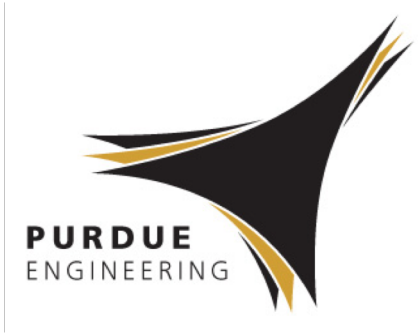
Fall, 2019

ME 323 –Mechanics of Materials

Lecture 2 – Normal stress and strain

Reading assignment: 2.1 – 2.3

News: Gradescope is already setup, please try to log in before Friday



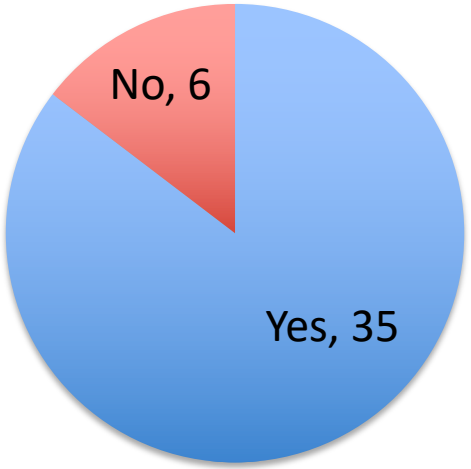
Instructor: Prof. Marcial Gonzalez

Last modified: 8/18/19 1:41:21 PM

General information

First assignment:

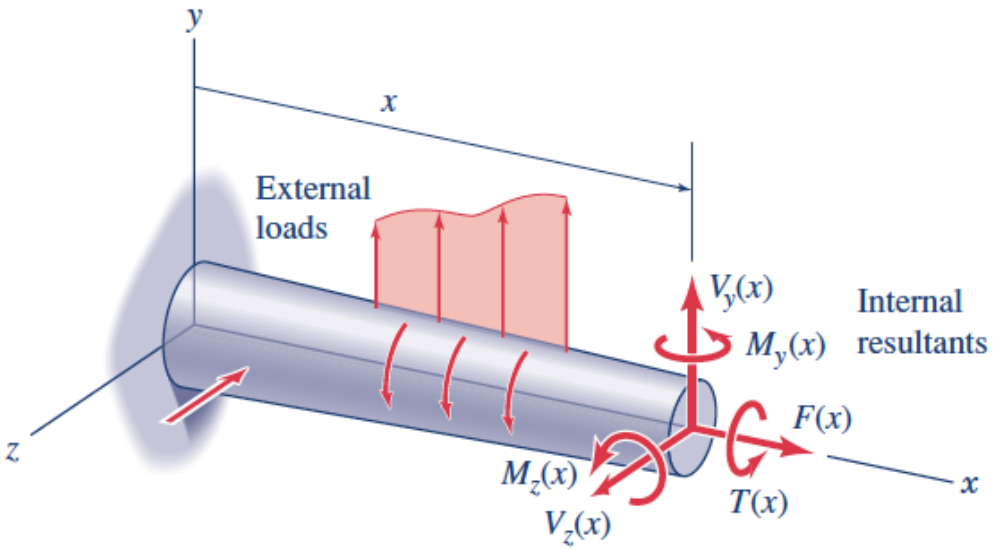
- Send me a photo of you to marcial-gonzalez@purdue.edu before next class.
- Format for the file name:
  FistNameLastName-PurdueID.jpg
  (e.g., MarcialGonzalez-002xxxxx.jpg)
- Subject of the email:
  ME 323 - Photo
- The easiest points of the semester!



Friday, August 23rd.

Theory of deformable bodies – Static equilibrium

Internal resultants (review):



$$\sum \boldsymbol{F} = \mathbf{0} \quad \left(\sum \boldsymbol{M}\right)_O = \mathbf{0}$$

Identify internal resultants:

- Axial force (normal force)
- Shear force
- Torque (twisting moment)
- Bending moment

Q: for given geometry, support and loading conditions, are these internal resultants a function of

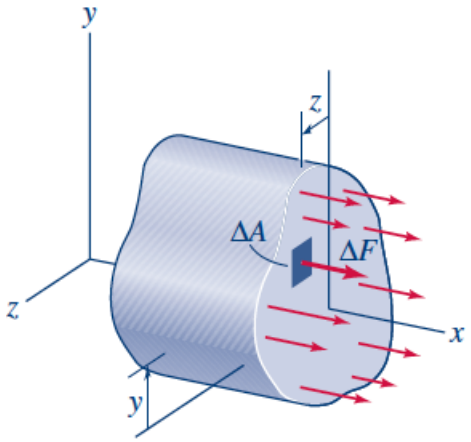
(a) spatial coordinates?

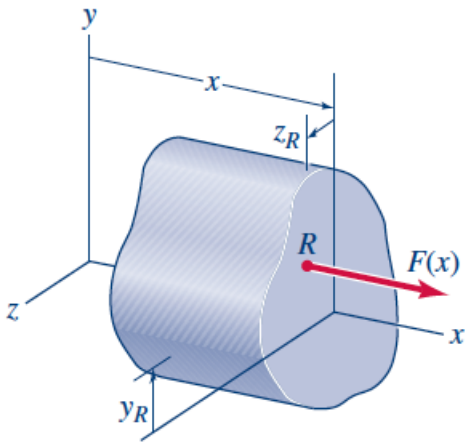
(b) material properties?

Stress and strain

Normal stress:

- Force per (undeformed) unit area, acting perpendicular to a given plane and at a given point.
  (e.g., normal stress at point (x,y,z) on cross section with normal x)





$$\sigma \equiv \lim_{\Delta A_0 \to 0} \frac{\Delta F}{\Delta A_0} = \frac{dF}{dA_0}$$

Resultant normal force:

$$F = \int_{A_0} dF = \int_{A_0} \sigma \, dA_0$$

Average normal stress:

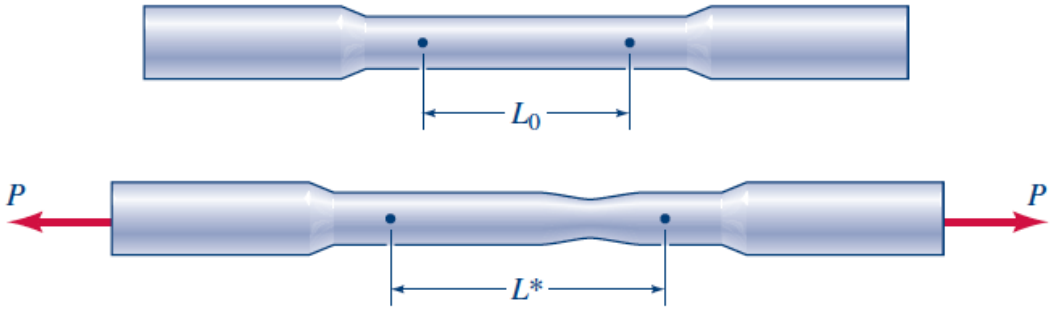
$$\sigma_{\text{avg}} = \frac{F}{A_0}$$

Q: is the normal stress always uniform over the cross section?
Q: if it is uniform, where is the resultant force then located?
Q: what is the sign convention for tension and compression?

Stress and strain

Extensional (engineering) strain:

- Elongation/shortening per (undeformed) unit length that goes with the normal stress.
  (e.g., extensional strain at point (x,y,z) in the x-direction)



$$\epsilon \equiv \frac{L_t - L_0}{L_0}$$

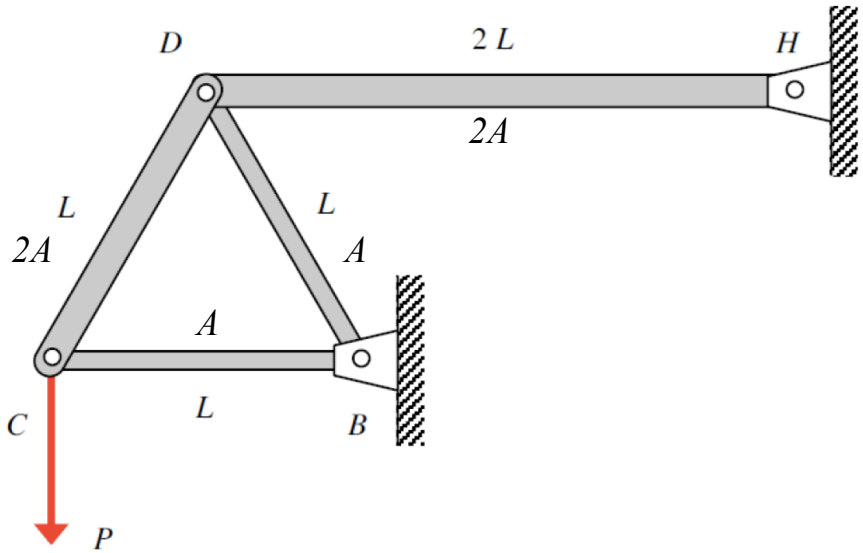
Q: is the extensional engineering strain uniform over the cross section?
Q: is the extensional engineering strain uniform along the length of the object?
Q: if it is uniform, does a plane cross section remain plane after deformation?
Q: what is the sign convention for tension and compression?
Q: are there other definitions of strain?

Yes, for example, the true strain: $\epsilon_{\text{true}} = \ln\left(\frac{L_t}{L_0}\right) = \ln(1+\epsilon)$

Normal stress

Example 2 (review):

Determine the stress in members BC, BD, CD, and DH. State whether each member is in tension or compression.

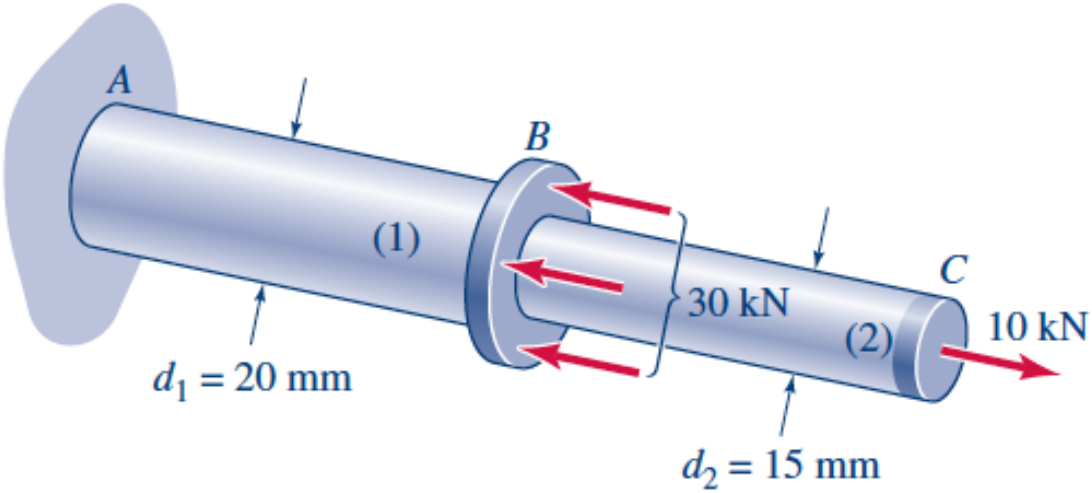


Answer:
$$\sigma_{CB} = P/A\sqrt{3} \quad (\text{C}))$$
$$\sigma_{CD} = P/A\sqrt{3} \quad (\text{T})$$
$$\sigma_{DB} = 2P/A\sqrt{3} \quad (\text{C})$$
$$\sigma_{DH} = P/A\sqrt{3} \quad (\text{T})$$

Normal stress

Example 3:

Two solid circular rods are welded to a plate at B to form a single rod, as shown in the figure. Consider the 30 kN force at B to be uniformly distributed around the circumference of the collar at B and the 10 kN load at C to be applied at the centroid of the end cross section. Determine the axial stress in each portion of the rod.



Answer: $\sigma_1 = 63.7 \text{ MPa} \quad (\text{C})$

$\sigma_2 = 56.6 \text{ MPa} \quad (\text{T})$

Stress and strain

Any questions?