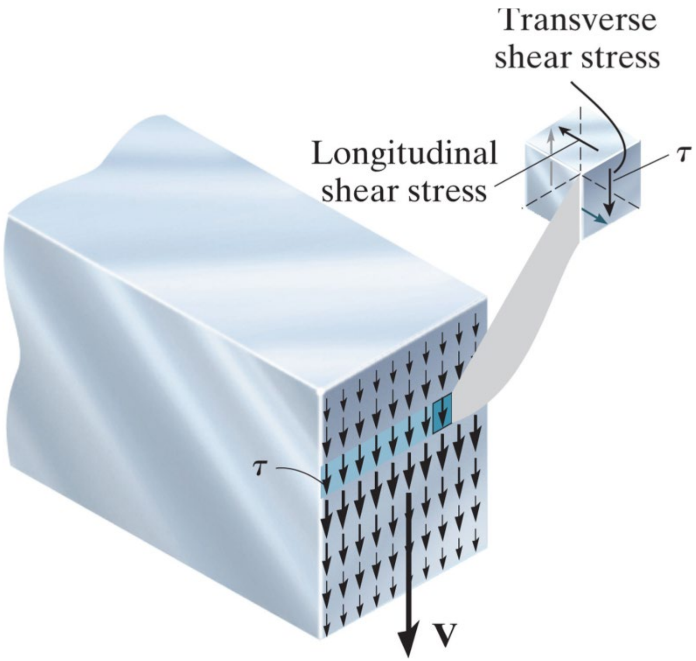
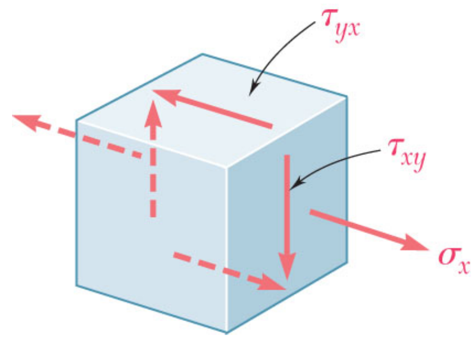
Chapter 7: Transverse Shear

Chapter Objectives

- ✓ Determine shear stress in a prismatic beam
- ✓ Determine shear flow in a built-up beam

Symmetry of shear stresses

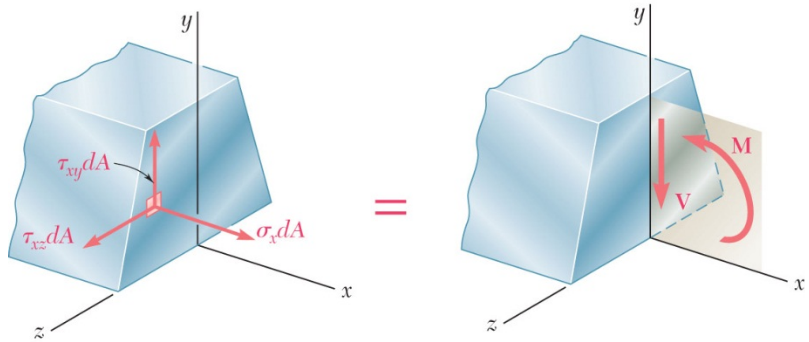


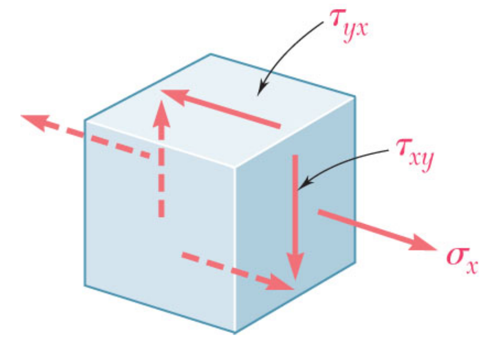


- When shearing stresses are exerted on the vertical faces of an element, equal stresses must be exerted on the horizontal faces
- Longitudinal shearing stresses must exist in any member subjected to transverse loading.

Shear stress in beams

- Transverse loading applied to a beam results in normal and shearing stresses in transverse sections.



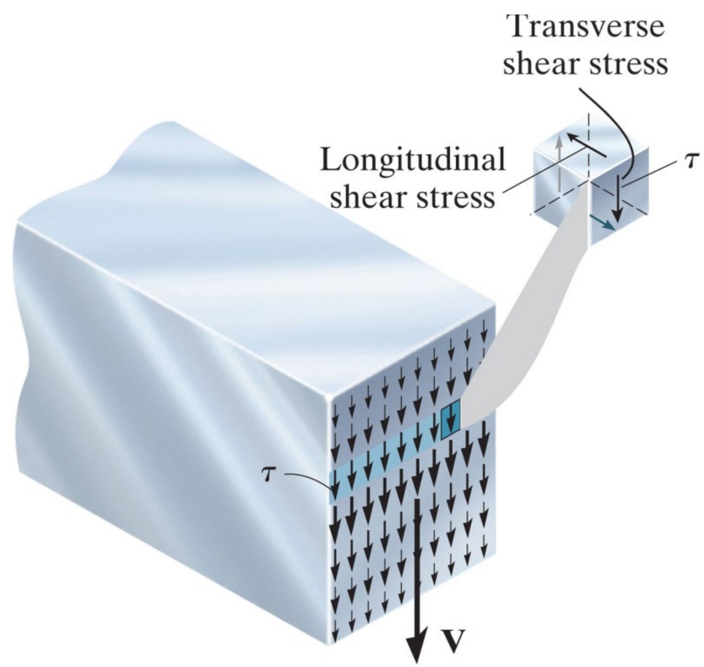


- Distribution of normal and shearing stresses satisfies

$$F_x = \int \sigma_x dA = 0 \qquad M_x = \int \left(y\tau_{xz} - z\tau_{xy}\right) dA = 0$$

$$F_y = \int \tau_{xy} dA = -V \qquad M_y = \int z\sigma_x dA = 0$$

$$F_z = \int \tau_{xz} dA = 0 \qquad M_z = \int \left(-y\sigma_x\right) = M$$

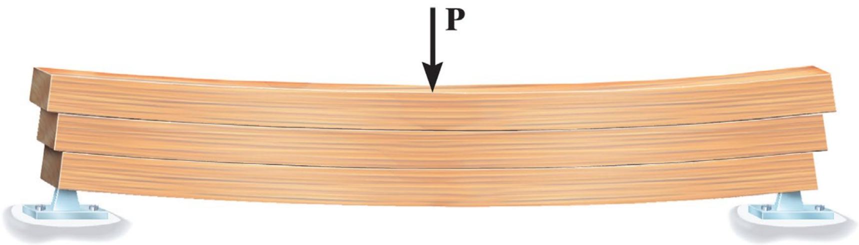


- When shearing stresses are exerted on the vertical faces of an element, equal stresses must be exerted on the horizontal faces

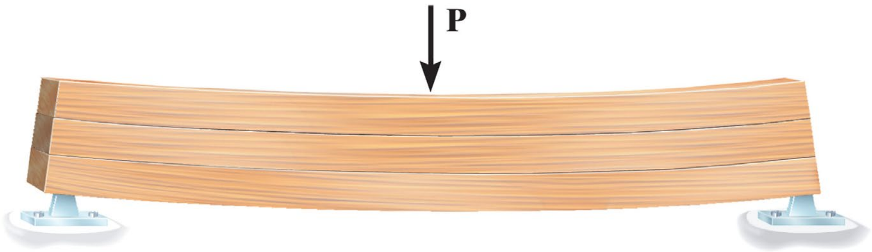
- Longitudinal shearing stresses must exist in any member subjected to transverse loading.

Transverse loading of beams

Shear forces due to transverse loading creates corresponding **longitudinal** shear stresses which will act along **longitudinal** planes of the beam.



Boards not bonded together

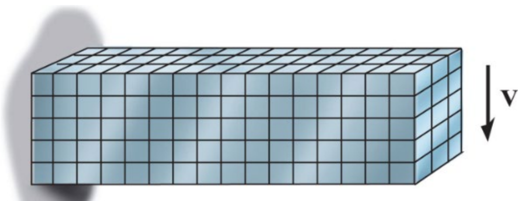


Boards bonded together

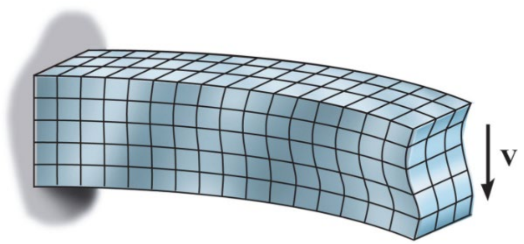
Transverse loading of beams

When a transverse shear load is applied, it tends to cause warping of the cross section. Therefore, when a beam is subject to moments and shear forces, the cross section will **not** remain plane as assumed in the derivation of the bending stress formula.

However, we can assume that the warping due to the transverse shear stresses is small enough that it can be neglected, which is particularly true for slender beams.



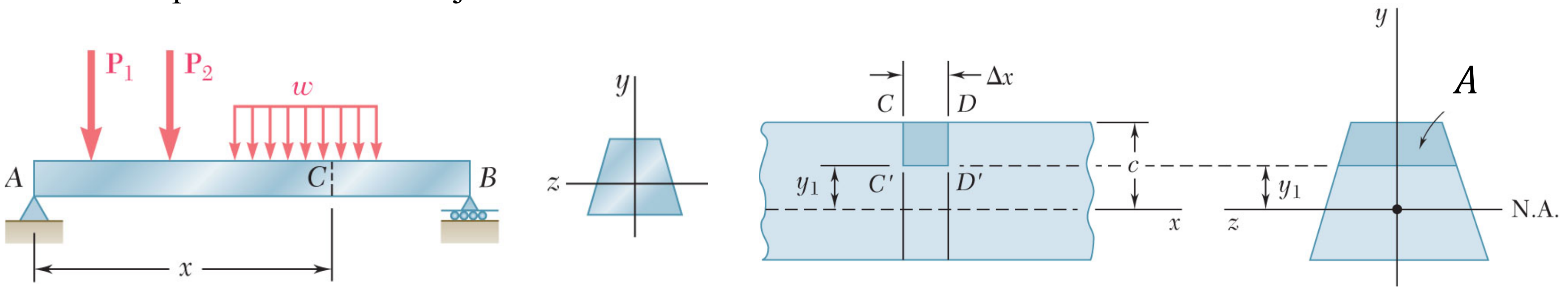
(a) Before deformation



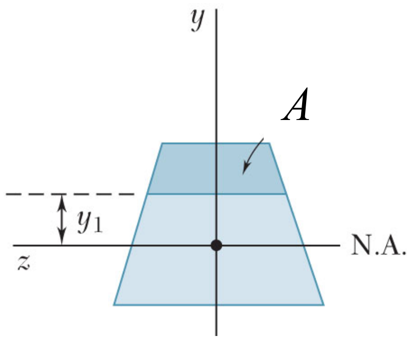
(b) After deformation

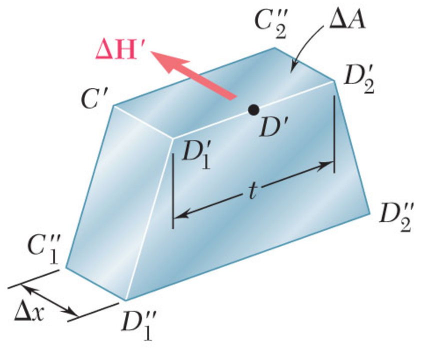
Longitudinal shear forces in beams

Consider a prismatic beam subjected to transverse loading

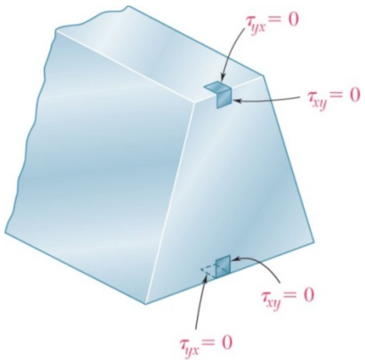


Average Shear Stress

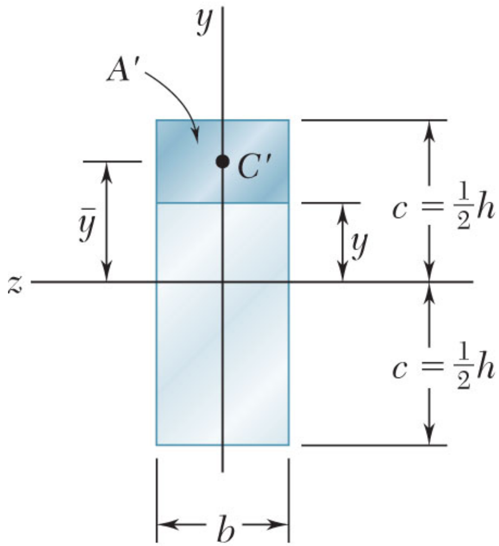




Shear stress at free edges



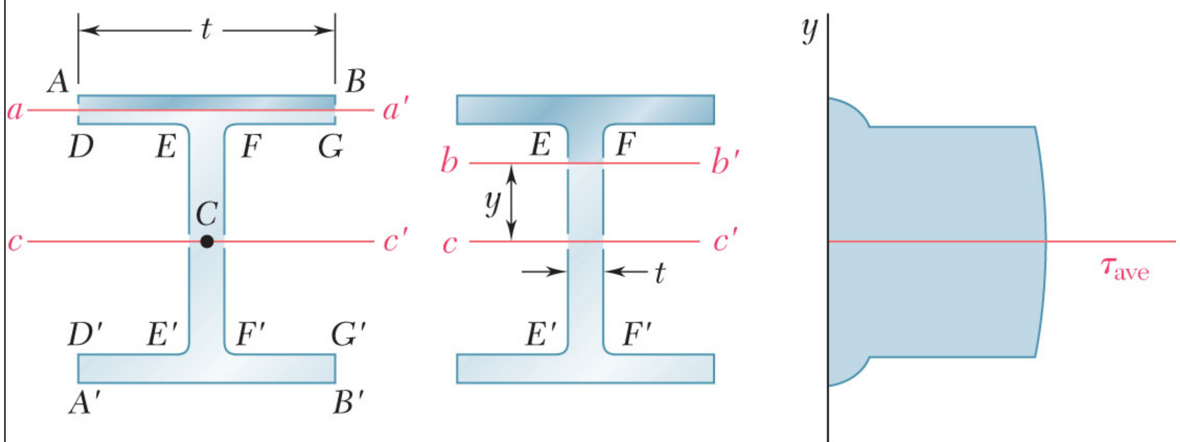
Shear Stress Distribution (rectangular cross-section)



Shear Stress Distribution: American Standard (S-beam) and wide-flange (W-beam) beams

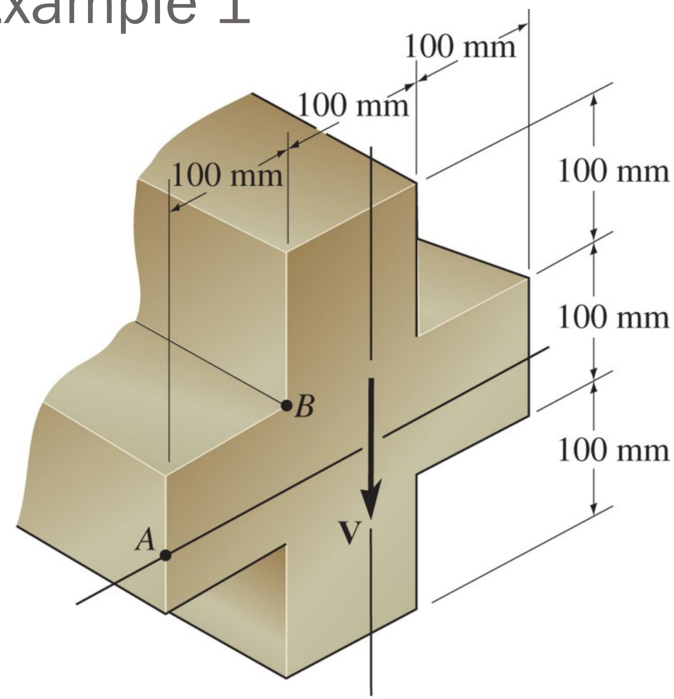
<u>Wide-flange beam</u>

Shear-stress distribution is parabolic but has a jump at the flange-to-web junctions.



(a) (b) (c)

Example 1

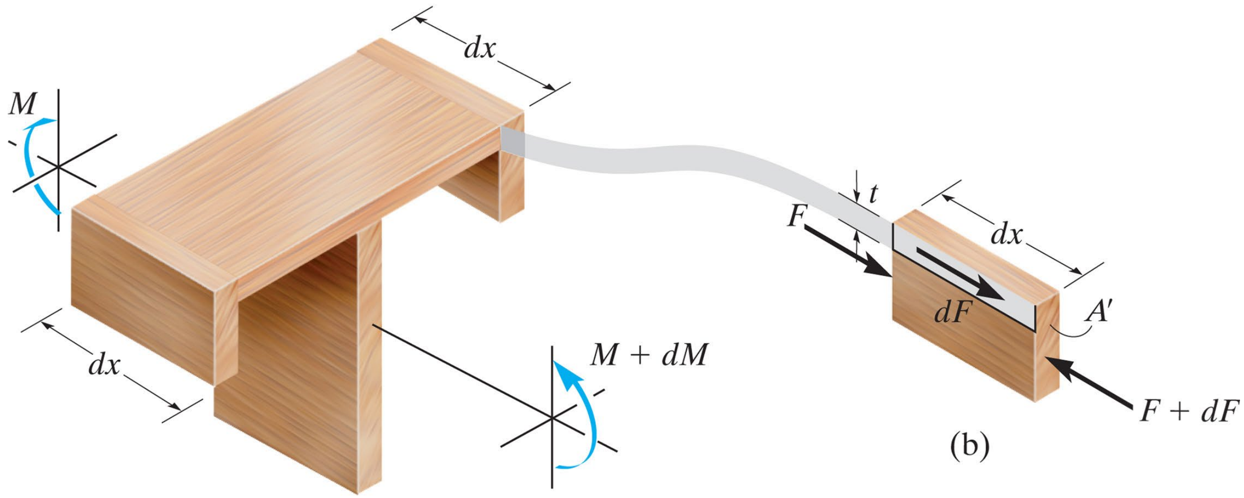


Knowing that the vertical shear in the beam is $V = 400$ N, determine the average shear stress at points A and B.

Shear Flow in Built-up Beams

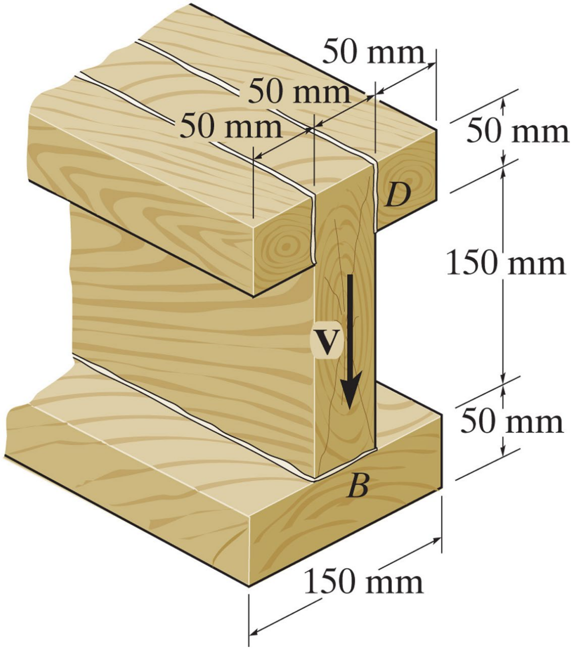
Consider the built-up beam below where the section is composed of 4 rectangular segments glued to one another.

How can we calculate the shear stress in the glued segments?



(a)

Example 2



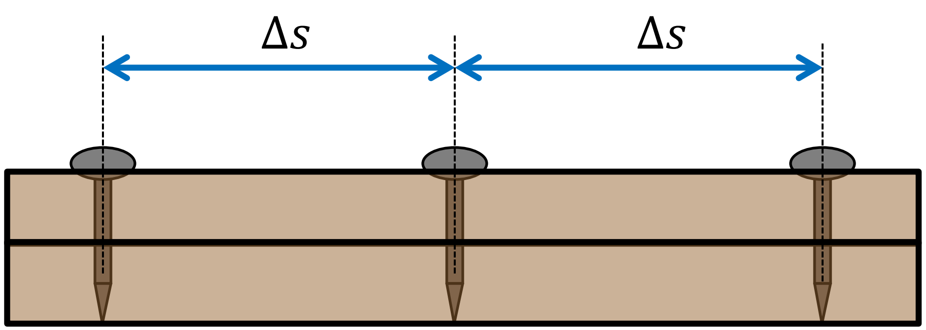
A beam is made of four planks glued together. Knowing that the vertical shear in the beam is $V = 500$ N, determine the minimum required shear strength τ_g for the glue.

Built up beams with fasteners (bolts or nails)

Unlike glue, fasteners supply resistance to longitudinal shear forces at fixed internals.

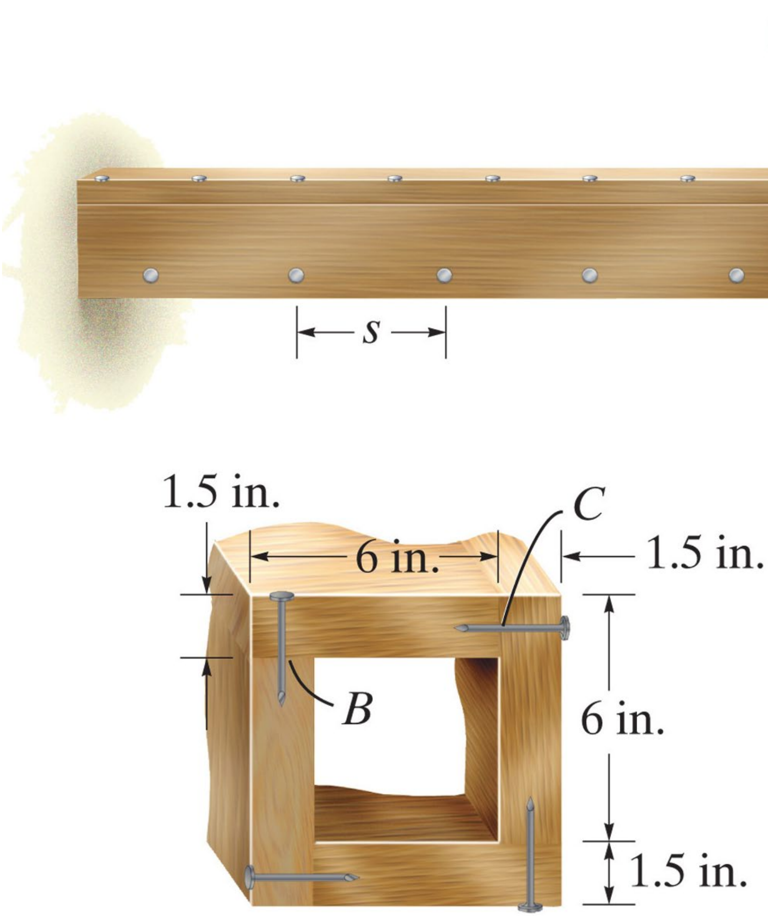
Fasteners are typically spaced at a constant interval Δs along the length of the beam.

If we know the shear flow q, how much load does each fastener carry?

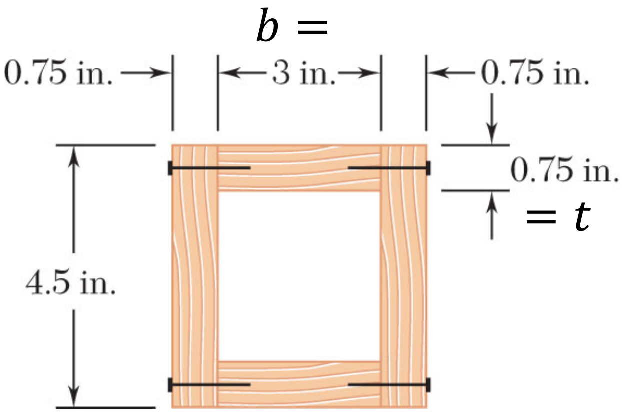


Example 3

A beam is made of four planks, nailed together as shown. If each nail can support a shear force of 30 lb, determine the maximum spacing s of the nails at B and at C so that the beam will support the force of 80lb.



Example 4



A square box beam is constructed from four planks as shown. Knowing that the spacing between nails is 1.5 in. and the beam is subjected to a vertical shear of magnitude $V = 600$ lb, determine the shearing force in each nail.