AE333

Mechanics of Materials

Lecture 2 - Stress

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January 24, 2020

schedule

- 25 Jan - Stress
- 28 Jan - Average stress, Intro HW Due
- 30 Jan - Assessment Test
- 1 Feb - Allowable stress, Strain, HW1 Due

office hours

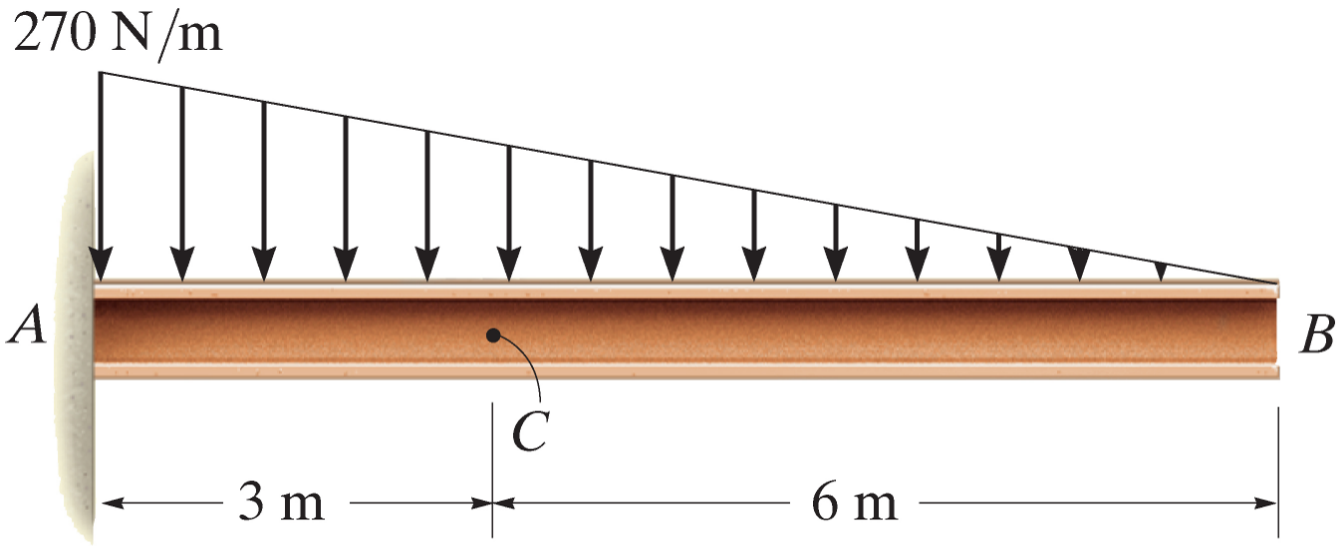
- TBD
- You have until next Monday's class to vote for your preferred time, that is when I would like to finalize office hours
- As always, if you can't make it to office hours, just send me an e-mail and we'll try to work something out

outline

- review
- stress
- average normal stress
- average shear stress

review

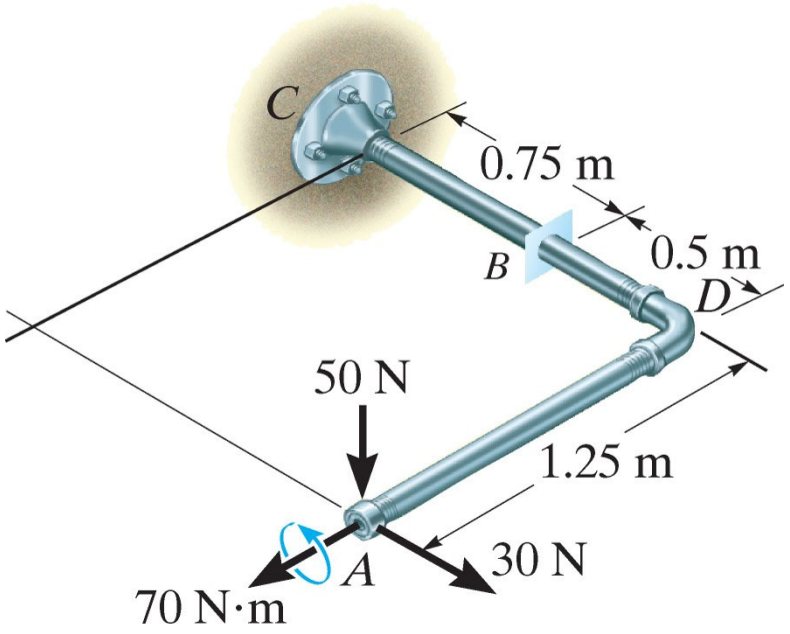
example 1.1



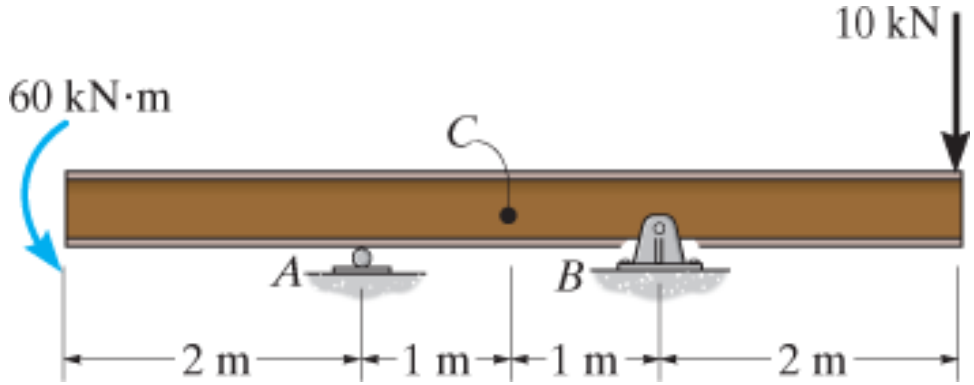
Find the internal forces at point C.

example 1.4

Find the internal forces at point D.

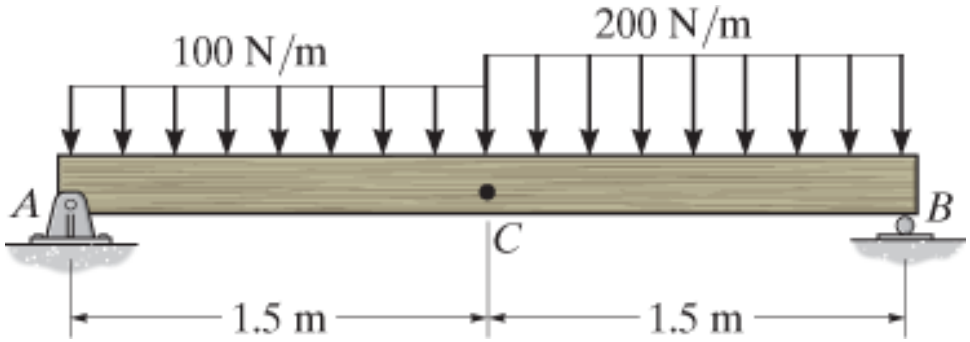


group one



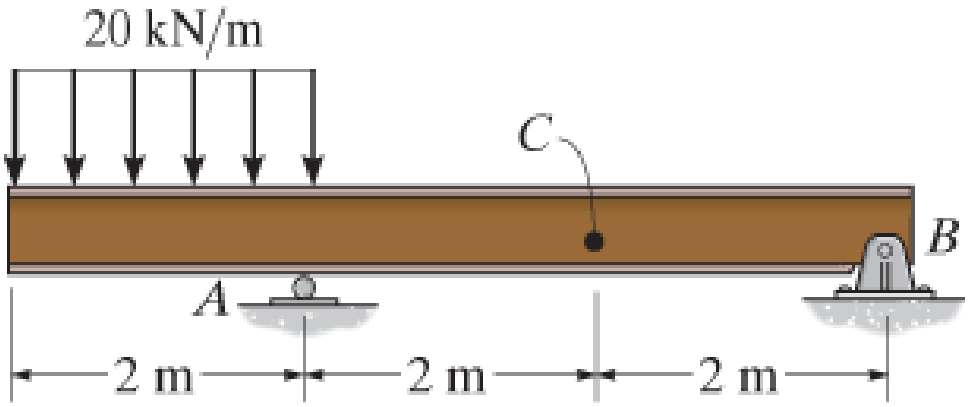
Find the internal forces at C.

group two



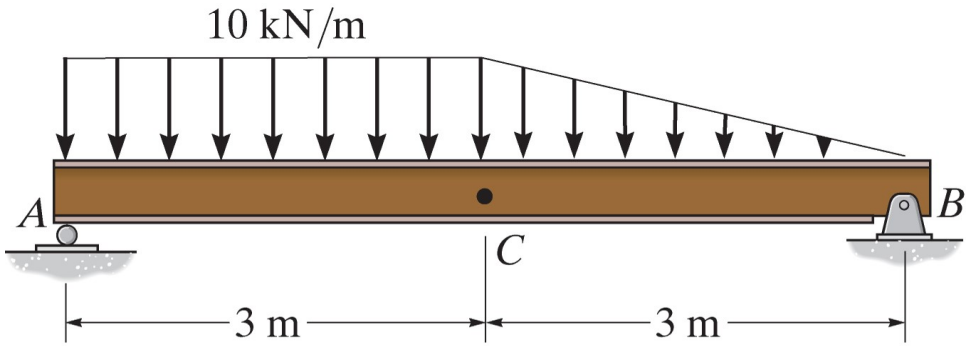
Find the internal forces at C.

group three



Find the internal forces at C.

group four



Find the internal forces at C.

stress

stress

- For a continuous and cohesive material, consider an infinitely small cube of material
- A finite force, ΔF will act on this material, and we can consider its three components, ΔF_x, ΔF_y, and ΔF_z
- The limit of the force divided by the area of the cube is defined as stress

normal stress

- The stress acting normal to a face of the cube is referred to as the normal stress

$$\sigma_x = \lim_{\Delta A_x \to 0} \frac{\Delta F_x}{\Delta A_x}$$
$$\sigma_y = \lim_{\Delta A_y \to 0} \frac{\Delta F_y}{\Delta A_y}$$
$$\sigma_z = \lim_{\Delta A_z \to 0} \frac{\Delta F_z}{\Delta A_z}$$

shear stress

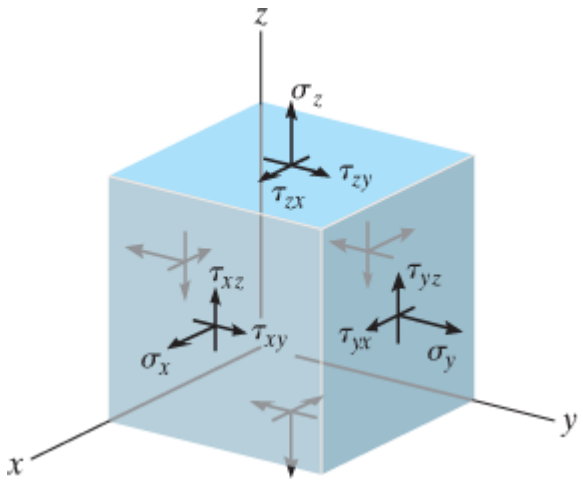
- Similarly, forces acting tangent to the face of the cube create shear stresses
- Often (but not always), τ is used instead of σ for shear stresses

$$\tau_{xy} = \lim_{\Delta A_y \to 0} \frac{\Delta F_x}{\Delta A_y}$$

$$\tau_{yz} = \lim_{\Delta A_z \to 0} \frac{\Delta F_y}{\Delta A_z}$$

$$\tau_{xz} = \lim_{\Delta A_x \to 0} \frac{\Delta F_z}{\Delta A_x}$$

general stress



units

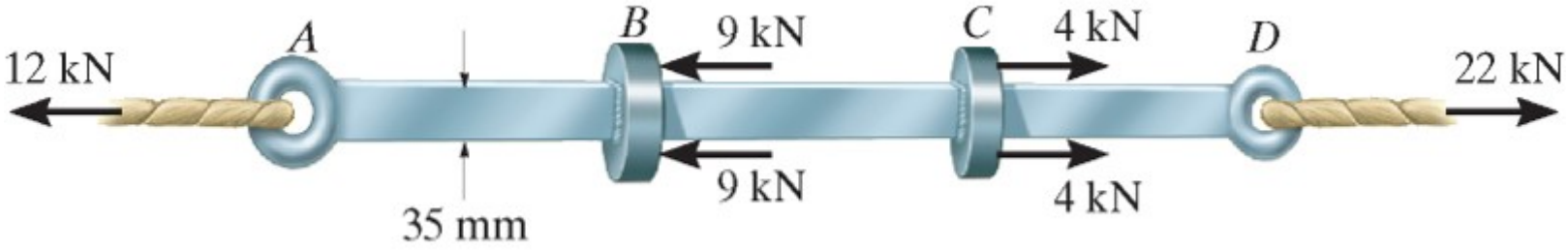
- stress has units of force per area
- In metric units, this is Pa (or often MPa and GPa)
- In english units, this is psi (or often ksi)

average normal stress

average normal stress

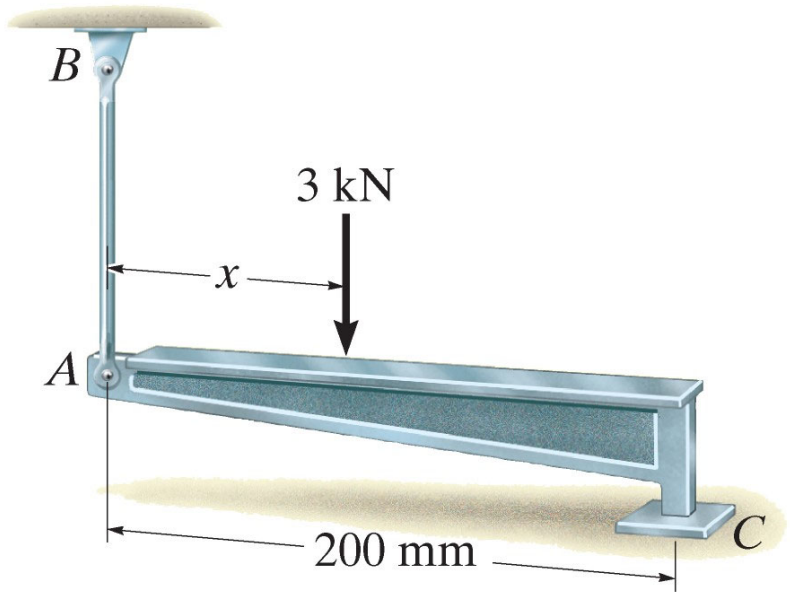
- We can use statics to find the statically equivalent normal force acting on some cross-section
- The average normal stress will be the normal force divided by the area of the cross-section
- If a bar is loaded at different points, or if it changes cross-sectional area, the average normal stress can vary, we can find the stress at different cross-sections to find the maximum average normal stress

example 1.5



The bar shown as a width of 35 mm and a thickness of 10 mm. Find the maximum average normal stress in the bar.

example 1.8



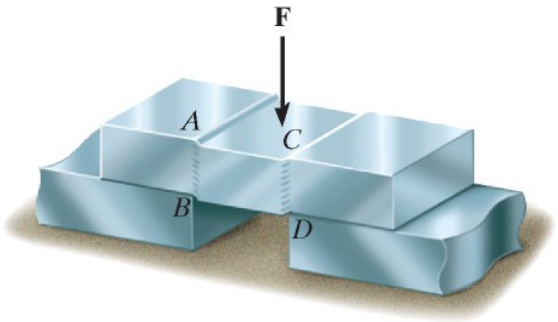
Determine the position, x, of the load so that the average compressive stress at C is equal to the average tensile stress in the rod AB. The rod has an area of $400\ \text{mm}^2$ and the contact at C has an area of $650\ \text{mm}^2$.

average shear stress

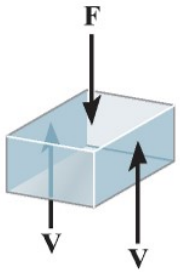
shear stress

- If we consider a section from a bridge-like structure we can demonstrate one way shear stress can be formed in a material
- As a reminder, shear stress is formed by forces acting in the plane of a section cut

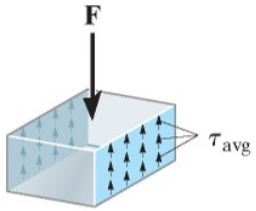
shear stress



(a)



(b)

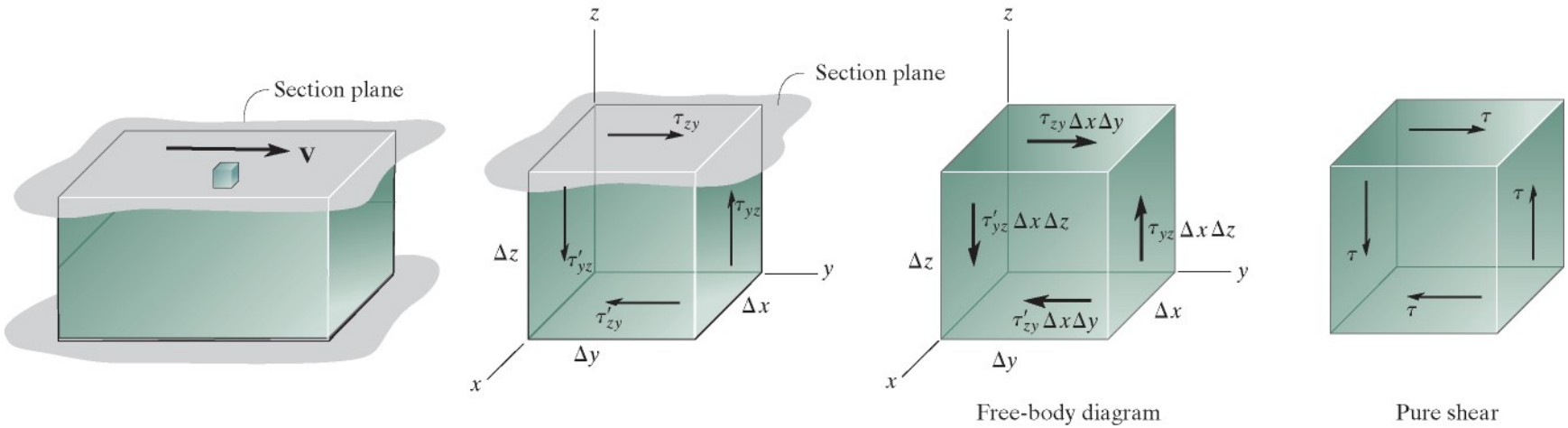


(c)

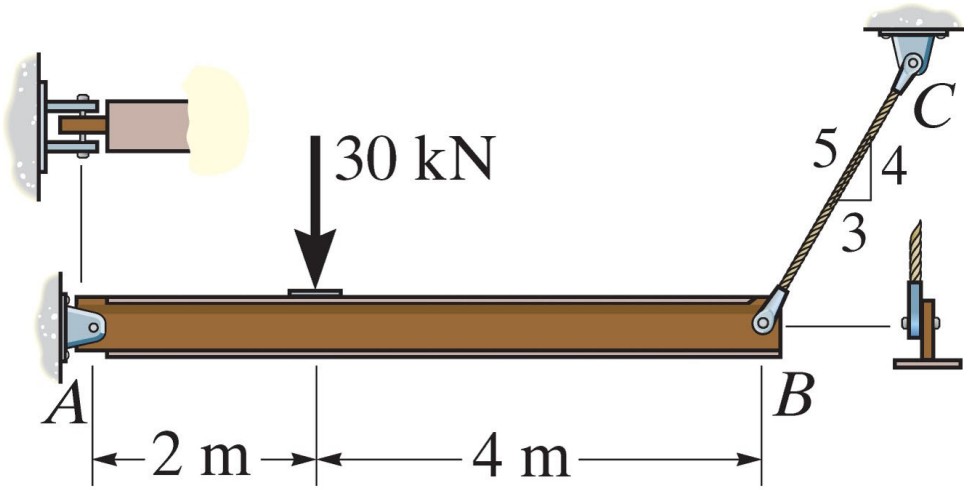
shear stress equilibrium

- If we consider equilibrium of an element subjected to shear on one face, we will find that there must be shear forces on other faces to remain in equilibrium
- In the following example, we will consider the sum of forces in the y-direction and the sum of moments about the x-axis
- We can convert between stresses and forces by recalling that $\sigma = F/A$, or $F = \sigma A$

shear stress equilibrium

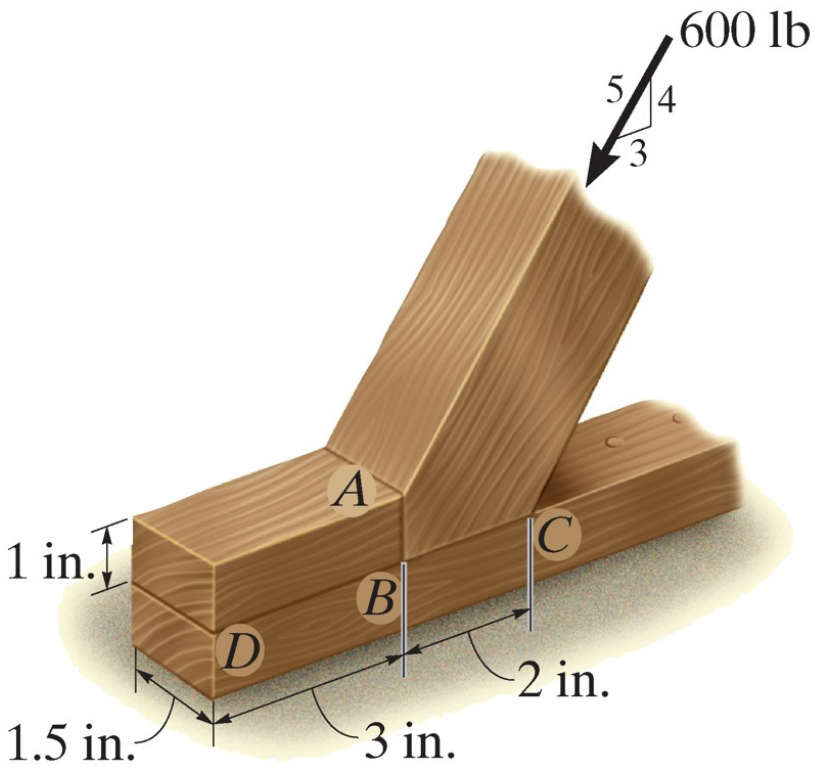


example 1-9



Determine the average shear stress in the 20-mm diameter pin at A and the 30-mm diameter pin at B.

example 1-11



Determine the average compressive stress along the smooth contact of AB and BC and the average shear stress along the horizontal plane DB.