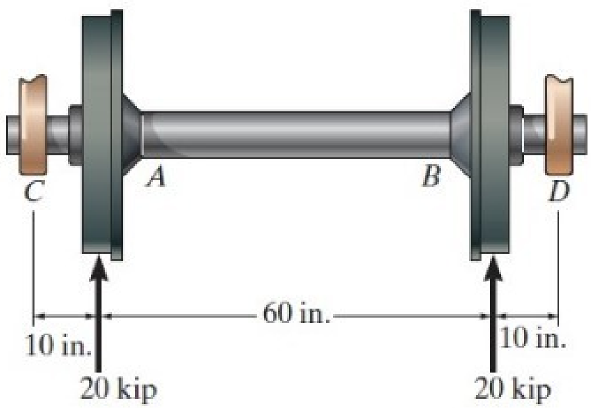
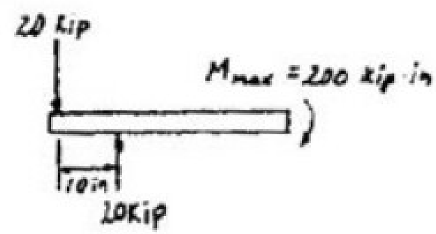
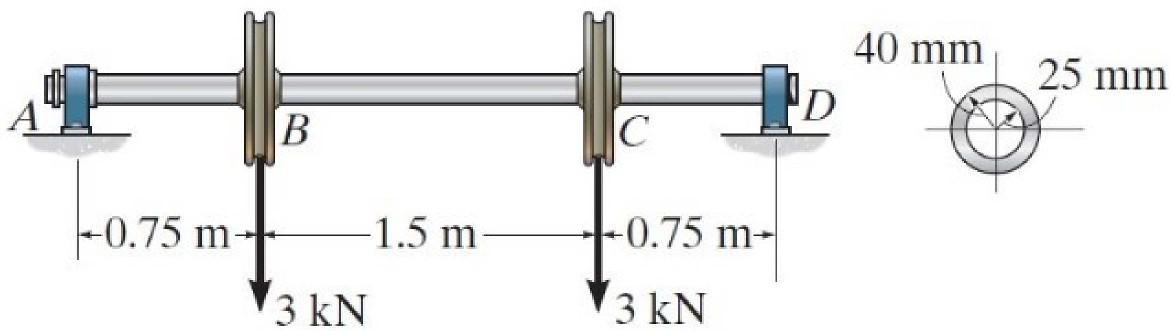
The axle of the freight car is subjected to wheel loading of 20 kip. If it is supported by two journal bearings at C and D, determine the maximum bending stress developed at the center of the axle, where the diameter is 5.5 in.





$$\sigma_{max} = \frac{Mc}{I} = \frac{200(2.75)}{\frac{1}{4}\pi(2.75)^4} = 12.2 \text{ ksi}$$

The shaft is supported by a smooth thrust bearing at A and smooth journal bearing at D. If the shaft has the cross section shown, determine the absolute maximum bending stress in the shaft.



Shear and Moment Diagrams: As shown in Fig. *a*.

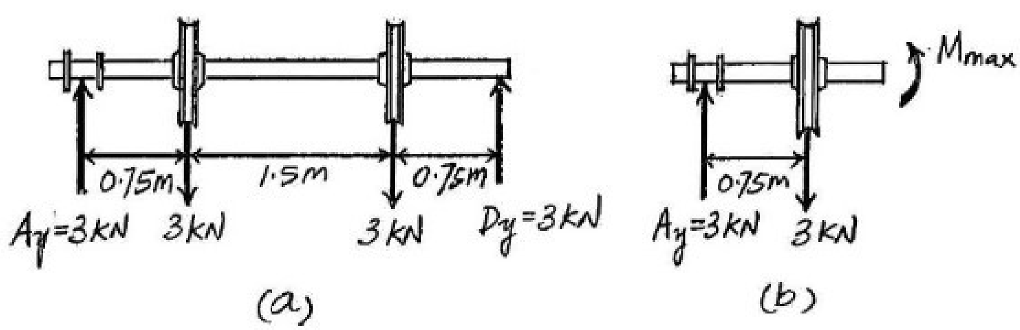
Maximum Moment: Due to symmetry, the maximum moment occurs in region *BC* of the shaft. Referring to the free-body diagram of the segment shown in Fig. *b*.

Section Properties: The moment of inertia of the cross section about the neutral axis is

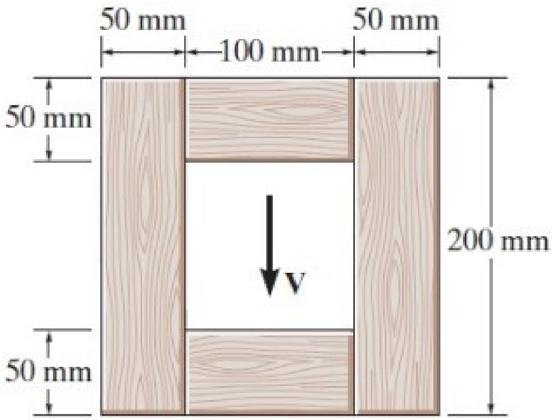
$$I = \frac{\pi}{4}\left(0.04^4 - 0.025^4\right) = 1.7038\left(10^{-6}\right)\text{m}^4$$

Absolute Maximum Bending Stress:

$$\sigma_{max} = \frac{M_{max}c}{I} = \frac{2.25\left(10^3\right)(0.04)}{1.7038\left(10^{-6}\right)} = 52.8 \text{ MPa}$$ **Ans.**



The wood beam has an allowable shear stress of τ_{allow}= 7 Mpa. Determine the maximum shear force V that can be applied to the cross section.

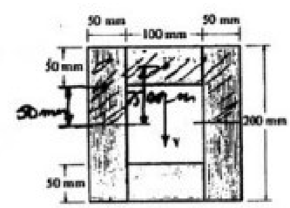


$$I = \frac{1}{12}(0.2)(0.2)^3 - \frac{1}{12}(0.1)(0.1)^3 = 125(10^{-6})\ \text{m}^4$$

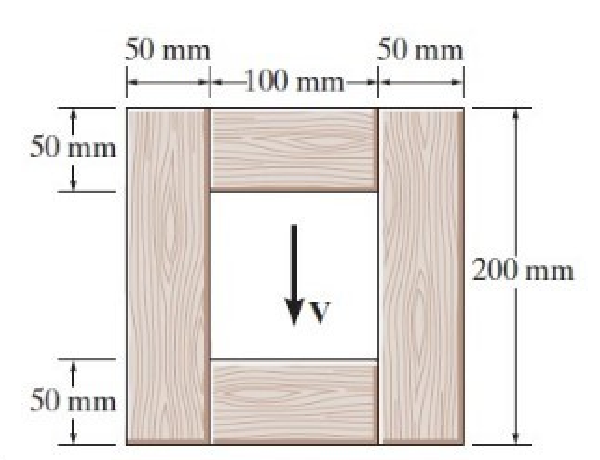
$$\tau_{\text{allow}} = \frac{VQ_{\text{max}}}{It}$$

$$7(10^6) = \frac{V[(0.075)(0.1)(0.05) + 2(0.05)(0.1)(0.05)]}{125(10^{-6})(0.1)}$$

$$V = 100 \text{ kN}$$ **Ans.**



The wood beam has an allowable shear force of V= 100 kN. Determine the maximum shear stress τ_{allow} in the cross section.

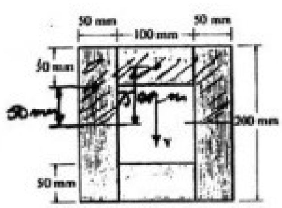


$$I = \frac{1}{12}(0.2)(0.2)^3 - \frac{1}{12}(0.1)(0.1)^3 = 125(10^{-6})\ \text{m}^4$$

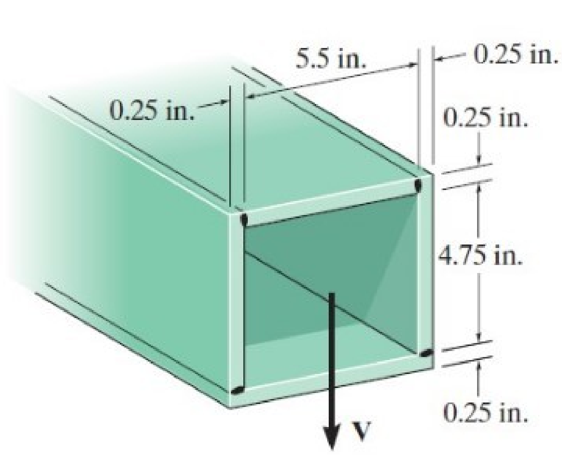
$$\tau_{allow} = \frac{VQ_{max}}{It}$$ V=100x10^3 N

$$= \frac{V[(0.075)(0.1)(0.05) + 2(0.05)(0.1)(0.05)]}{125(10^{-6})(0.1)}$$

Ans=7x10^6 Pa **Ans.**

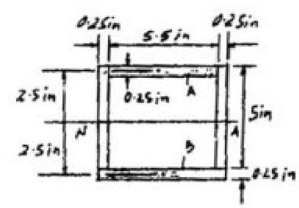


The box beam is made from four pieces of plastic that are glued together as shown. If the glue has an allowable strength of 400 lb/in^2, determine the maximum shear the beam will support.



$$I = \frac{1}{12}(6)(5.25^3) - \frac{1}{12}(5.5)(4.75^3) = 23.231 \text{ in}^4$$

$$Q_B = \bar{y}'A' = 2.5(6)(0.25) = 3.75 \text{ in}^3$$

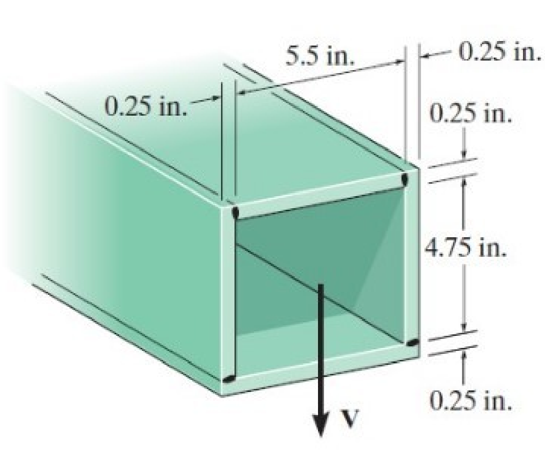


The beam will fail at the glue joint for board B since Q is a maximum for this board.

$$\tau_{allow} = \frac{VQ_B}{It}; \qquad 400 = \frac{V(3.75)}{23.231(2)(0.25)}$$

$V = 1239 \text{ lb} = 1.24 \text{ kip}$ **Ans.**

The box beam is made from four pieces of plastic that are glued together as shown. If V=2 *kip*, determine the shear stress resisted by the seam at each of the glued joints.



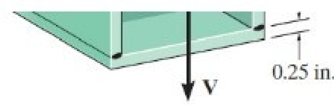
$$I = \frac{1}{12}(6)(5.25^3) - \frac{1}{12}(5.5)(4.75^3) = 23.231 \text{ in}^4$$

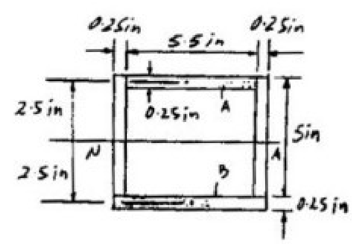
$$Q_B = \overline{y}'A' = 2.5(6)(0.25) = 3.75 \text{ in}^3$$

$$Q_A = 2.5(5.5)(0.25) = 3.4375$$

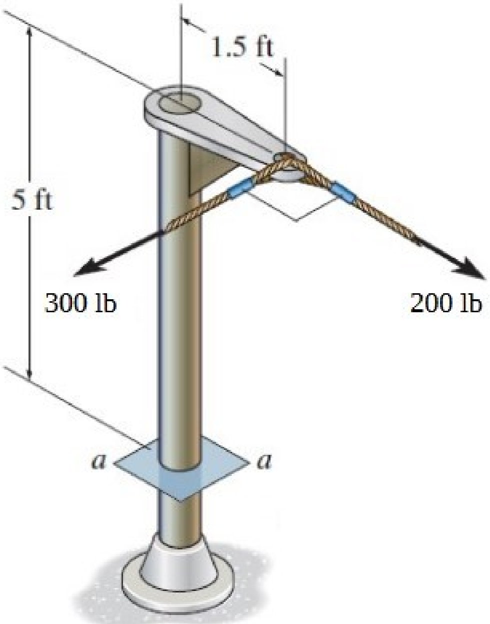
$$\tau_B = \frac{VQ_B}{It} = \frac{2(10^3)(3.75)}{23.231(2)(0.25)} = 646 \text{ psi}$$ **Ans.**

$$\tau_A = \frac{VQ_A}{It} = \frac{2(10^3)(3.4375)}{23.231(2)(0.25)} = 592 \text{ psi}$$ **Ans.**



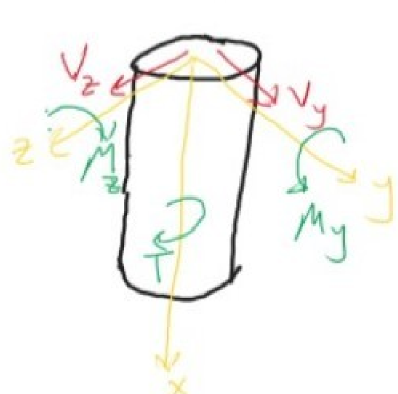


Determine all forces and moment on the cross section of a–a.



Q9-1

a-a section



$V_y = 200$ lb

$V_z = 300$ lb

$M_x = T = 300 . 1,5$

$= 450$ lb.ft

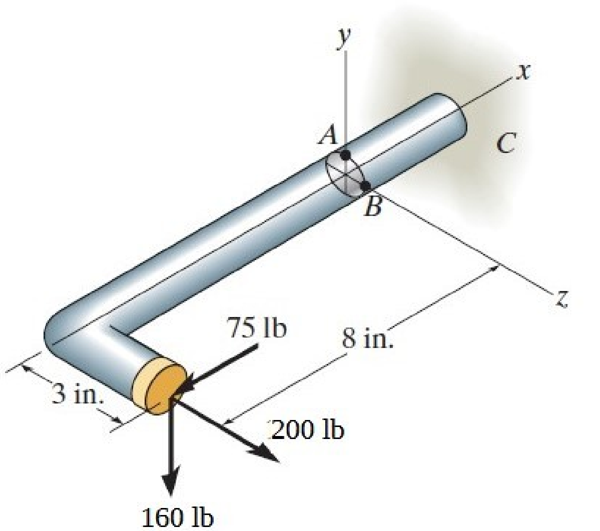
$M_y = 300 . 5$

$= 1500$ lb.ft

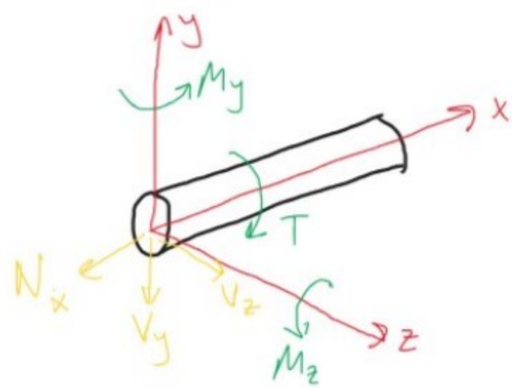
$M_z = 200 . 5$

$= 1000$ lb.ft

The 1-in.-diameter rod is subjected to the loads shown. Determine all forces and moment on the cross section of A-B plane.



Q 9-2 A-B Section



$N_x = 75$ lb

$V_y = 160$ lb

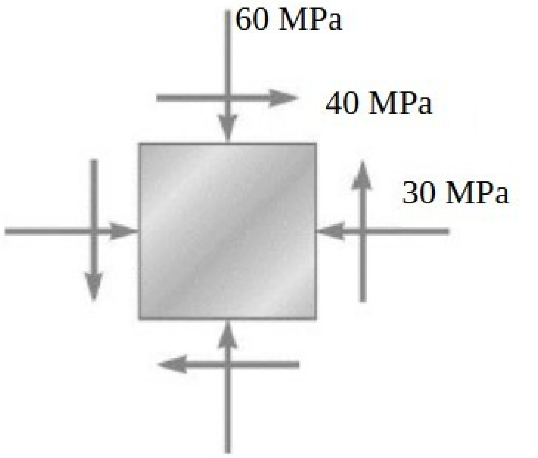
$V_z = 200$ lb

$M_x = T = 160 \cdot 3 = 480$ lb.ft

$M_y = 200 \cdot 8 - 75 \cdot 3$
$= 1375$ lb.ft

$M_z = 160 \cdot 8$
$= 1280$ lb.ft

For the given state of stress, draw the Mohr Circle and determine the maximum shearing stress.



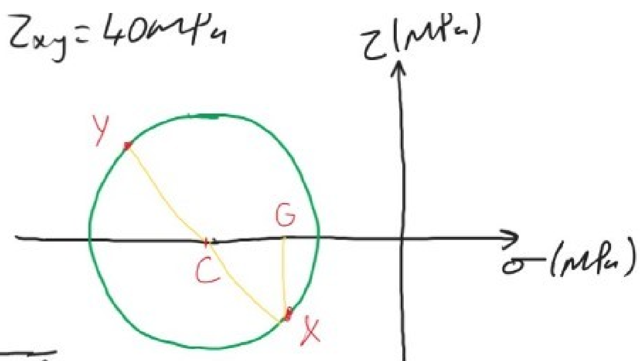
$\sigma_x = -30$ MPa, $\sigma_y = -60$ MPa, $\tau_{xy} = 40$ MPa

$\sigma_{ave} = \frac{\sigma_x + \sigma_y}{2} = -45$ MPa

X: $(\sigma_x, -\tau_{xy}) = (-30, -40)$

Y: $(\sigma_y, \tau_{xy}) = (-60, 40)$

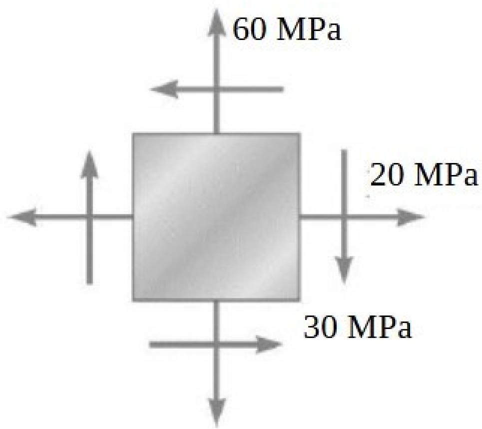
C: $(\sigma_{ave}, 0) = (-45, 0)$



$R = \sqrt{|CG|^2 + |GX|^2} = \sqrt{|-45+30|^2 + |40|^2}$

$= 42,72$ MPa $\Rightarrow \tau_{max} = R = 42,72$ MPa

For the given state of stress, draw the Mohr Circle and determine the maximum shearing stress.



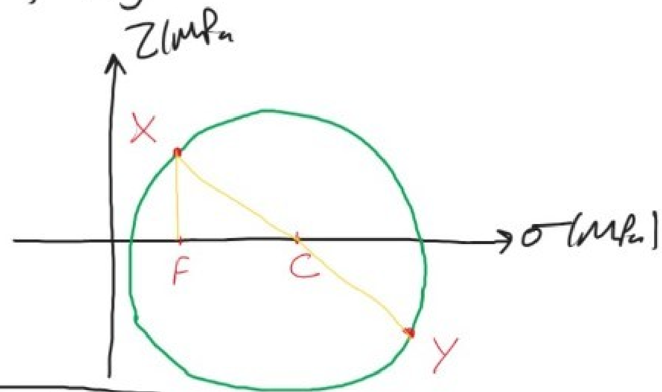
$\sigma_x = 20\,MPa$, $\sigma_y = 60\,MPa$, $\tau_{xy} = -30\,MPa$

$\sigma_{ave} = \frac{\sigma_x + \sigma_y}{2} = 40\,MPa$

X: $(\sigma_x, -\tau_{xy}) = (20, 30)$

Y: $(\sigma_y, \tau_{xy}) = (60, -30)$

C: $(\sigma_{ave}, 0) = (40, 0)$



$$R = \sqrt{|CF|^2 + |FX|^2} = \sqrt{|40-20|^2 + |30-0|^2}$$

$$= 36{,}05\,MPa \Rightarrow R = \tau_{max} = 36{,}05\,MPa$$