Course Roadmap

Ch 13: Mohr's Circles

- Given the loading conditions at a point, what are the stress states at different angles?
- At what angle does the max normal stress and max shear stress occur?

Ch 14: Combined Loading ←

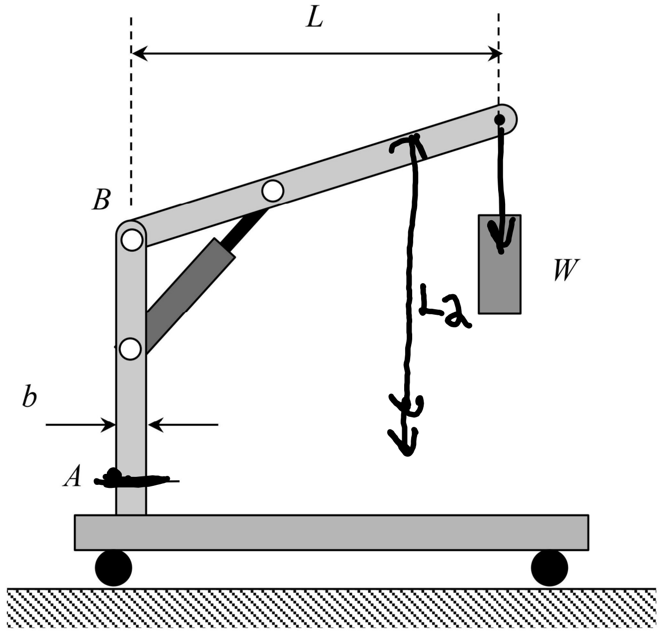
- What are the normal and shear stresses at points on a cross section due to combined axial, torsion, and bending loading?
- Determine the principal stresses and max shear stress at these points – use Mohr's circles.

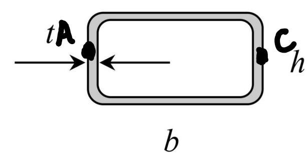
Ch 15: Failure Analysis

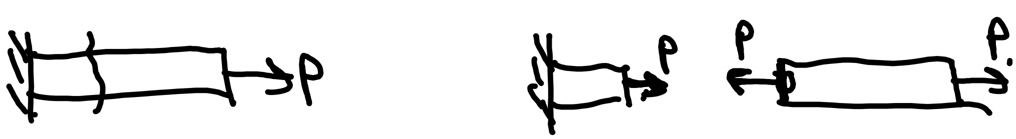
- Given the stress states at a point, under what condition will a 3D structure fail?

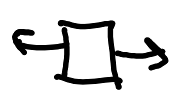
Example 14.2

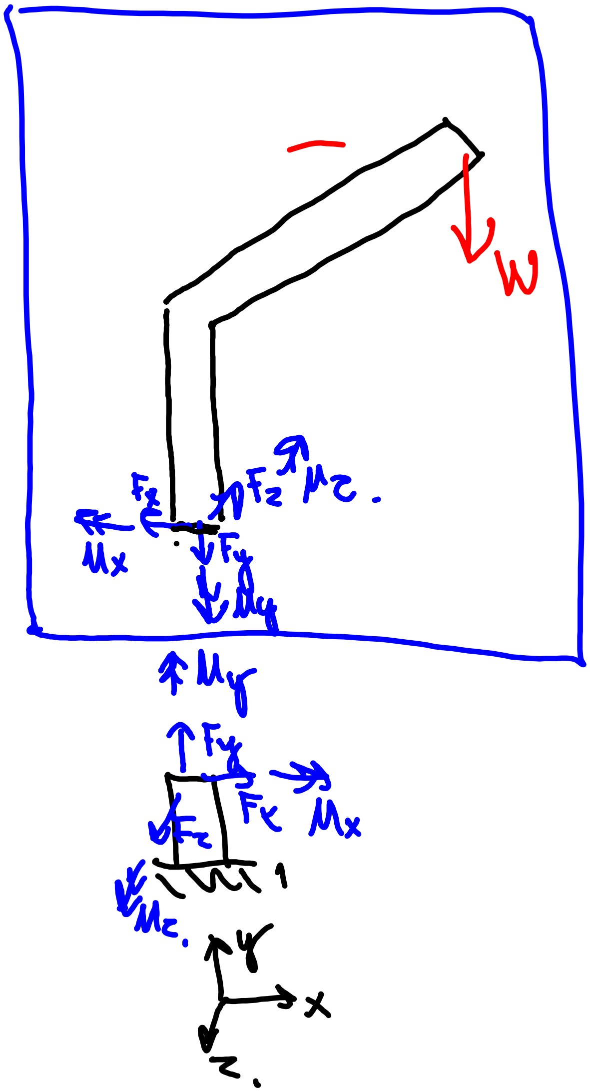
A crane is made up of a vertical column AB with a boom pinned to the column at B. The columnn has a tubular cross section of thickness t, as shown below. The boom supports a block with a weight of W. Determine the maximum tensile stress and maximum compressive stress near the base cross section at A when the boom is in the position shown.











$$\Sigma F = -F_x \hat{i} - F_y \hat{j} - F_z \hat{k} - W\hat{j} = 0$$

$$F_x = 0$$

$$F_z = 0$$

$$F_y = -W.$$

$$\Sigma M = -M_x \hat{i} - M_y \hat{j} - M_z \hat{k} + \vec{r} \times \vec{F} = 0$$

$$\vec{r} = (L, L_2, 0)$$

$$\vec{F} = (0, -W, 0)$$

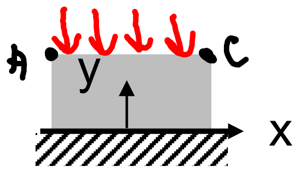
$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ L & L_2 & 0 \\ 0 & -W & 0 \end{vmatrix} = (0, 0, -WL)$$

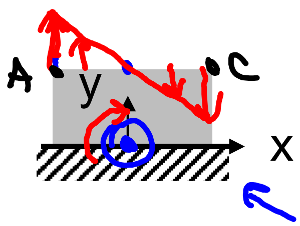
$$0 = -M_x \hat{i} - M_y \hat{j} - M_z \hat{k} - WL\hat{k} = 0$$

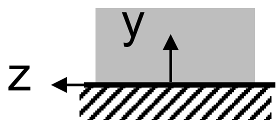
$$M_x = 0$$

$$M_y = 0$$

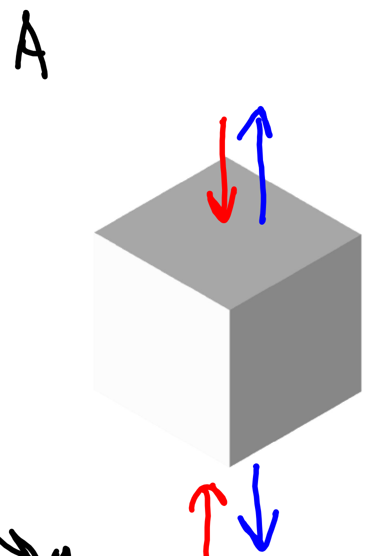
$$M_z = -WL.$$

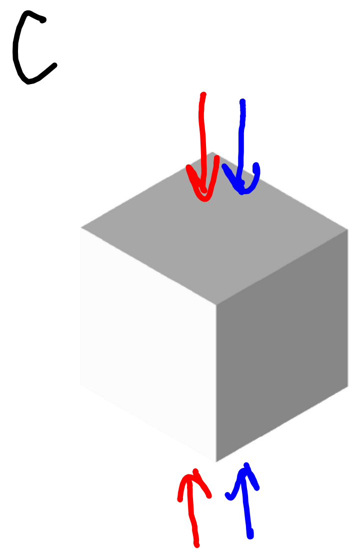


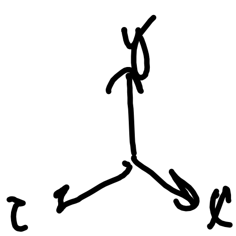


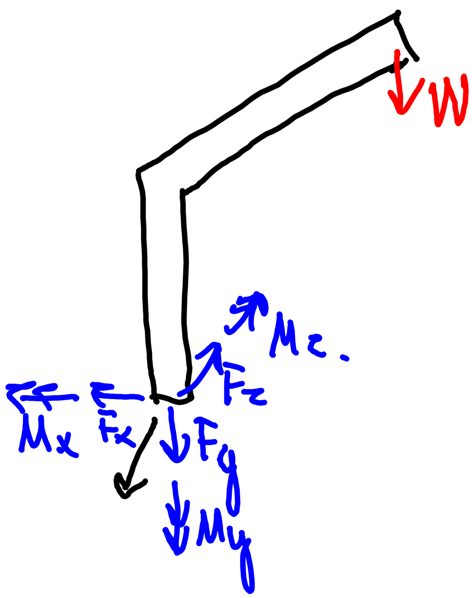


Force	A Stress	C Stress
F_y	$\sigma_y = -\frac{W}{A}$	$\sigma_y = -\frac{W}{A}$
M_z	$\sigma_y = \frac{WL(b/2)}{I}$	$\sigma_y = -\frac{WL(b/2)}{I}$









$$\Sigma F_x = -F_x = 0$$

$$\Sigma F_y = -F_y - W = 0$$

$$\Sigma F_z = -F_z = 0$$

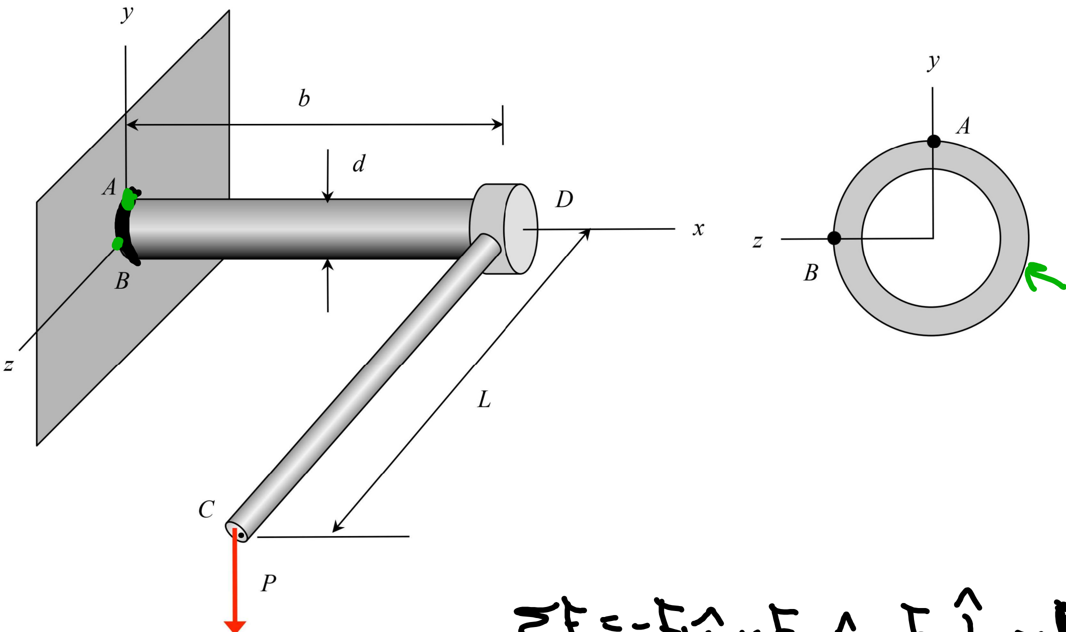
$$(\Sigma M)_x = -M_x = 0$$

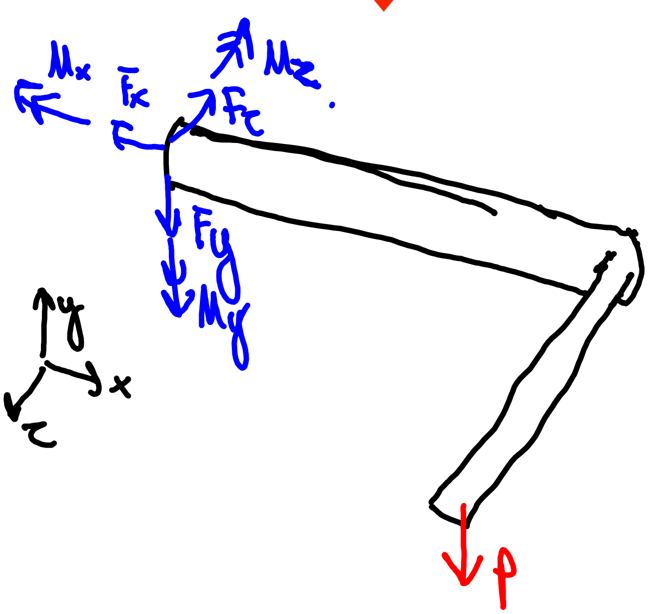
$$(\Sigma M)_y = -M_y = 0$$

$$(\Sigma M)_z = -M_z - LW = 0$$

Example 14.4

A vertical force of P is applied to the end of a pipe wrench CD, whose handle is parallel to the z-axis. Determine the pipe has an outer diameter of d and wall thickness of t. Determine the principal stresses at points A and B on the cross section of the pipe.





$$\Sigma F = -F_x\hat{i} - F_y\hat{j} - F_z\hat{k} - P\hat{j} = 0$$

$$F_x = 0$$

$$F_y = -P$$

$$F_z = 0$$

$$\Sigma M = -M_x\hat{i} - M_y\hat{j} - M_z\hat{k} + \vec{r}\times\vec{F} = 0$$

$$\vec{r} = (b, 0, L) \qquad \vec{F} = (0, -P, 0)$$

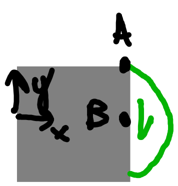
$$\vec{r}\times\vec{F} = (PL, 0, -Pb)$$

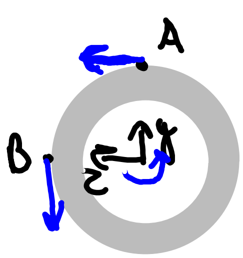
$$0 = (-M_x + PL)\hat{i} + M_y\hat{j} + (-M_z - Pb)\hat{k}$$

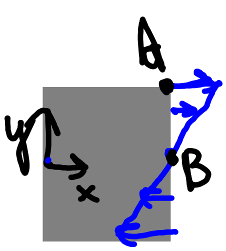
$M_x = PL$

$M_y = 0$

$M_z = -Pb$







	A	B
F_y	0	$\tau_{xy} = -\frac{VQ}{It}$
M_x	$\tau_{xz} = \frac{PL(d/2)}{I_p}$	$\tau_{xy} = -\frac{PL(d/2)}{I_p}$
M_z	$\sigma_x = \frac{Pb(d/2)}{I}$	0

$$\sigma = -\frac{My}{I} = -\frac{(-Pb)(d/2)}{I} =$$