# AE333

## Mechanics of Materials

Lecture 2 - Stress
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# schedule

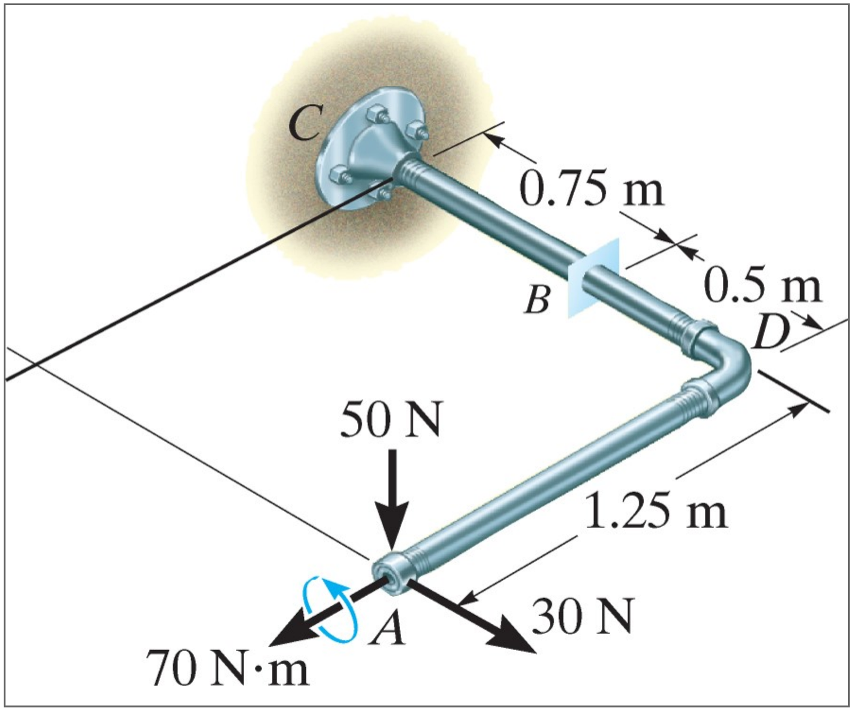
- 25 Jan - Stress
- 28 Jan - Average stress, Intro HW Due
- 30 Jan - Assessment Test
- 1 Feb - Allowable stress, Strain

# outline

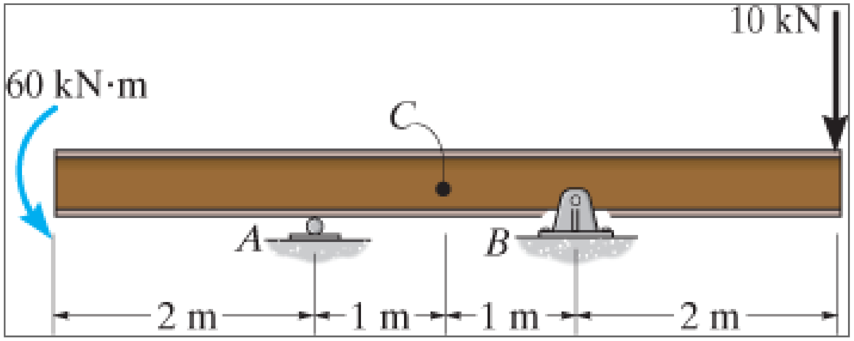
- review
- stress
- average normal stress
- average shear stress

# review

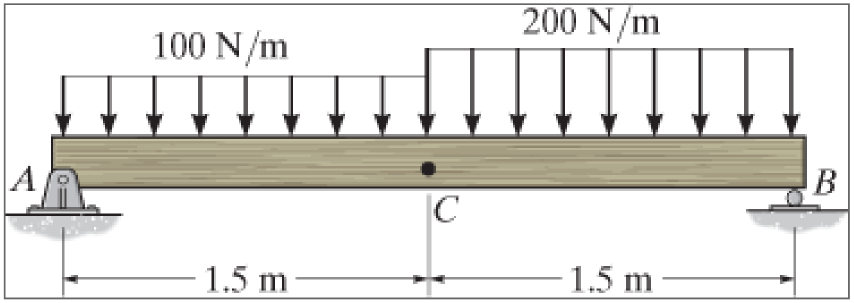
# example 1.4



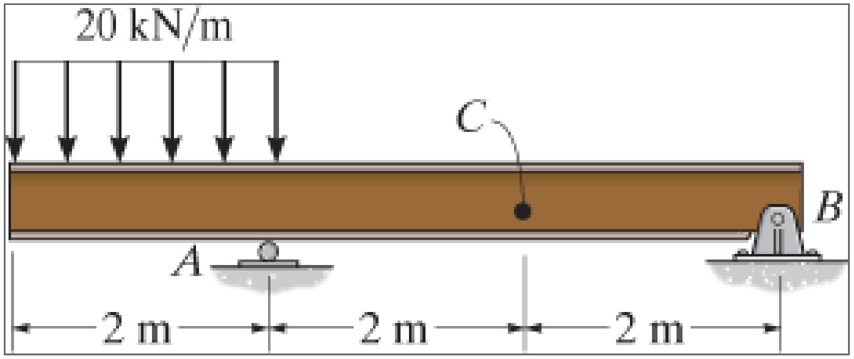
# group one



# group two



# group three



# stress

# stress

- For a continuous and cohesive material, consider an infinitely small cube of material
- A finite force, $\Delta F$ will act on this material, and we can consider its three components, $\Delta F_x$, $\Delta F_y$, and $\Delta F_z$
- 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

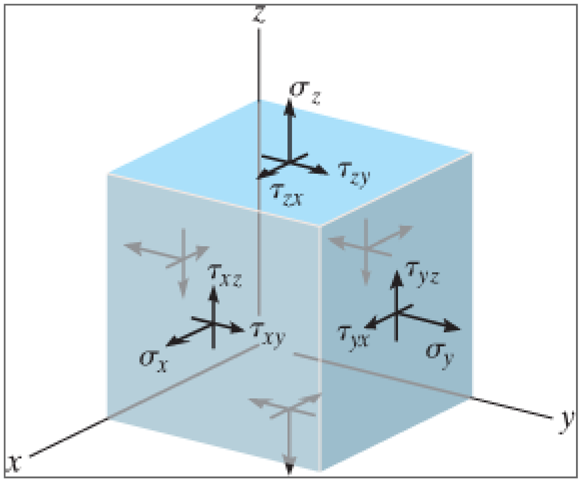
- Similarly, forces acting tangent to the face of the cube create shear stresses
- Often (but not always), $\tau$ is used instead of $\sigma$ for shear stresses

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

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

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

# general stress



# units

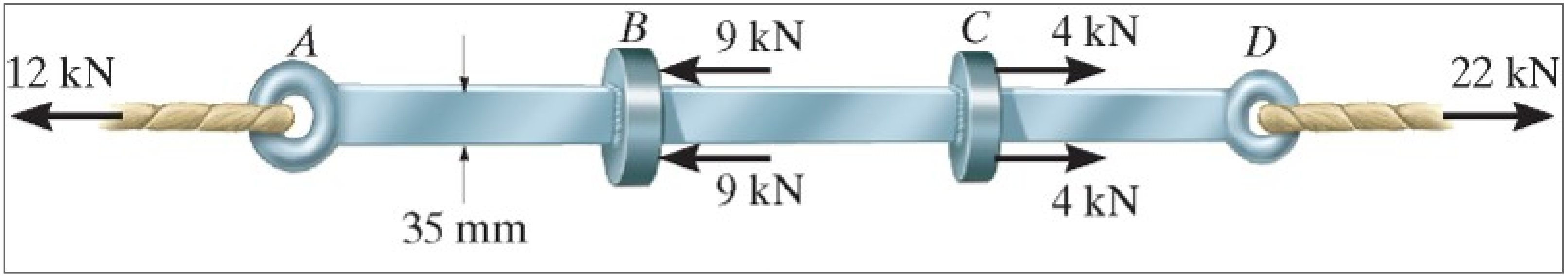
- stress has units of force per area
- In metric units, this is Pa (or often MPa and GPa)
- In english units, this is psi (or often ksi)

# average normal stress

# average normal stress

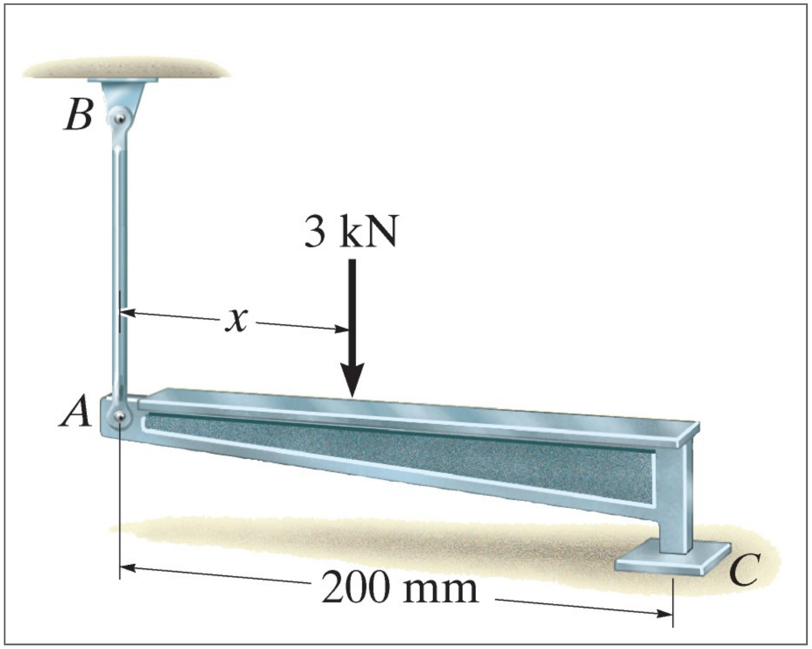
- We can use statics to find the statically equivalent normal force acting on some cross-section
- The average normal stress will be the normal force divided by the area of the cross-section
- If a bar is loaded at different points, or if it changes cross-sectional area, the average normal stress can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



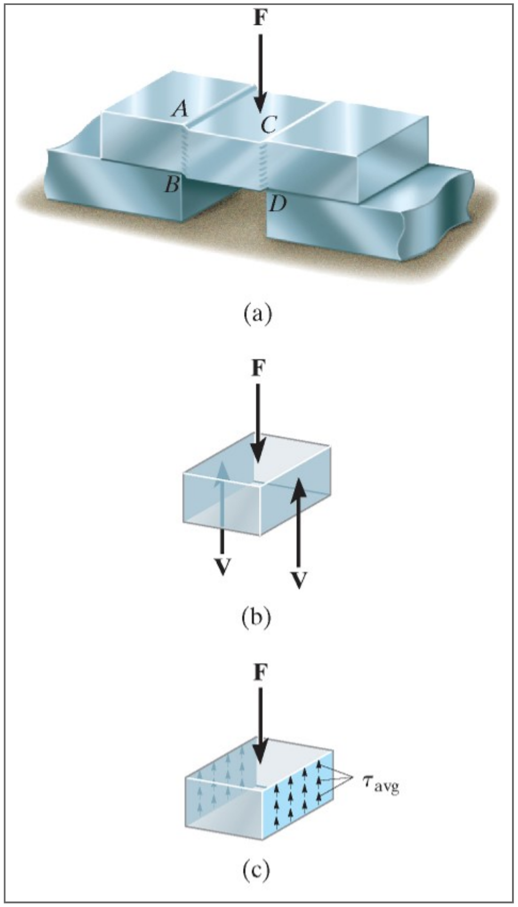

Determine the position, x, of the load so that the average compressive stress at C is equal to the average tensile stress in the rod AB. The rod has an area of 400\si$mm^2$ and the contact at $C$ has an area of 650\si$mm^2$.

# 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

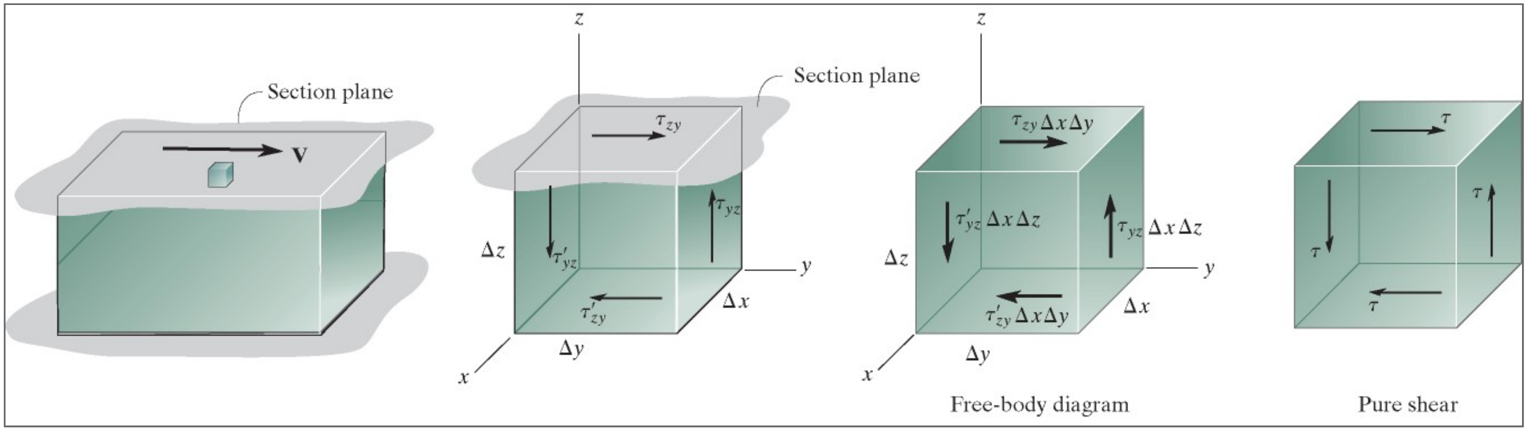
# shear stress



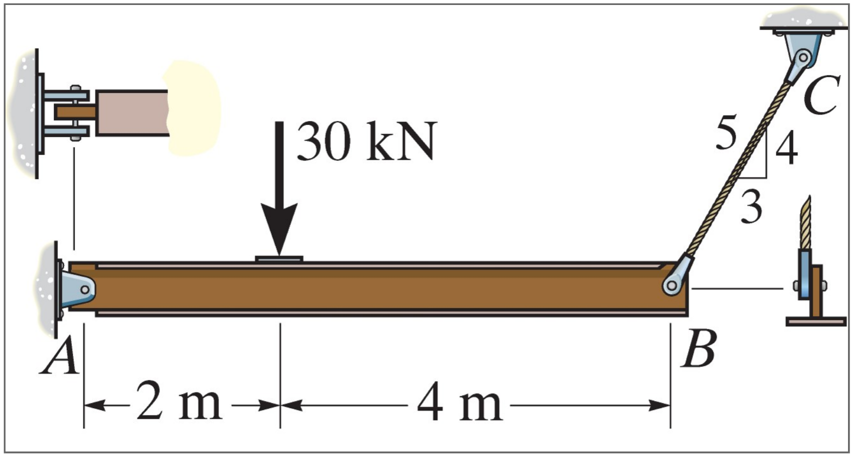
# shear stress equilibrium

- 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

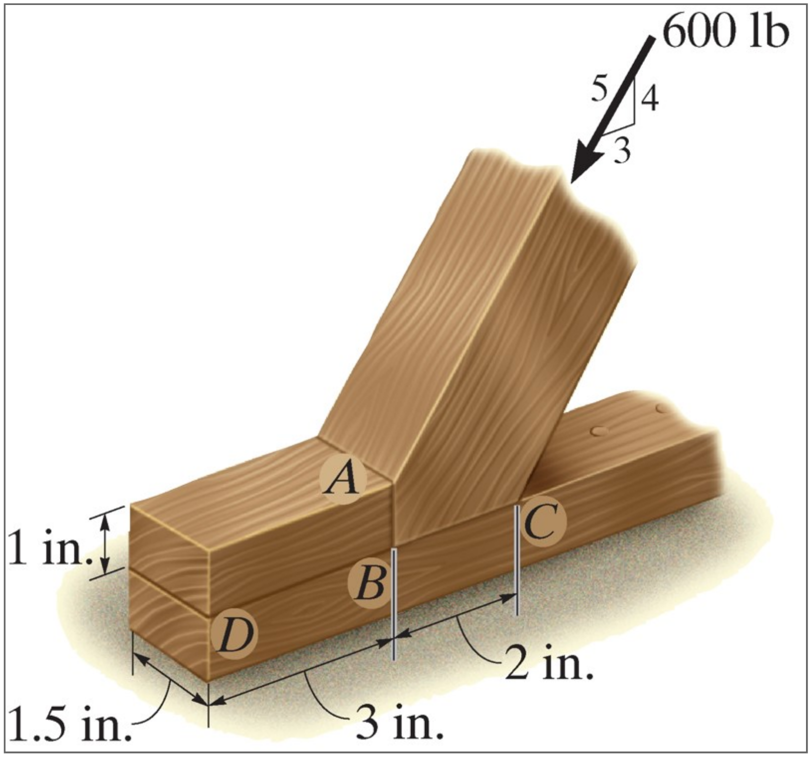


# example 1-9




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 $DB$.