Mechanics of Materials

Lecture 2 - Stress

Dr. Nicholas Smith

Wichita State University, Department of Aerospace Engineering

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schedule

- 18 Aug - Stress
- 23 Aug - Strain, Homework 1 Due
- 25 Aug - Mechanical Properties
- 30 Aug - Exam Review, Homework 2 Due

office hours

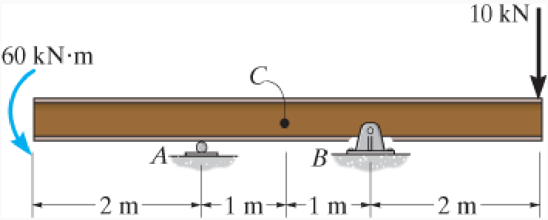
- We need to be careful about social distancing (avoid congregating in the main AE office)
- I will send out a Doodle to schedule
- Office appointments can also be scheduled via e-mail

outline

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

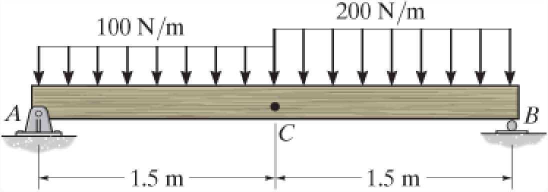
review

group one



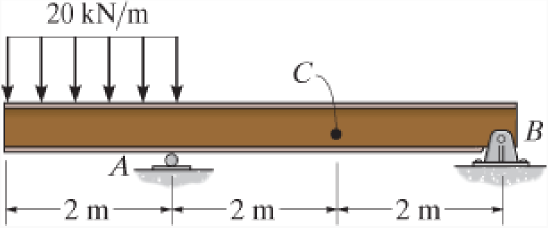
Find the internal forces at C.

group two

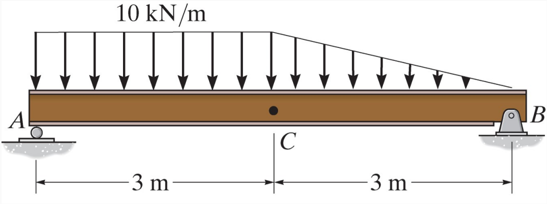


Find the internal forces at C.

group three



Find the internal forces at C.



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

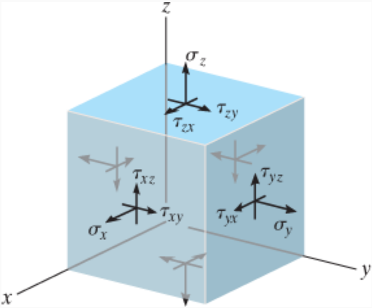


Figure 1: A cube with stresses illustrated on each of the faces, following the notation described previously.

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

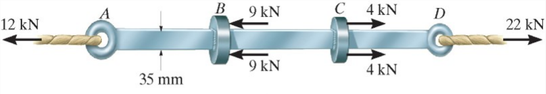


Figure 2: The bar with a width of 35 mm and a thickness of 10 mm is loaded at multiple locations. From the left end, at point A, there is a 12 kilonewton load (in the left direction) to the right of this at point B load another left-pointing load of 9 kilonewtons is applied. To the right of that, point C, another load of 4 kilonewtons is applied in the right direction, and finally at the right end, point D, a 22 kilonewton load is applied pointing to the right. Find the maximum average normal stress in the bar.

The bar shown as a width of 35 mm and a thickness of 10 mm.

example 1.8

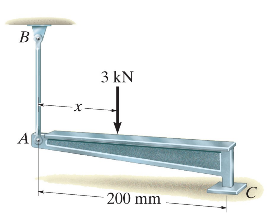


Figure 3: A block 200 mm long has a leg resting against the floor at its right end, point C, and is supported by a vertical hanging rod at its left end (points A and B). A 3 kilonewton force pointing

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 mm^2 and the contact at C has an area of 650 mm^2.

example

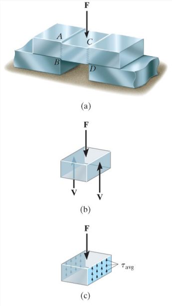
Calculate the stresses for elements in last week's lecture: - Stress in the workpiece - Stress in the vise screw - Stress in the pinboard - Stress in St. Peter's Cross

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

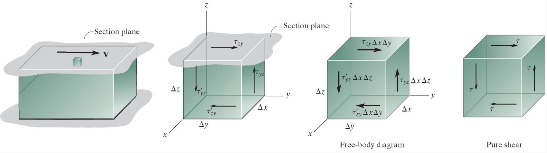
shear stress



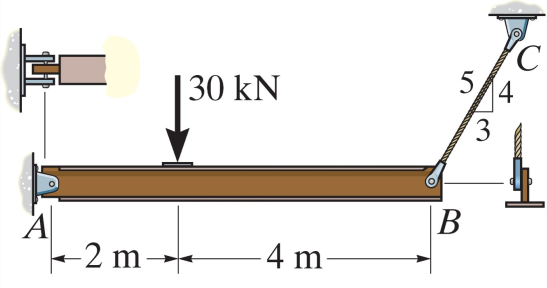
shear stress equilibrium

- 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

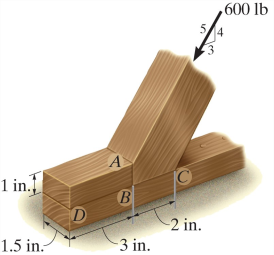


Figure 4: A wooden block is shown with one leg at a 3-4-5 angle and a 600 pound compressive load acting in the direction of that leg.

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

example

Calculate the average shear stress in the pin connecting the two legs in "St. Peter's Cross" from the leg vise example.