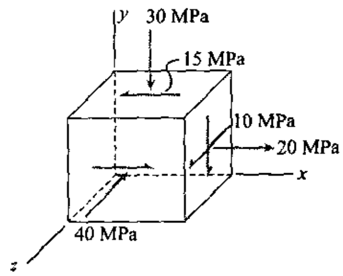
CEE 220 # Midterm I **April 30, 2002**

Name: ______________________________
Closed Book; 1 page of notes.

τ_{yz} = τ on y direction elevated z.

Part I: Short Answer (3 points each)

1. For the stress state shown, fill in the stress component blanks.



$\sigma_x =$ ____ 20 MPa ____
$\sigma_z =$ ____ -40 MPa ____
$\tau_{xy} =$ ____ -15 MPa ____
$\tau_{yx} =$ ____ -15 MPa ____
$\tau_{xz} =$ ____ 10 MPa ____
$\tau_{yz} =$ ____ 0 MPa ____

2. What is the engineering significance of principal stresses (i.e., why do we care about determining them)?

   Principal stresses correspond to the maximum (and minimum) values of normal stress. and these extreme values are often useful for predicting or understanding material failure.

3. A colleague of yours is working on a computer program to compute principal stresses and maximum in-plane shear stress. You try the program and get the following results. Explain why these results either are or are not reasonable.

$$\begin{aligned}\sigma_1 &= 100 \text{ psi}\\ \sigma_2 &= 50 \text{ psi}\\ \tau_{\max} &= 75 \text{ psi}\end{aligned}$$

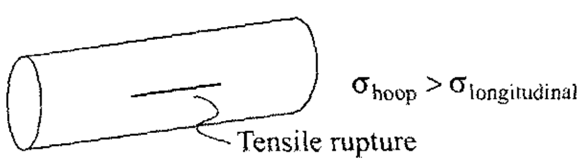
   For plane stress, $\tau_{\max} = (\sigma_1 - \sigma_2)/2$. These results are bogus.

4. Show how the following fundamental relations can be combined to obtain a direct relation between the applied force, P, and the elongation, δ, for an axially-loaded rod.

   - Equilibrium: $P = \sigma A$
   - Kinematics: $\epsilon = \delta/L$
   - Constitutive: $\sigma = E\epsilon$

$$\delta = \epsilon L = (\sigma/E)L = ((P/A)/E)L = PL/AE$$

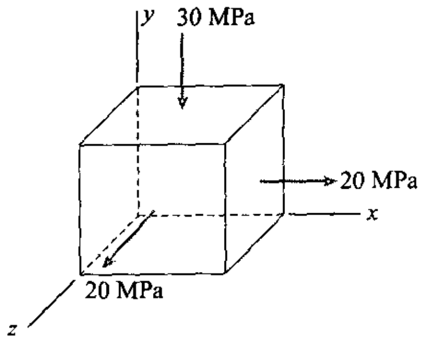
5. Show on a sketch how you would expect a cylindrical pressure vessel to fail due to tensile overloading of the material away from the ends.



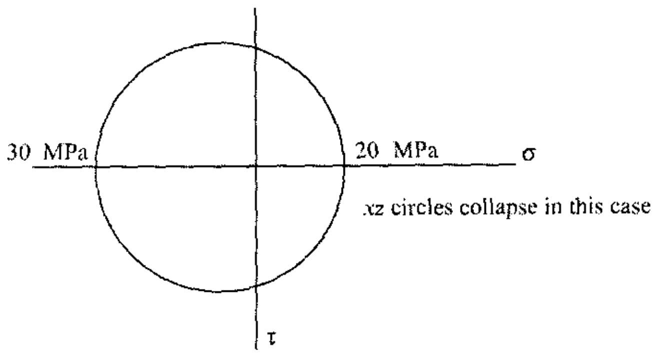
(see also the photo on p.411 in the textbook).

Part II: Problems

1. Consider the stress block shown below.

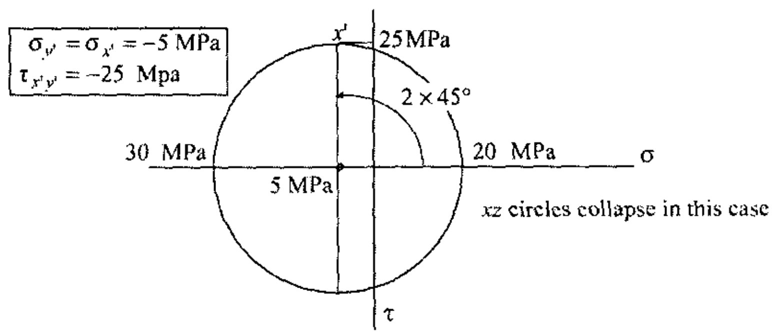


(a) Plot the full set of Mohr's circles for this stress state (5 pts).

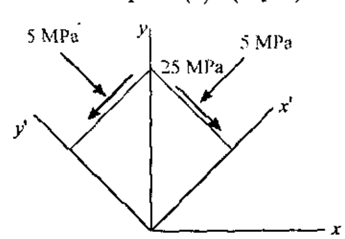


(b) What is the maximum in-plane shear stress for the case of rotation about the y-axis? (5 pts)
Zero, since $\sigma_z = \sigma_x$ and $\tau_{xz} = 0$, which implies pure pressure in the xz-plane.

(c) Determine the normal and shear stresses, $\sigma_{x'}$, $\sigma_{y'}$, and $\tau_{x'y'}$, for the case in which the block is rotated 45 degrees counterclockwise about the z-axis. (5 pts)



(d) Show on the figure below your results from part (c). (5 pts)



2. Two weights are hung from a support rod as shown. What is the overall elongation of the rod, δ_{AC}? (10 points)