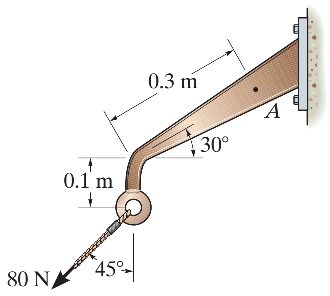
***1–4.** A force of 80 N is supported by the bracket as shown. Determine the resultant internal loadings acting on the section through point A.



Equations of Equilibrium:

$\overset{+}{\nearrow}\Sigma F_{x'} = 0;\quad N_A - 80\cos 15° = 0$

$N_A = 77.3\text{ N}$ **Ans.**

$\nwarrow^{+}\ \Sigma F_{y'} = 0;\quad V_A - 80\sin 15° = 0$

$V_A = 20.7\text{ N}$ **Ans.**

$\circlearrowleft +\quad \Sigma M_A = 0;\quad M_A + 80\cos 45°(0.3\cos 30°)$

$-80\sin 45°(0.1 + 0.3\sin 30°) = 0$

$M_A = -0.555\text{ N}\cdot\text{m}$ **Ans.**

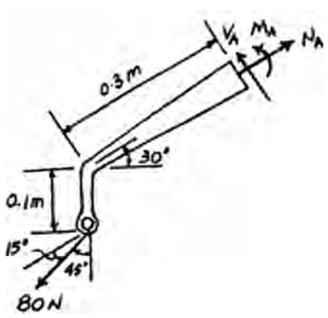
or

$\circlearrowleft +\quad \Sigma M_A = 0;\quad M_A + 80\sin 15°(0.3 + 0.1\sin 30°)$

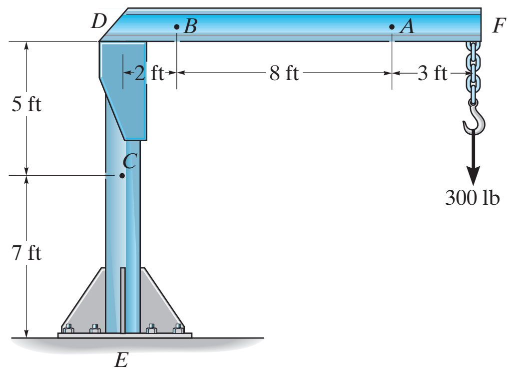
$-80\cos 15°(0.1\cos 30°) = 0$

$M_A = -0.555\text{ N}\cdot\text{m}$ **Ans.**

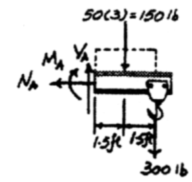
Negative sign indicates that M_A acts in the opposite direction to that shown on FBD.



1–10. The boom *DF* of the jib crane and the column *DE* have a uniform weight of 50 lb/ft. If the hoist and load weigh 300 lb, determine the resultant internal loadings in the crane on cross sections through points *A*, *B*, and *C*.



Equations of Equilibrium: For point *A*



$\overset{+}{\leftarrow} \Sigma F_x = 0; \qquad N_A = 0$ **Ans.**

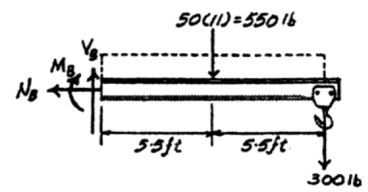
$+\uparrow \Sigma F_y = 0; \qquad V_A - 150 - 300 = 0$

$V_A = 450 \text{ lb}$ **Ans.**

$\circlearrowleft +\Sigma M_A = 0; \qquad -M_A - 150(1.5) - 300(3) = 0$

$M_A = -1125 \text{ lb}\cdot\text{ft} = -1.125 \text{ kip}\cdot\text{ft}$ **Ans.**

Negative sign indicates that M_A acts in the opposite direction to that shown on FBD.



Equations of Equilibrium: For point *B*

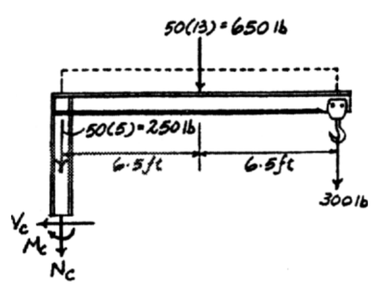
$\overset{+}{\leftarrow} \Sigma F_x = 0; \qquad N_B = 0$ **Ans.**

$+\uparrow \Sigma F_y = 0; \qquad V_B - 550 - 300 = 0$

$V_B = 850 \text{ lb}$ **Ans.**

$\circlearrowleft +\Sigma M_B = 0; \qquad -M_B - 550(5.5) - 300(11) = 0$

$M_B = -6325 \text{ lb}\cdot\text{ft} = -6.325 \text{ kip}\cdot\text{ft}$ **Ans.**



Negative sign indicates that M_B acts in the opposite direction to that shown on FBD.

Equations of Equilibrium: For point *C*

$\overset{+}{\leftarrow} \Sigma F_x = 0; \qquad V_C = 0$ **Ans.**

$+\uparrow \Sigma F_y = 0; \qquad -N_C - 250 - 650 - 300 = 0$

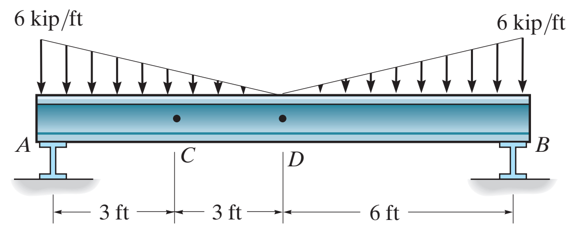
$N_C = -1200 \text{ lb} = -1.20 \text{ kip}$ **Ans.**

$\circlearrowleft +\Sigma M_C = 0; \qquad -M_C - 650(6.5) - 300(13) = 0$

$M_C = -8125 \text{ lb}\cdot\text{ft} = -8.125 \text{ kip}\cdot\text{ft}$ **Ans.**

Negative signs indicate that N_C and M_C act in the opposite direction to that shown on FBD.

***1–20.** Determine the resultant internal loadings acting on the cross section through point D. Assume the reactions at the supports A and B are vertical.



Referring to the FBD of the entire beam, Fig. *a*,

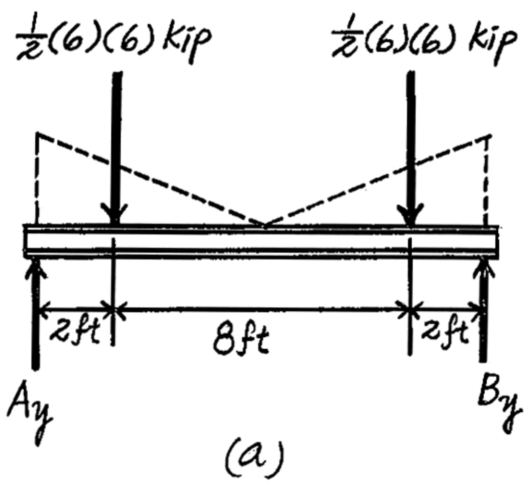
$\circlearrowleft + \Sigma M_B = 0; \quad \frac{1}{2}(6)(6)(2) + \frac{1}{2}(6)(6)(10) - A_y(12) = 0 \quad A_y = 18.0 \text{ kip}$

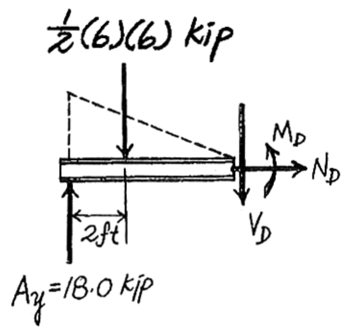
Referring to the FBD of this segment, Fig. *b*,

$\xrightarrow{+} \Sigma F_x = 0; \quad N_D = 0$ **Ans.**

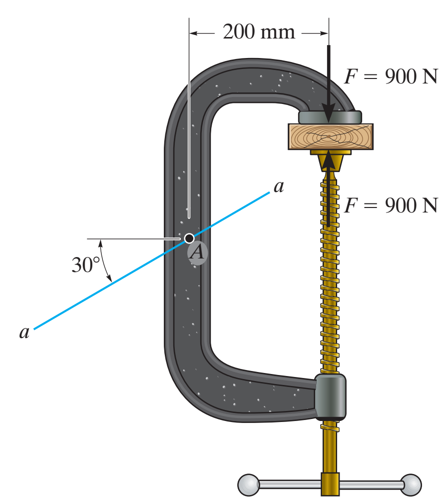
$+\uparrow \Sigma F_y = 0; \quad 18.0 - \frac{1}{2}(6)(6) - V_D = 0 \quad V_D = 0$ **Ans.**

$\circlearrowleft + \Sigma M_A = 0; \quad M_D - 18.0\,(2) = 0 \quad M_D = 36.0 \text{ kip} \cdot \text{ft}$ **Ans.**





•1–21. The forged steel clamp exerts a force of $F = 900$ N on the wooden block. Determine the resultant internal loadings acting on section a–a passing through point A.

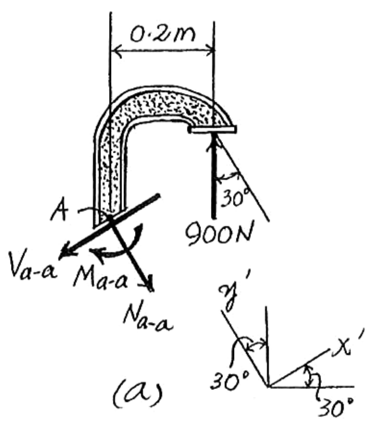


Internal Loadings: Referring to the free-body diagram of the section of the clamp shown in Fig. *a*,

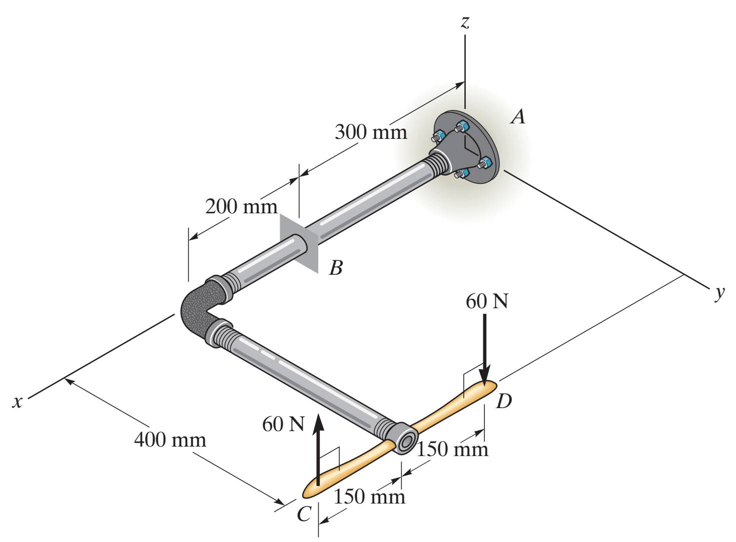
$\Sigma F_{y'} = 0; \quad 900 \cos 30° - N_{a-a} = 0 \quad N_{a-a} = 779 \text{ N}$ **Ans.**

$\Sigma F_{x'} = 0; \quad V_{a-a} - 900 \sin 30° = 0 \quad V_{a-a} = 450 \text{ N}$ **Ans.**

$\circlearrowleft + \Sigma M_A = 0; \quad 900(0.2) - M_{a-a} = 0 \quad M_{a-a} = 180 \text{ N} \cdot \text{m}$ **Ans.**



1–27. The pipe has a mass of 12 kg/m. If it is fixed to the wall at A, determine the resultant internal loadings acting on the cross section at B. Neglect the weight of the wrench CD.



$\Sigma F_x = 0;\qquad (N_B)_x = 0$ **Ans.**

$\Sigma F_y = 0;\qquad (V_B)_y = 0$ **Ans.**

$\Sigma F_z = 0;\qquad (V_B)_z - 60 + 60 - (0.2)(12)(9.81) - (0.4)(12)(9.81) = 0$

$(V_B)_z = 70.6 \text{ N}$ **Ans.**

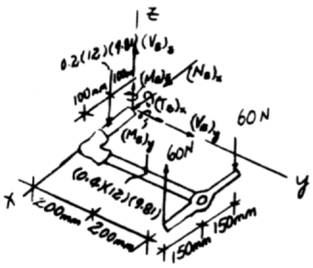
$\Sigma M_x = 0;\qquad (T_B)_x + 60(0.4) - 60(0.4) - (0.4)(12)(9.81)(0.2) = 0$

$(T_B)_x = 9.42 \text{ N} \cdot \text{m}$ **Ans.**

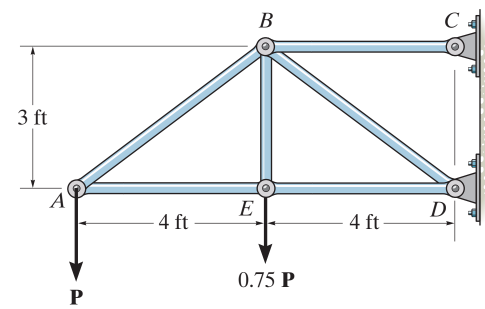
$\Sigma M_y = 0;\qquad (M_B)_y + (0.2)(12)(9.81)(0.1) + (0.4)(12)(9.81)(0.2) - 60(0.3) = 0$

$(M_B)_y = 6.23 \text{ N} \cdot \text{m}$ **Ans.**

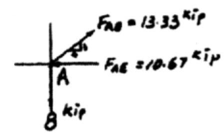
$\Sigma M_z = 0;\qquad (M_B)_z = 0$ **Ans.**



1–35. The bars of the truss each have a cross-sectional area of 1.25 in^2. Determine the average normal stress in each member due to the loading $P = 8$ kip. State whether the stress is tensile or compressive.



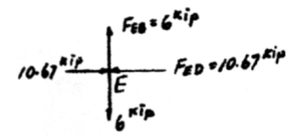
Joint A:



$$\sigma_{AB} = \frac{F_{AB}}{A_{AB}} = \frac{13.33}{1.25} = 10.7 \text{ ksi} \qquad \text{(T)}$$ **Ans.**

$$\sigma_{AE} = \frac{F_{AE}}{A_{AE}} = \frac{10.67}{1.25} = 8.53 \text{ ksi} \qquad \text{(C)}$$ **Ans.**

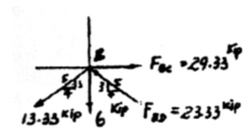
Joint E:



$$\sigma_{ED} = \frac{F_{ED}}{A_{ED}} = \frac{10.67}{1.25} = 8.53 \text{ ksi} \qquad \text{(C)}$$ **Ans.**

$$\sigma_{EB} = \frac{F_{EB}}{A_{EB}} = \frac{6.0}{1.25} = 4.80 \text{ ksi} \qquad \text{(T)}$$ **Ans.**

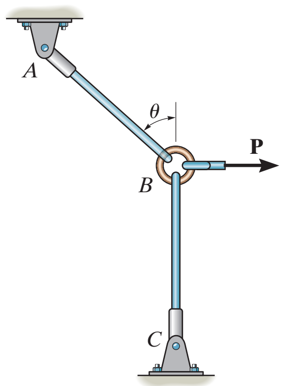
Joint B:



$$\sigma_{BC} = \frac{F_{BC}}{A_{BC}} = \frac{29.33}{1.25} = 23.5 \text{ ksi} \qquad \text{(T)}$$ **Ans.**

$$\sigma_{BD} = \frac{F_{BD}}{A_{BD}} = \frac{23.33}{1.25} = 18.7 \text{ ksi} \qquad \text{(C)}$$ **Ans.**

1–55. Rods AB and BC each have a diameter of 5 mm. If the load of $P = 2$ kN is applied to the ring, determine the average normal stress in each rod if $\theta = 60°$.



Consider the equilibrium of joint B, Fig. a,

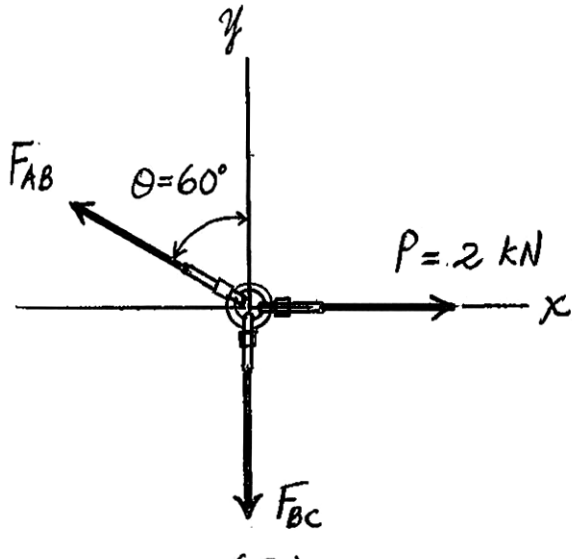
$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad 2 - F_{AB} \sin 60° = 0 \qquad F_{AB} = 2.309 \text{ kN}$

$+\uparrow \Sigma F_y = 0; \qquad 2.309 \cos 60° - F_{BC} = 0 \qquad F_{BC} = 1.155 \text{ kN}$

The cross-sectional area of wires AB and BC are $A_{AB} = A_{BC} = \frac{\pi}{4}(0.005^2)$ $= 6.25(10^{-6})\pi \text{ m}^2$. Thus,

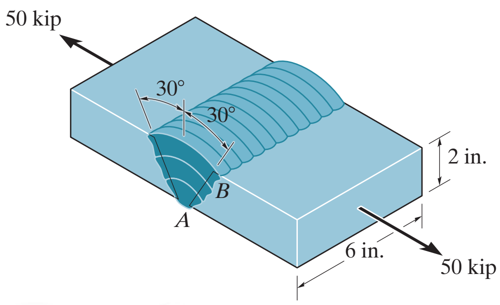
$$\left(\sigma_{\text{avg}}\right)_{AB} = \frac{F_{AB}}{A_{AB}} = \frac{2.309(10^3)}{6.25(10^{-6})\pi} = 117.62(10^6) \text{ Pa} = 118 \text{ MPa} \qquad \textbf{Ans.}$$

$$\left(\sigma_{\text{avg}}\right)_{BC} = \frac{F_{BC}}{A_{BC}} = \frac{1.155(10^3)}{6.25(10^{-6})\pi} = 58.81(10^6) \text{ Pa} = 58.8 \text{ MPa} \qquad \textbf{Ans.}$$



(a)

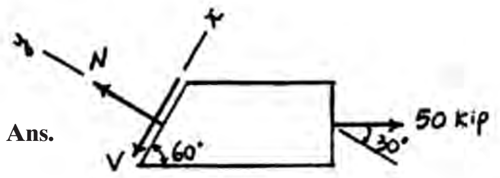
1–59. The open square butt joint is used to transmit a force of 50 kip from one plate to the other. Determine the average normal and average shear stress components that this loading creates on the face of the weld, section AB.



Equations of Equilibrium:

$\nwarrow^{+}\Sigma F_y = 0;\quad N - 50\cos 30° = 0\quad N = 43.30\text{ kip}$

$^{+}\nearrow\Sigma F_x = 0;\quad -V + 50\sin 30° = 0\quad V = 25.0\text{ kip}$



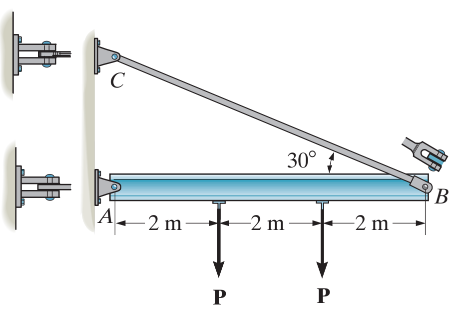
Average Normal and Shear Stress:

$$A' = \left(\frac{2}{\sin 60°}\right)(6) = 13.86\text{ in}^2$$

$$\sigma = \frac{N}{A'} = \frac{43.30}{13.86} = 3.125\text{ ksi}\qquad\textbf{Ans.}$$

$$\tau_{\text{avg}} = \frac{V}{A'} = \frac{25.0}{13.86} = 1.80\text{ ksi}\qquad\textbf{Ans.}$$

***1–60.** If $P = 20$ kN, determine the average shear stress developed in the pins at A and C. The pins are subjected to double shear as shown, and each has a diameter of 18 mm.



Referring to the FBD of member AB, Fig. a

$\circlearrowleft +\Sigma M_A = 0;\quad F_{BC}\sin 30°(6) - 20(2) - 20(4) = 0\quad F_{BC} = 40\text{ kN}$

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad A_x - 40\cos 30° = 0\quad A_x = 34.64\text{ kN}$

$+\uparrow\Sigma F_y = 0;\quad A_y - 20 - 20 + 40\sin 30°\quad A_y = 20\text{ kN}$

Thus, the force acting on pin A is

$$F_A = \sqrt{A_x^2 + A_y^2} = \sqrt{34.64^2 + 20^2} = 40\text{ kN}$$

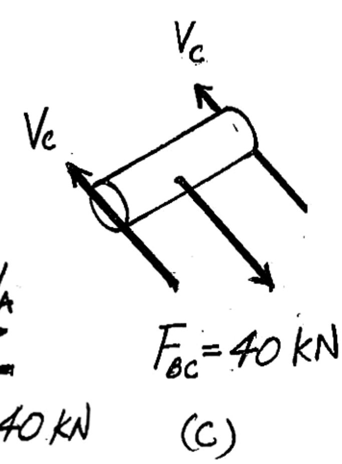
Pins A and C are subjected to double shear. Referring to their FBDs in Figs. b and c,

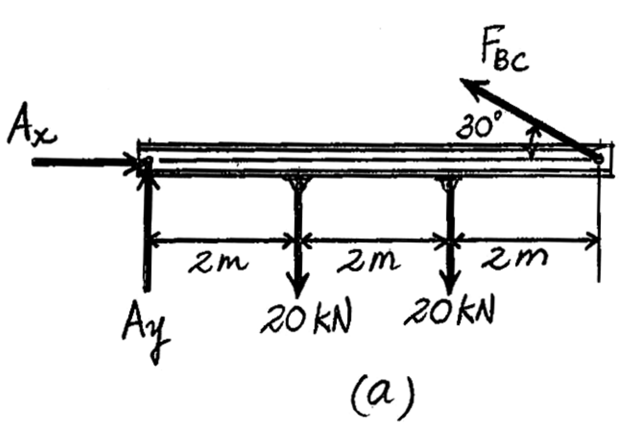
$$V_A = \frac{F_A}{2} = \frac{40}{2} = 20\text{ kN}\qquad V_C = \frac{F_{BC}}{2} = \frac{40}{2} = 20\text{ kN}$$

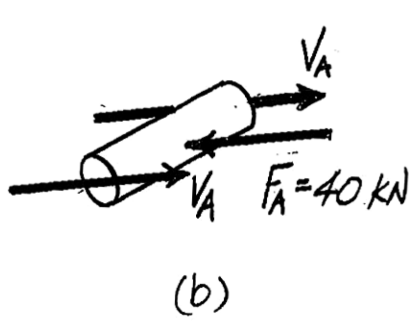
The cross-sectional area of Pins A and C are $A_A = A_C = \frac{\pi}{4}(0.018^2) = 81(10^{-6})\pi\text{ m}^2$. Thus

$$\tau_A = \frac{V_A}{A_A} = \frac{20(10^3)}{81(10^{-6})\pi} = 78.59(10^6)\text{ Pa} = 78.6\text{ MPa}\qquad\textbf{Ans.}$$

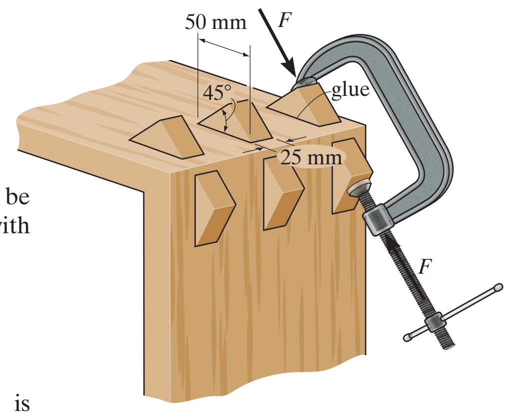
$$\tau_C = \frac{V_C}{A_C} = \frac{20(10^3)}{81(10^{-6})\pi} = 78.59(10^6)\text{ Pa} = 78.6\text{ MPa}\qquad\textbf{Ans.}$$







***1–64.** The triangular blocks are glued along each side of the joint. A C-clamp placed between two of the blocks is used to draw the joint tight. If the glue can withstand a maximum average shear stress of 800 kPa, determine the maximum allowable clamping force **F**.



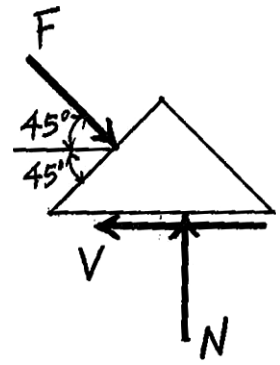
Internal Loadings: The shear force developed on the glued shear plane can be obtained by writing the force equation of equilibrium along the *x* axis with reference to the free-body diagram of the triangular block, Fig. *a*.

$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad F \cos 45° - V = 0 \quad V = \frac{\sqrt{2}}{2} F$

Average Normal and Shear Stress: The area of the glued shear plane is $A = 0.05(0.025) = 1.25(10^{-3})\text{m}^2$. We obtain

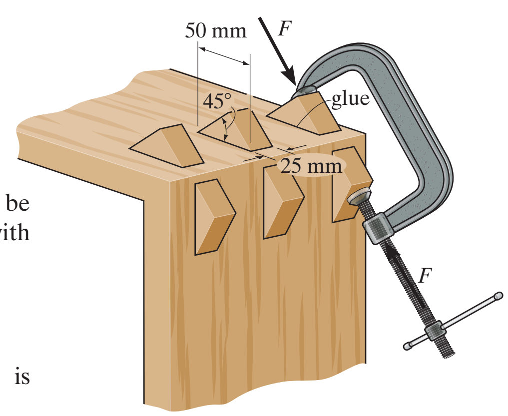
$$\tau_{avg} = \frac{V}{A}; \qquad 800(10^3) = \frac{\frac{\sqrt{2}}{2}F}{1.25(10^{-3})}$$

$$F = 1414 \text{ N} = 1.41 \text{ kN}$$ **Ans.**



(a)

•1–65. The triangular blocks are glued along each side of the joint. A C-clamp placed between two of the blocks is used to draw the joint tight. If the clamping force is $F = 900$ N, determine the average shear stress developed in the glued shear plane.

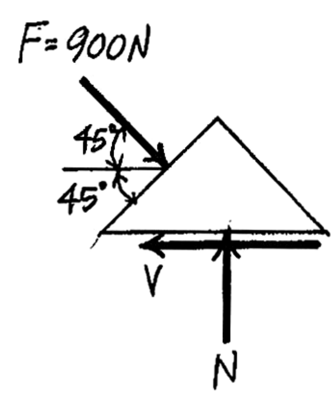


Internal Loadings: The shear force developed on the glued shear plane can be obtained by writing the force equation of equilibrium along the *x* axis with reference to the free-body diagram of the triangular block, Fig. *a*.

$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad 900 \cos 45° - V = 0 \quad V = 636.40 \text{ N}$

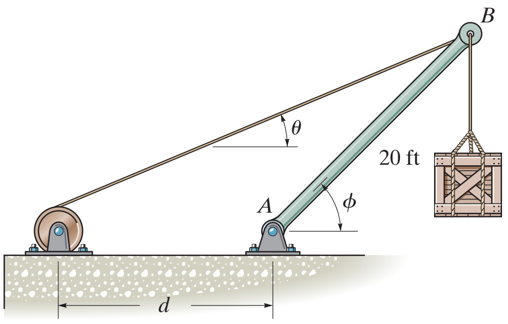
Average Normal and Shear Stress: The area of the glued shear plane is $A = 0.05(0.025) = 1.25(10^{-3})\text{m}^2$. We obtain

$$\tau_{avg} = \frac{V}{A} = \frac{636.40}{1.25(10^{-3})} = 509 \text{ kPa}$$ **Ans.**



(a)

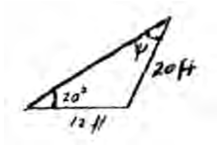
1–86. The boom is supported by the winch cable that has an allowable normal stress of $\sigma_{allow} = 24$ ksi. If it is required that it be able to slowly lift 5000 lb, from $\theta = 20°$ to $\theta = 50°$, determine the smallest diameter of the cable to the nearest $\frac{1}{16}$ in. The boom AB has a length of 20 ft. Neglect the size of the winch. Set $d = 12$ ft.



Maximum tension in cable occurs when $\theta = 20°$.

$$\frac{\sin 20°}{20} = \frac{\sin \psi}{12}$$

$$\psi = 11.842°$$

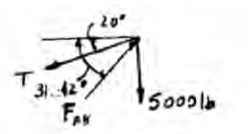


$$\xrightarrow{+} \Sigma F_x = 0; \qquad -T\cos 20° + F_{AB}\cos 31.842° = 0$$

$$+\uparrow \Sigma F_y = 0; \qquad F_{AB}\sin 31.842° - T\sin 20° - 5000 = 0$$

$$T = 20\,698.3 \text{ lb}$$

$$F_{AB} = 22\,896 \text{ lb}$$

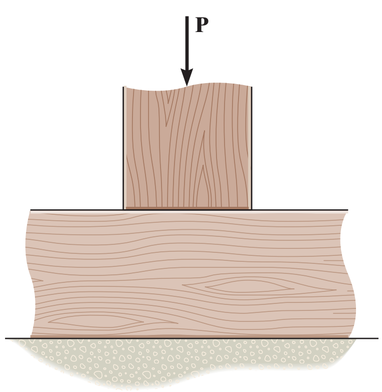


$$\sigma = \frac{P}{A}; \qquad 24(10^3) = \frac{20\,698.3}{\frac{\pi}{4}(d)^2}$$

$$d = 1.048 \text{ in.}$$

Use $\quad d = 1\frac{1}{16}$ in. **Ans.**

1–87. The 60 mm × 60 mm oak post is supported on the pine block. If the allowable bearing stresses for these materials are $\sigma_{oak} = 43$ MPa and $\sigma_{pine} = 25$ MPa, determine the greatest load P that can be supported. If a rigid bearing plate is used between these materials, determine its required area so that the maximum load P can be supported. What is this load?



For failure of pine block:

$$\sigma = \frac{P}{A}; \qquad 25(10^6) = \frac{P}{(0.06)(0.06)}$$

$$P = 90 \text{ kN}$$ **Ans.**

For failure of oak post:

$$\sigma = \frac{P}{A}; \qquad 43(10^6) = \frac{P}{(0.06)(0.06)}$$

$$P = 154.8 \text{ kN}$$

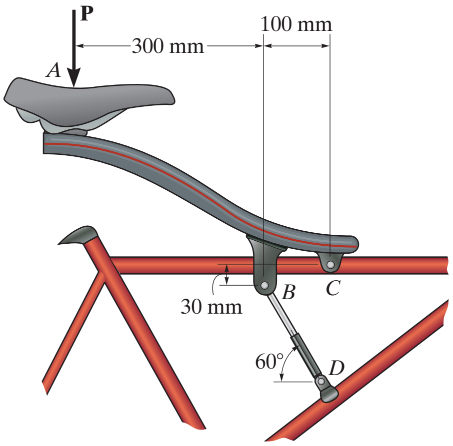
Area of plate based on strength of pine block:

$$\sigma = \frac{P}{A}; \qquad 25(10^6) = \frac{154.8(10)^3}{A}$$

$$A = 6.19(10^{-3})\text{m}^2$$ **Ans.**

$$P_{max} = 155 \text{ kN}$$ **Ans.**

1–91. The soft-ride suspension system of the mountain bike is pinned at C and supported by the shock absorber BD. If it is designed to support a load of $P = 1500$ N, determine the factor of safety of pins B and C against failure if they are made of a material having a shear failure stress of $\tau_{\text{fail}} = 150$ MPa. Pin B has a diameter of 7.5 mm, and pin C has a diameter of 6.5 mm. Both pins are subjected to double shear.



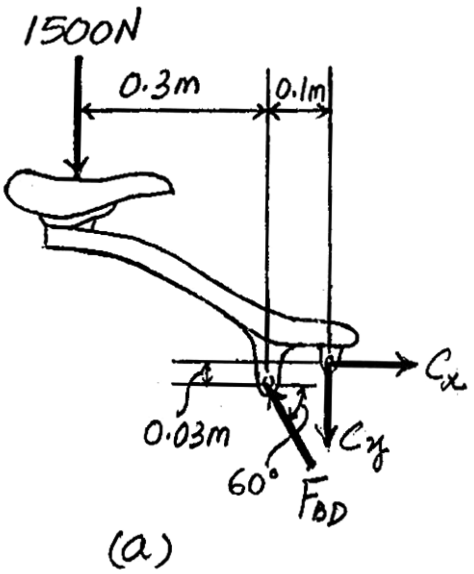
Internal Loadings: The forces acting on pins B and C can be determined by considerning the equilibrium of the free-body diagram of the soft-ride suspension system shown in Fig. *a*.

$+\Sigma M_C = 0;\quad 1500(0.4) - F_{BD}\sin 60°(0.1) - F_{BD}\cos 60°(0.03) = 0$

$F_{BD} = 5905.36$ N

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad C_x - 5905.36\cos 60° = 0 \qquad C_x = 2952.68$ N

$+\uparrow\Sigma F_y = 0;\quad 5905.36\sin 60° - 1500 - C_y = 0 \quad C_y = 3614.20$ N



Thus,

$F_B = F_{BD} = 5905.36 \text{ N} \qquad F_C = \sqrt{C_x^2 + C_y^2} = \sqrt{2952.68^2 + 3614.20^2}$

$= 4666.98$ N

Since both pins are in double shear,

$V_B = \dfrac{F_B}{2} = \dfrac{5905.36}{2} = 2952.68\text{N} \qquad V_C = \dfrac{F_C}{2} = \dfrac{4666.98}{2} = 2333.49 \text{ N}$

Allowable Shear Stress: The areas of the shear plane for pins B and C are $A_B = \frac{\pi}{4}(0.0075^2) = 44.179(10^{-6})\text{m}^2$ and $A_C = \frac{\pi}{4}(0.0065^2) = 33.183(10^{-6})\text{m}^2$. We obtain

$$(\tau_{\text{avg}})_B = \frac{V_B}{A_B} = \frac{2952.68}{44.179(10^{-6})} = 66.84 \text{ MPa}$$

$$(\tau_{\text{avg}})_C = \frac{V_C}{A_C} = \frac{2333.49}{33.183(10^{-6})} = 70.32 \text{ MPa}$$

Using these results,

$$(\text{F.S.})_B = \frac{\tau_{\text{fail}}}{(\tau_{\text{avg}})_B} = \frac{150}{66.84} = 2.24 \qquad \textbf{Ans.}$$

$$(\text{F.S.})_C = \frac{\tau_{\text{fail}}}{(\tau_{\text{avg}})_C} = \frac{150}{70.32} = 2.13 \qquad \textbf{Ans.}$$