} = \int du$$

$$\boxed{u(x) = \frac{-b_0 x}{EA}}$$

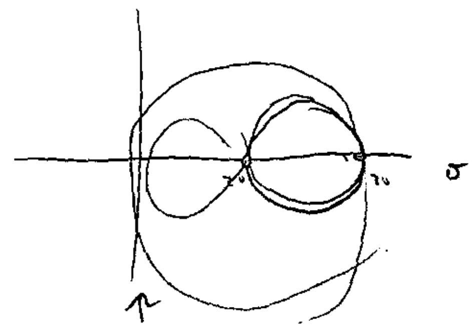
$\boxed{\text{NO SATISFACTION !}}$

I'm not satisfied by the squared term & the 2 in the denominator.

5. What is the absolute maximum shear stress for the stress state shown?



$$\tau_{abs\,max} = \frac{\sigma_{max} - \sigma_{min}}{2}\ \text{MPa}$$



princ stresses:

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \cancel{\tau_{xy}^2}}\ \text{MPa}$$

0

$$= 25 \pm 5\ \text{MPa}$$

$\sigma_{max} = 30$ MPa

$\sigma_{min} = 20$ MPa

$$\tau_{abs\,max} = \frac{30 - 20}{2}\ \text{MPa}$$

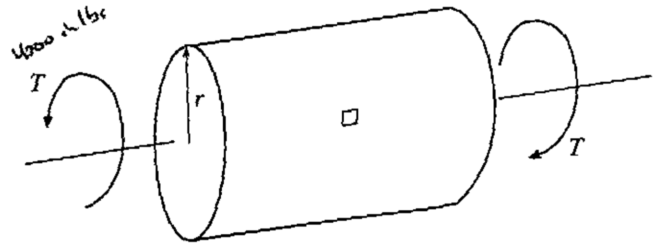
$$\boxed{\tau_{abs\,max} = 5\ \text{MPa}}$$

4

$\tau = \frac{T}{2\pi r^2 t}$

Part II: Problems

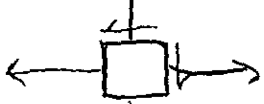
1. The thin-walled cylinder shown below is loaded both by an internal pressure, $p = 20$ psi, and an applied torque, $T = 4000$ in·lbs. The radius of the cylinder is $r = 4.0$ inches and the wall thickness is $t = 0.125$ inches.



$r = 4''$
$t = .125''$

(a) Determine the stress components and show them on a material block aligned with the axes of the cylinder (4 pts).

σ_1 = hoop stress = $\frac{pr}{t}$

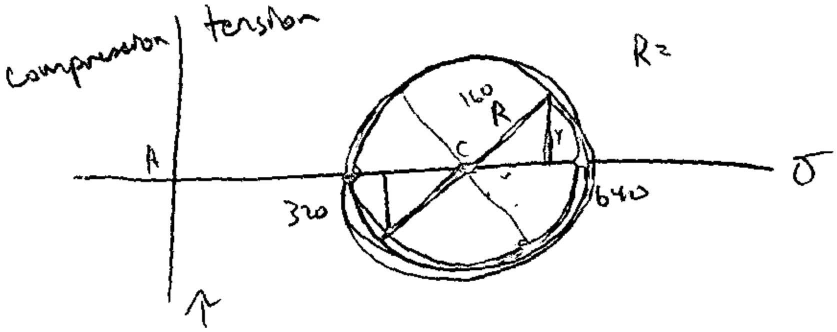


σ_2 = longitudinal stress = $\frac{pr}{2t}$

2

$\boxed{\sigma_1 = \frac{(20psi)(4'')}{.125''} = 640 \text{ psi}}$ $\boxed{\sigma_2 = \frac{(20psi)(4'')}{(2)(.125'')} = 320 \text{ psi}}$

(b) Construct a Mohr's circle plot for this stress state. ~~(4 pts)~~



R =

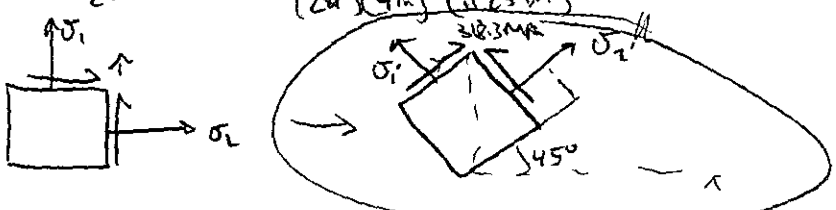
$\frac{\sigma_x + \sigma_y}{2} = AC = 480$

$R = 160$

3

(c) Determine the maximum tensile stress for this stress state and show this stress on an appropriately oriented stress block . (4 pts)

$\tau_{max} = \frac{T}{2\pi r^2 t} = \frac{4000 \text{ in lbs}}{(2\pi)(4 in)^2 (.125 in)} = \boxed{318.3 \text{ psi} = \tau_{max}}$ ✓



2

(d) What would be the effect of increasing the pressure (p) in the cylinder on the absolute maximum shear stress (i.e., would it increase, decrease, or stay the same)? (3 pts)

If the pressure is increased the stresses σ_1 & σ_2 increase thus increasing the value of $\tau_{max\,abs}$ which is easily seen by a Mohr's Circle diagram or experimented w/ a pop can. 2

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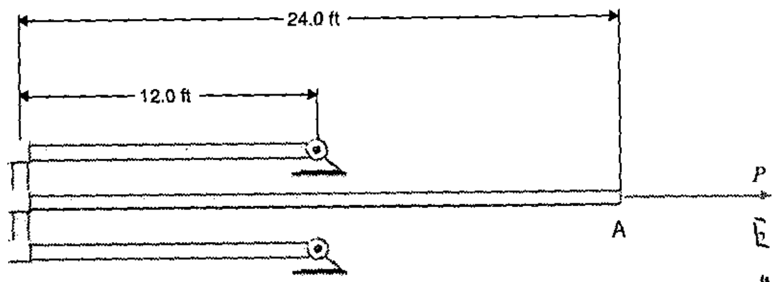
2. Determine the displacement of point A due to the applied load $P = 10$ kips. The three horizontal rods all have a cross-sectional area of 1.2 in^2 and are made of steel ($E = 29,000$ ksi). Assume the vertical connection pieces on the left are rigid. (10 points)



$P = 10$ kips
$E = 29000$ ksi
$A = 1.2$ in^2
$L = 24.0$ ft.

$$\delta = \frac{PL}{AE}$$

$$\delta = \frac{(10\ \cancel{kip})(24.0\ \cancel{ft} \cdot \frac{12''}{\cancel{ft}})}{(1.2\ \cancel{in^2})(29,000\ \frac{\cancel{kip}}{\cancel{in^2}})} = \boxed{\delta = .0828 \text{ inches}}$$

* constant Load & cross sectional Area!

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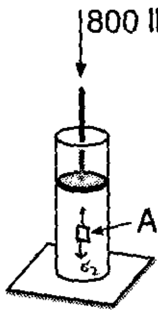
3. The air pressure in a cylinder is increased by a loaded piston as shown below. The cross-sectional area of the piston face is ~~5.8 in²~~, the thickness of the cylinder wall is 0.125 inches, and the radius of the cylinder is 2.4 inches. Determine ~~the principal stresses~~ in the cylinder wall at the point A indicated. (10 pts)



$F = 800\,lb.$

$A = 18.1\,in^2$

$t = .125\,in.$

$r = 2.4$ inches.

FIND: principal stress in cylinder wall @ pt. A

$\sigma_1 = \frac{pr}{t}$

$\sigma_2 = \frac{pr}{2t}$

$$p = psi = \frac{lb}{in^2} = \frac{F}{A} = \frac{800}{18.1} = 44.2\ psi$$

$$\sigma_1 = \frac{(44.2\,psi)(2.4\,in)}{(.125\,in)} = 848.6\ psi = \sigma_1 = \sigma_y$$

$$\sigma_2 = \frac{848.6}{2}\ psi = 424.3\ psi = \sigma_2 = \sigma_x$$

Principal Stresses: $$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}\ psi$$

$$= 636.45 \pm \sqrt{(45007.6) + 0}\ psi$$

$$= 636.45 \pm 212.15\ psi$$

princ. stresses
$$\boxed{\begin{cases} \sigma_{max} = 849\ psi \\ \sigma_{min} = 424\ psi \end{cases}}$$