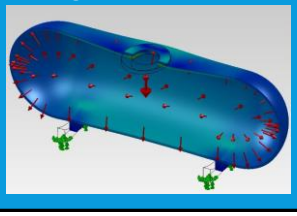
# MECE 3321 MECHANICS OF SOLIDS CHAPTER 8

Samantha Ramirez

## THIN-WALLED PRESSURE VESSELS

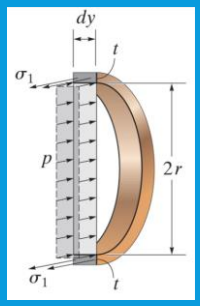
- Cylindrical or spherical vessels are commonly used in industry to serve boilers or tanks.
- A "thin wall" refers to a vessel having an inner radius to wall thickness ratio of 10 or more $\left(\frac{r}{t} \geq 10\right)$.
- We will assume a uniform or constant stress distribution throughout the thickness because it is thin.
- Pressure vessels are subjected to loadings in all directions.



# CYLINDRICAL VESSELS

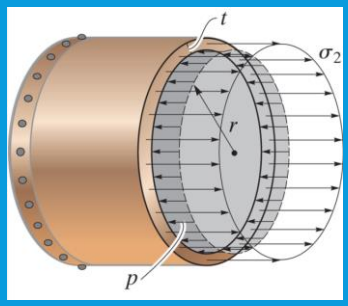
**Circumferential or hoop stress ($\sigma_1$)**

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




**Longitudinal or axial stress ($\sigma_2$)**

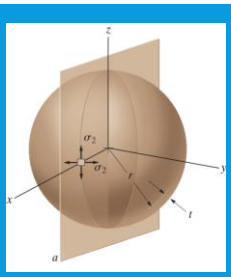
$$\sigma_2 = \frac{pr}{2t}$$

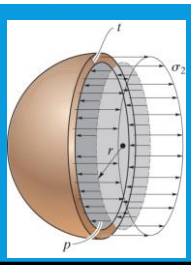



# SPHERICAL VESSELS

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

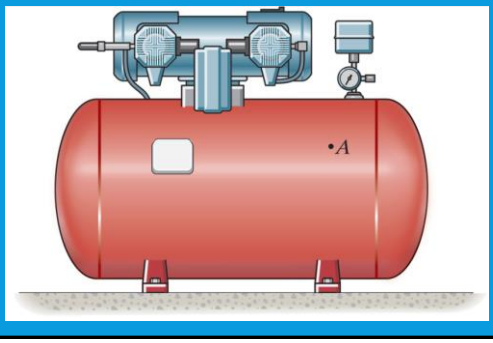
- $\sigma_1$,$\sigma_2$: the normal stress in the hoop and longitudinal directions, respectively.
  - Each is assumed to be constant throughout the wall of the cylinder, and each subjects the material to tension.
- p: the internal gauge pressure developed by the contained gas
- r: the inner radius of the cylinder
- t: the wall thickness (r/t≥10)



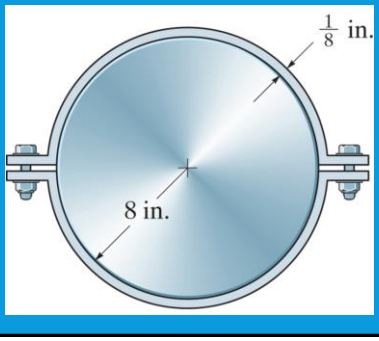
# PROBLEM 8-4

- The tank of the air compressor is subjected to an internal pressure of 90 psi. If the internal diameter of the tank is 22 in, and the wall thickness is 0.25 in, determine the stress components acting at point A. Draw a volume element of the material at this point, and show the results on the element.



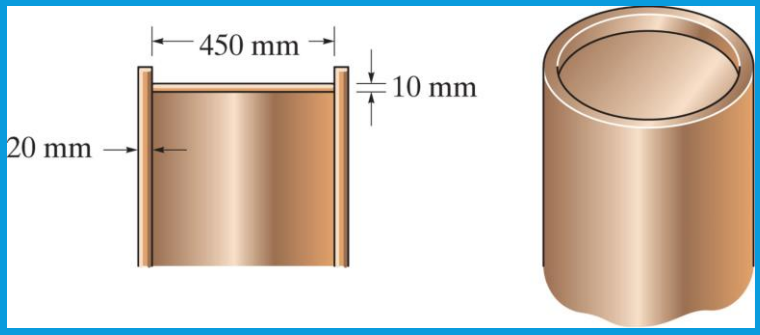

# PROBLEM 8-10

- The A-36 steel band is 2 in wide and is secured around the smooth rigid cylinder. If the bolts are tightened so that the tension in them is 400 lb, determine the normal stress in the band, the pressure exerted on the cylinder, and the distance half the band stretches.



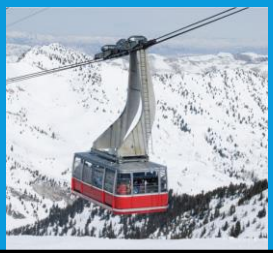
# PROBLEM 8-12

- A pressure-vessel head is fabricated by gluing the circular plate to the end of the vessel as shown. If the vessel sustains an internal pressure of 450 kPa, determine the average shear stress in the glue and the state of stress in the wall of the vessel.




# STATE OF STRESS CAUSED BY COMBINED LOADING

- The cross section of a member is subjected to several loadings simultaneously.
- The method of superposition can be used to determine the resultant stress distribution on the cross section as long as:
  - A linear relationship exists between the stress and the loads
  - The geometry of the member should not undergo significant changes when the loads are applied

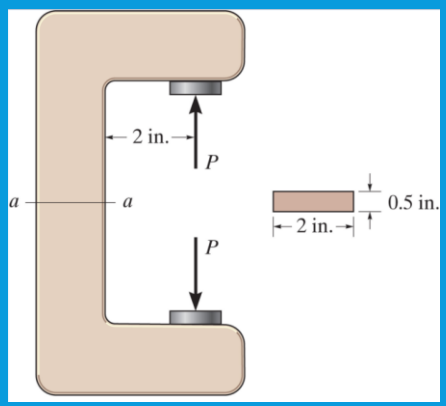


# PROCEDURE FOR ANALYSIS

1. Internal Loadings
   - Cut member perpendicular to its axis at the point where the stress is to be determined.
   - Obtain the resultant internal normal force, shear force, bending moment, and torsional moment.
     - Force components act through the centroid of the cross section
     - Moment components are computed about centroidal axes
2. Stress Components
   - Determine the stress component associated with each internal loading
     - Normal Force: $\sigma = \frac{F}{A}$
     - Shear Force: $\tau = \frac{VQ}{It}$
     - Bending Moment: $\sigma = -\frac{My}{I}$
     - Torsional Moment: $\tau = \frac{T\rho}{J}$
3. Superposition
   - Determine the resultant normal and shear stress components and represent using a volume element or stress distribution.

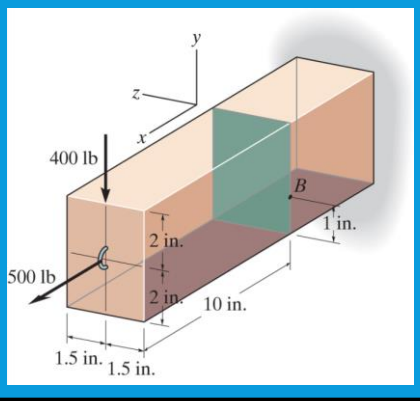
# PROBLEM F8-4

- Determine the magnitude of the load P that will cause a maximum normal stress of 30 ksi in the link along section a-a.



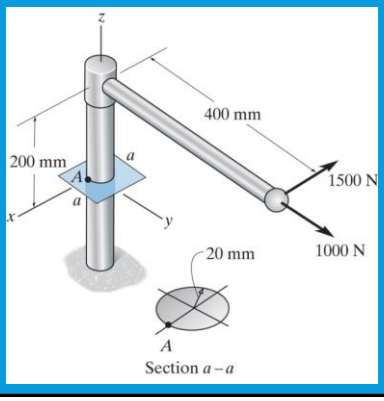
# PROBLEM F8-5

- The beam has a rectangular cross section and is subjected to the loading shown. Determine the state of stress at point B. Show the results in a differential element at the point.



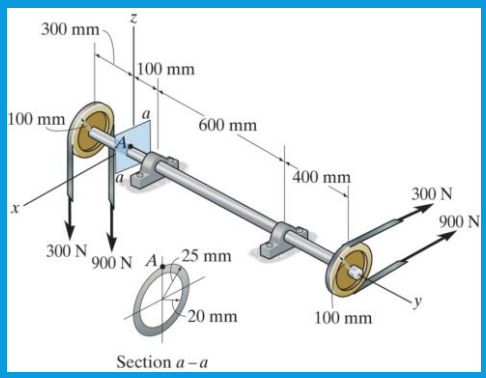

# PROBLEM F8-6

- Determine the state of stress at point A on the cross section of the pipe assembly at section a-a. Show the results in a differential element at the point.



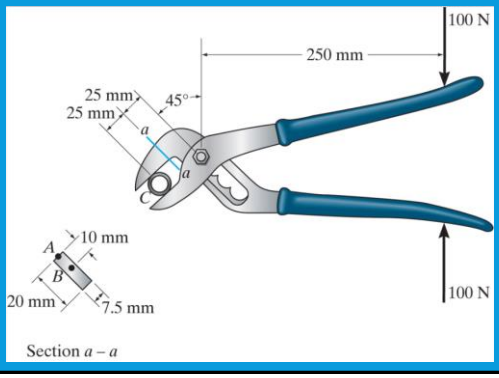
# PROBLEM F8-8

- Determine the state of stress at point A on the cross section of the shaft at section a-a. Show the results in a differential element at the point.



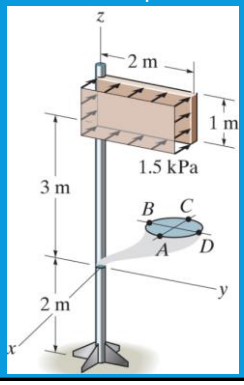

# PROBLEM 8-30

- The rib-joint pliers are used to grip the smooth pipe C. If the force of 100 N is applied to the handles, determine the state of stress at points A and B on the cross section of the jaw at section a-a. Indicate the results on an element at each point.



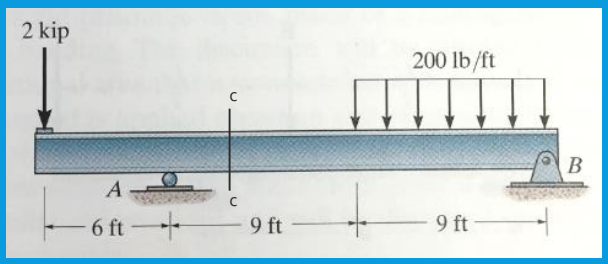
# PROBLEM 8-57

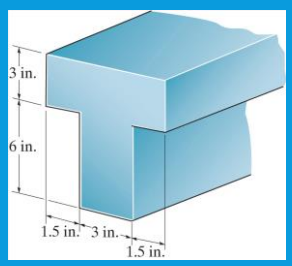
- The sign is subjected to the uniform wind loading. Determine the stress components at points A and B on the 100 mm diameter supporting post. Show the results on a volume element located at each of these points.




# EXAMPLE 1

- Determine the state of stress at point C of the cross-section at section c-c. Section c-c is 3 ft from point A and point C is 2 in from the bottom of the cross section. Sketch the results on a volume element.



# PROBLEM 8-47, 48, 49

- The bent shaft is fixed in the wall at A. If a force F of 12 lb is applied at B, determine the stress components at points D and E. Show the results on a differential element located at each of these points. Θ=0°, 90°, and 45°.