

## Lecture 15 - Combined Loading

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## schedule

- 25 Oct - SPTE, Combined Loading
- 27 Oct - Exam Return, Stress Transformation
- 1 Nov - Mohr's Circle
- 29 Oct - Project 2 Due, HW 6 Self-Grade Due
- 3 Nov - Strain Transformation

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- pressure vessels
- combined loading
- group problems

## pressure vessels

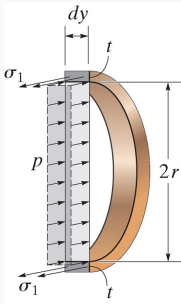
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## thin-walled pressure vessels

- If the radius to wall thickness ratio is 10 or more, we can treat a pressure vessel as “thin-walled”
- Cylindrical pressure vessels will have two primary sources of stress, and serve as an introduction to more general states of combined loading

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## cylindrical vessels

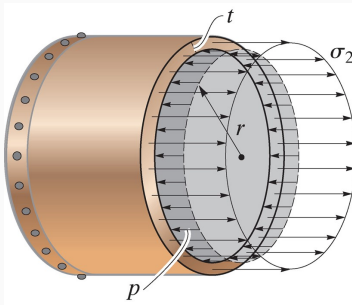


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- From equilibrium of a section of a cylindrical vessel, we see that

$$\begin{aligned}\sum F_x &= 0 \\ &= 2(\sigma_1 t dy) - p(2r)dy \\ \sigma_1 &= \frac{pr}{t}\end{aligned}$$

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- Considering another section we can find the longitudinal stress

$$\begin{aligned}\sum F_y &= 0 \\ &= \sigma_2(2\pi rt) - p(\pi r^2) \\ \sigma_2 &= \frac{pr}{2t}\end{aligned}$$

## spherical vessels

- We can find the stress in spherical vessels using an identical section to the longitudinal section for a cylindrical vessel, and we find that

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

- Which is valid everywhere in a cylindrical vessel

## example 8.1

- A cylindrical pressure vessel has an inner diameter of 4 ft and a thickness of  $1/2$  in.
- Determine the maximum internal pressure it can sustain if the maximum stress it can support is 20 ksi.
- What is the maximum internal pressure a spherical pressure vessel could sustain under identical conditions?

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## combined loading

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- We can use the principle of superposition to treat various loading conditions separately and then add them together to find the total stress

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## procedure

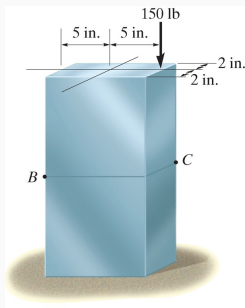
- Section the member at the point of interest, internal force components should be drawn acting through the centroid of the section
- Moment components should be calculated about the centroidal axis

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- Normal stress:  $\sigma = N/A$
- Torsion:  $\tau = \frac{T\rho}{J}$
- Bending:  $\sigma = \frac{-My}{I}$
- Transverse Shear:  $\tau = \frac{VQ}{It}$
- Pressure Vessels:  $\sigma_1 = \frac{pr}{t}$ ,  $\sigma_2 = \frac{pr}{2t}$

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### example 8.2

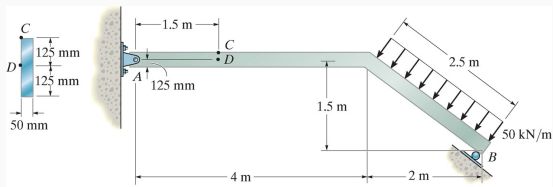


Neglect the weight of the member and find the stress at B and C.

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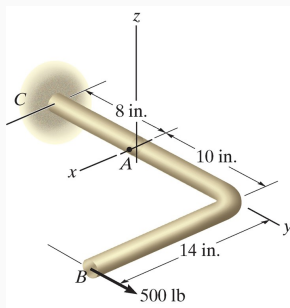
## example 8.4



Determine the stress at C and D.

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## example 8.5



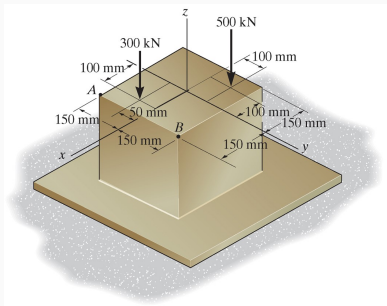
The rod shown has a radius of 0.75 in. Find the stress at A.

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## group problems

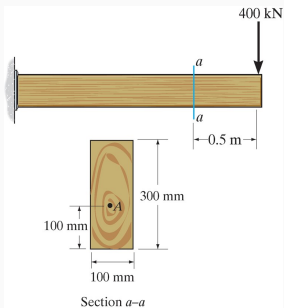
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### group one



Find the stress at the corners A and B for the column shown.

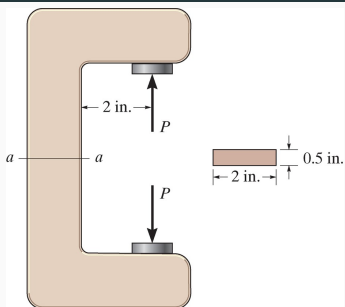
## group two



Find the stress at point A for the cantilever beam shown.

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## group three



Find the load  $P$  that will cause a maximum normal stress of  $\sigma = 30$  ksi along the section a-a.

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