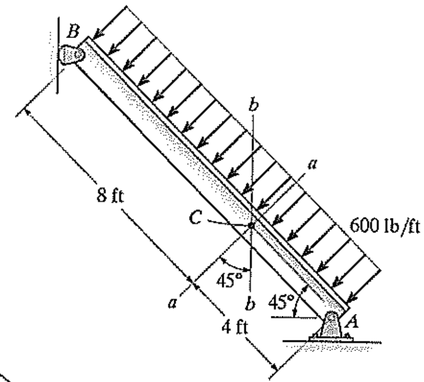
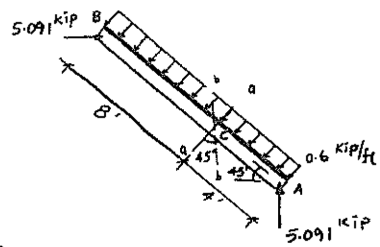
*1–12. Determine the resultant internal loadings acting on (a) section a–a and (b) section b–b. Each section is located through the centroid, point C.





(a)

$\nwarrow + \Sigma F_x = 0;\quad N_C + 5.091 \sin 45° = 0$

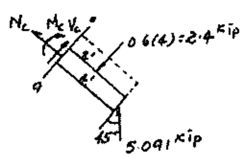
$N_C = -3.60 \text{ kip}$ **Ans**

$\nearrow + \Sigma F_y = 0;\quad V_C + 5.091 \cos 45° - 2.4 = 0$

$V_C = -1.20 \text{ kip}$ **Ans**

$\circlearrowleft + \Sigma M_C = 0;\quad -M_C - 2.4(2) + 5.091 \cos 45°(4) = 0$

$M_C = 9.60 \text{ kip} \cdot \text{ft}$ **Ans**



(b)

$\overset{+}{\leftarrow} \Sigma F_x = 0;\quad N_C + 2.4 \cos 45° = 0$

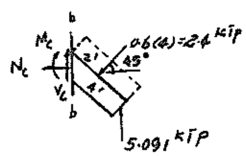
$N_C = -1.70 \text{ kip}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad V_C + 5.091 - 2.4 \sin 45° = 0$

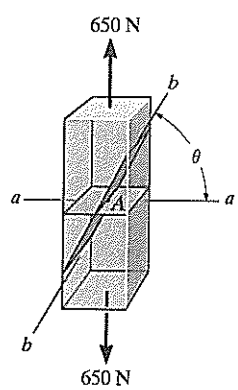
$V_C = -3.39 \text{ kip}$ **Ans**

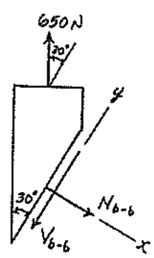
$\circlearrowleft + \Sigma M_C = 0;\quad -M_C - 2.4(2) + 5.091 \cos 45°(4) = 0$

$M_C = 9.60 \text{ kip} \cdot \text{ft}$ **Ans**



1–13. Determine the resultant internal normal and shear forces in the member at (a) section a–a and (b) section b–b, each of which passes through point A. Take $\theta = 60°$. The 650-N load is applied along the centroidal axis of the member.





Equations of Equilibrium : For section a–a

$+\uparrow \Sigma F_y = 0;\quad 650 - N_{a-a} = 0$

$N_{a-a} = 650 \text{ N}$ **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad V_{a-a} = 0$ **Ans**

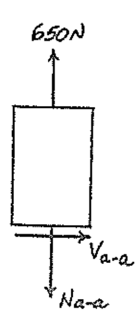
Equations of Equilibrium : For section b–b

$\nearrow + \Sigma F_y = 0;\quad 650 \cos 30° - V_{b-b} = 0$

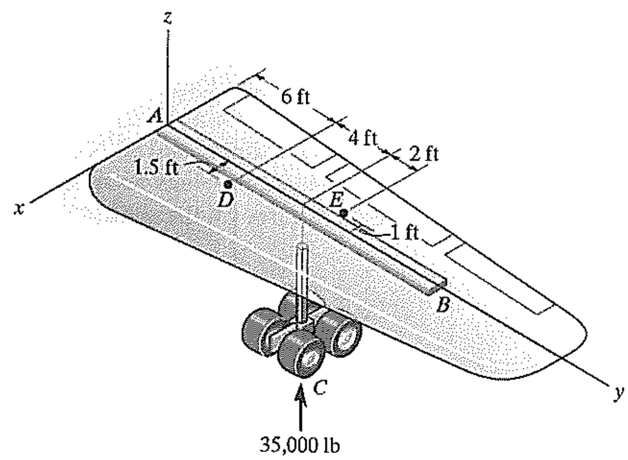
$V_{b-b} = 563 \text{ N}$ **Ans**

$\searrow + \Sigma F_x = 0;\quad N_{b-b} - 650 \sin 30° = 0$

$N_{b-b} = 325 \text{ N}$ **Ans**



***1–24.** The main beam AB supports the load on the wing of the airplane. The loads consist of the wheel reaction of 35,000 lb at C, the 1200-lb weight of fuel in the tank of the wing, having a center of gravity at D, and the 400-lb weight of the wing, having a center of gravity at E. If it is fixed to the fuselage at A, determine the resultant internal loadings on the beam at this point. Assume that the wing does not transfer any of the loads to the fuselage, except through the beam.



$\Sigma F_x = 0;\quad (V_A)_x = 0$ **Ans**

$\Sigma F_y = 0;\quad (N_A)_y = 0$ **Ans**

$\Sigma F_z = 0;\quad (V_A)_z - 1200 - 400 + 35000 = 0$

$(V_A)_z = -33.4\ \text{kip}$ **Ans**

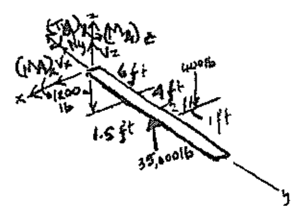
$\Sigma M_x = 0;\quad (M_A)_x - 1200(6) + 35000(10) - 400(12) = 0$

$(M_A)_x = 338\ \text{kip}\cdot\text{ft}$ **Ans**

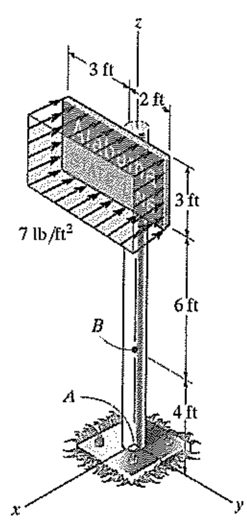
$\Sigma M_y = 0;\quad (T_A)_y + 1200(1.5) - 400(1) = 0$

$(T_A)_y = -1.40\ \text{kip}\cdot\text{ft}$ **Ans**

$\Sigma M_z = 0;\quad (M_A)_z = 0$ **Ans**



1–25. Determine the resultant internal loadings acting on the cross section through point B of the signpost. The post is fixed to the ground and a uniform pressure of 7 lb/ft^2 acts perpendicular to the face of the sign.



$\Sigma F_x = 0;\quad (V_B)_x - 105 = 0;\quad (V_B)_x = 105\ \text{lb}$ **Ans**

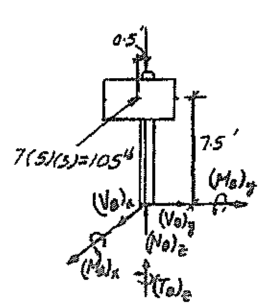
$\Sigma F_y = 0;\quad (V_B)_y = 0$ **Ans**

$\Sigma F_z = 0;\quad (N_B)_z = 0$ **Ans**

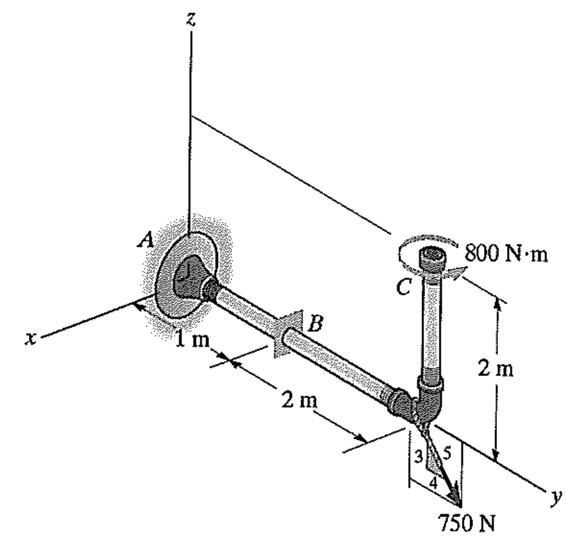
$\Sigma M_x = 0;\quad (M_B)_x = 0$ **Ans**

$\Sigma M_y = 0;\quad (M_B)_y - 105(7.5) = 0;\quad (M_B)_y = 788\ \text{lb}\cdot\text{ft}$ **Ans**

$\Sigma M_z = 0;\quad (T_B)_z - 105(0.5) = 0;\quad (T_B)_z = 52.5\ \text{lb}\cdot\text{ft}$ **Ans**



1–30. 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 through B.



Equations of Equilibrium : For point B

$\Sigma F_x = 0;$ $\quad (V_B)_x = 0$ **Ans**

$\Sigma F_y = 0;$ $\quad (N_B)_y + \frac{4}{5}(750) = 0$

$(N_B)_y = -600\text{ N}$ **Ans**

$\Sigma F_z = 0;$ $\quad (V_B)_z - 235.44 - 235.44 - \frac{3}{5}(750) = 0$

$(V_B)_z = 921\text{ N}$ **Ans**

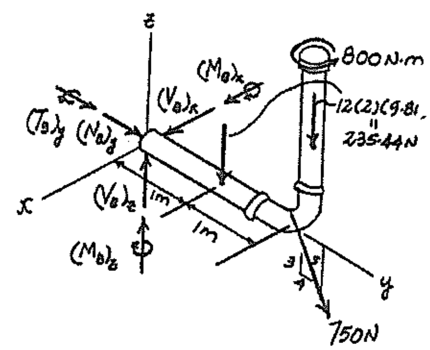
$\Sigma M_x = 0;$ $\quad (M_B)_x - 235.44(1) - 235.44(2) - \frac{3}{5}(750)(2) = 0$

$(M_B)_x = 1606\text{ N}\cdot\text{m}$ **Ans**

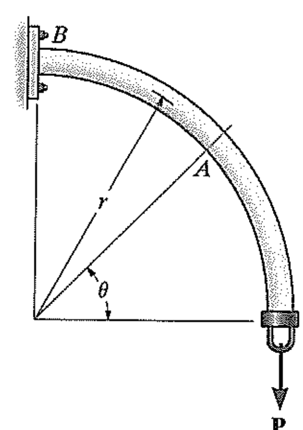
$\Sigma M_y = 0;$ $\quad (T_B)_y = 0$ **Ans**

$\Sigma M_z = 0;$ $\quad (M_B)_z + 800 = 0$

$(M_B)_z = -800\text{ N}\cdot\text{m}$ **Ans**



1–31. The curved rod has a radius r and is fixed to the wall at B. Determine the resultant internal loadings acting on the cross section through A which is located at an angle θ from the horizontal.



Equations of Equilibrium : For point A

$\searrow + \Sigma F_x = 0;$ $\quad P\cos\theta - N_A = 0$

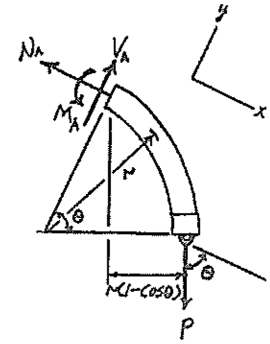
$N_A = P\cos\theta$ **Ans**

$\nearrow + \Sigma F_y = 0;$ $\quad V_A - P\sin\theta = 0$

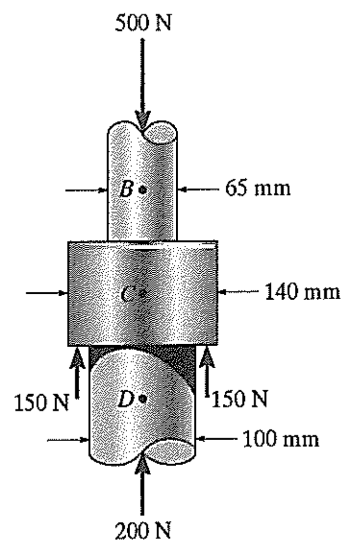
$V_A = P\sin\theta$ **Ans**

$\circlearrowleft + \Sigma M_A = 0;$ $\quad M_A - P[r(1-\cos\theta)] = 0$

$M_A = Pr(1-\cos\theta)$ **Ans**



1–37. The thrust bearing is subjected to the loads shown. Determine the average normal stress developed on cross sections through points B, C, and D. Sketch the results on a differential volume element located at each section.

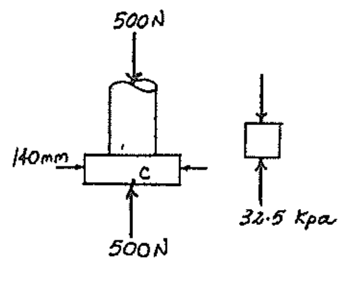


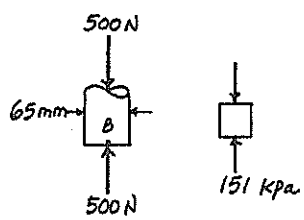
Average Normal Stress :

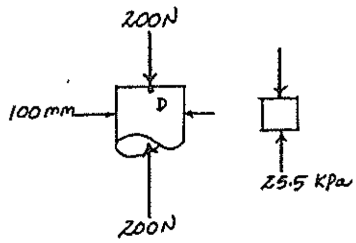
$$\sigma_B = \frac{500}{\frac{\pi}{4}(\frac{65}{1000})^2} = 151 \text{ kPa} \qquad \text{Ans}$$

$$\sigma_C = \frac{500}{\frac{\pi}{4}(\frac{140}{1000})^2} = 32.5 \text{ kPa} \qquad \text{Ans}$$

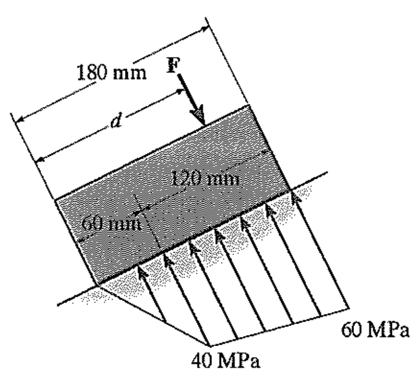
$$\sigma_D = \frac{200}{\frac{\pi}{4}(\frac{100}{1000})^2} = 25.5 \text{ kPa} \qquad \text{Ans}$$







1–38. The small block has a thickness of 5 mm. If the stress distribution at the support developed by the load varies as shown, determine the force **F** applied to the block, and the distance d to where it is applied.



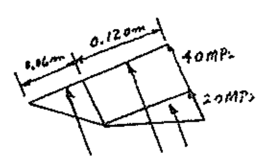
$F = \int \sigma\, dA$ = volume under stress diagram

$$F = \frac{1}{2}(0.06)(40)(10^6)(0.005) + (0.120)(40)(10^6)(0.005) + \frac{1}{2}(0.120)(20)(10^6)(0.005)$$

$F = 36$ kN **Ans**

Require

$$F\,d = \int x(\sigma\, dA)$$



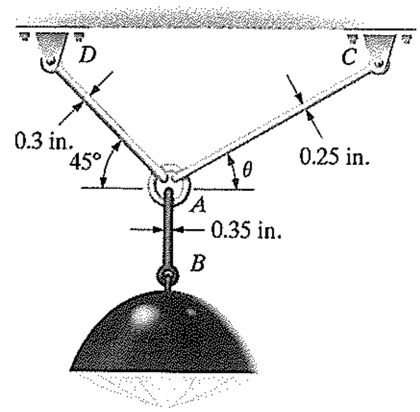
$$36.0(10^3)d = \frac{2}{3}(0.06)(\frac{1}{2})(0.06)(40)(10^6)(0.005) + (0.06 + \frac{1}{2}(0.120))(0.120)(40)(10^6)(0.005) +$$

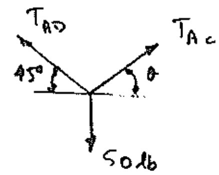
$$(0.06 + \frac{2}{3}(0.120))(\frac{1}{2})(0.120)(20)(10^6)(0.005)$$

$$36.0(10^3)d = 3960$$

$d = 0.110 = 110$ mm **Ans**

***1–44.** The 50-lb lamp is supported by three steel rods connected by a ring at A. Determine the angle of orientation θ of AC such that the average normal stress in rod AC is twice the average normal stress in rod AD. What is the magnitude of stress in each rod? The diameter of each rod is given in the figure.





$$\sigma_{AD} = \frac{T_{AD}}{\frac{\pi}{4}(0.3)^2}; \qquad T_{AD} = (0.070686)\sigma_{AD}$$

$$\sigma_{AC} = 2\sigma_{AD} = \frac{T_{AC}}{\frac{\pi}{4}(0.25)^2}; \qquad T_{AC} = (0.098175)\sigma_{AD}$$

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad -T_{AD}\cos 45^\circ + T_{AC}\cos\theta = 0 \qquad (1)$$

$$+\uparrow \Sigma F_y = 0; \qquad T_{AC}\sin\theta + T_{AD}\sin 45^\circ - 50 = 0 \qquad (2)$$

Thus

$$-(0.070686)\sigma_{AD}(\cos 45^\circ) + (0.098175)\sigma_{AD}(\cos\theta) = 0$$

$$\theta = 59.39^\circ = 59.4^\circ \qquad \textbf{Ans}$$

From Eq. (2) :

$$(0.098175)\sigma_{AD}\sin 59.39^\circ + (0.070686)\sigma_{AD}\sin 45^\circ - 50 = 0$$

$$\sigma_{AD} = 371.8 \text{ psi} = 372 \text{ psi} \qquad \textbf{Ans}$$

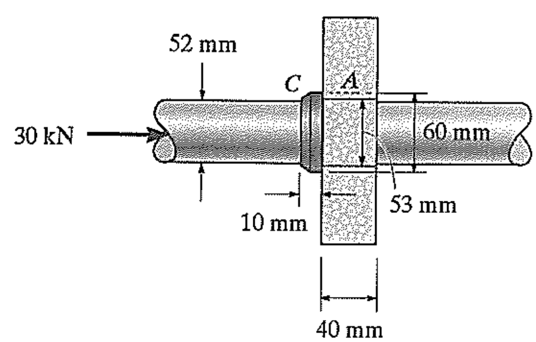
Hence,

$$\sigma_{AC} = 2(371.8) = 744 \text{ psi} \qquad \textbf{Ans}$$

And,

$$\sigma_{AB} = \frac{T_{AB}}{\frac{\pi}{4}(0.35)^2} = \frac{50}{\frac{\pi}{4}(0.35)^2} = 520 \text{ psi} \qquad \textbf{Ans}$$

1–45. The shaft is subjected to the axial force of 30 kN. If the shaft passes through the 53-mm diameter hole in the fixed support A, determine the bearing stress acting on the collar C. Also, what is the average shear stress acting along the inside surface of the collar where it is fixed connected to the 52-mm diameter shaft?



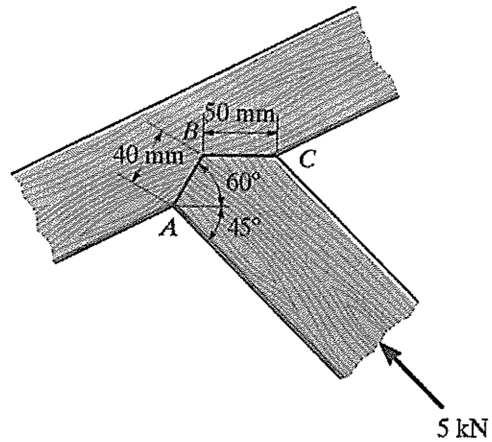
Bearing Stress :

$$\sigma_b = \frac{P}{A} = \frac{30(10^3)}{\frac{\pi}{4}(0.06^2 - 0.053^2)} = 48.3 \text{ MPa} \qquad \textbf{Ans}$$

Average Shear Stress :

$$\tau_{avg} = \frac{V}{A} = \frac{30(10^3)}{\pi(0.052)(0.01)} = 18.4 \text{ MPa} \qquad \textbf{Ans}$$

***1–52.** The joint is subjected to the axial member force of 5 kN. Determine the average normal stress acting on sections *AB* and *BC*. Assume the member is smooth and is 50-mm thick.

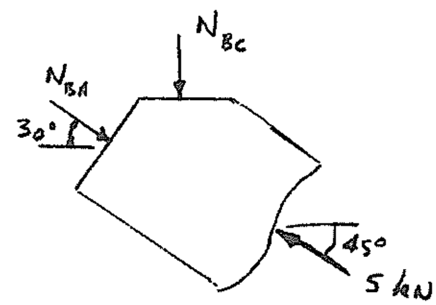


$\xrightarrow{+} \Sigma F_x = 0;\quad N_{BA}\cos 30° - 5\cos 45° = 0$

$N_{BA} = 4.082 \text{ kN}$

$+\uparrow \Sigma F_y = 0;\quad -N_{BC} - 4.082\sin 30° + 5\sin 45° = 0$

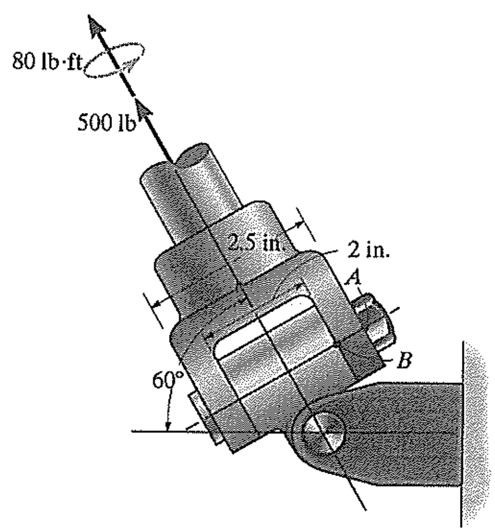
$N_{BC} = 1.494 \text{ kN}$



$$\sigma_{BA} = \frac{N_{BA}}{A_{BA}} = \frac{4.082(10^3)}{(0.04)(0.05)} = 2.04 \text{ MPa} \qquad \textbf{Ans}$$

$$\sigma_{BC} = \frac{N_{BC}}{A_{BC}} = \frac{1.494(10^3)}{(0.05)(0.05)} = 0.598 \text{ MPa} \qquad \textbf{Ans}$$

1–53. The yoke is subjected to the force and couple moment. Determine the average shear stress in the bolt acting on the cross sections through *A* and *B*. The bolt has a diameter of 0.25 in. *Hint:* The couple moment is resisted by a set of couple forces developed in the shank of the bolt.



At *A* force on bolt shank is zero, then

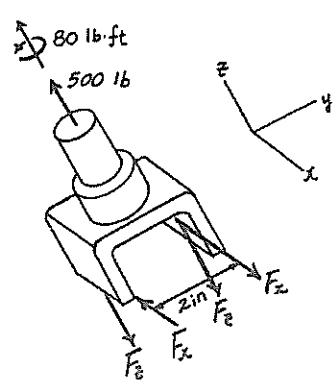
$\tau_A = 0$ **Ans**

Equations of Equilibrium : Force on bolt shank at *B*.

$\Sigma F_z = 0;\quad 500 - 2F_z = 0 \quad F_z = 250 \text{ lb}$

$\Sigma M_z = 0;\quad 80 \text{ lb}\cdot\text{ft}\left(\frac{12 \text{ in}}{\text{ft}}\right) - F_x(2 \text{ in.}) = 0$

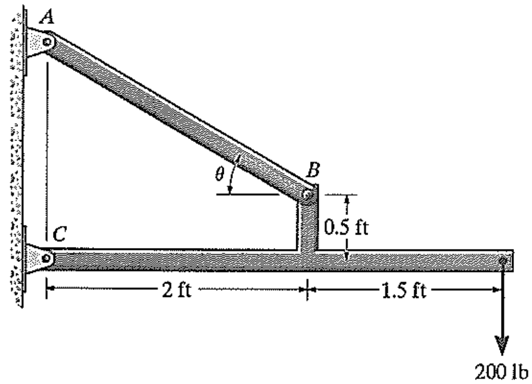
$F_x = 480 \text{ lb}$



Average Shear Stress : The bolt shank subjected to a shear force of $V_B = F_B = \sqrt{250^2 + 480^2} = 541.2$ lb.

$$(\tau_B)_{avg} = \frac{541.2}{\frac{\pi}{4}(0.25)^2} = 11.0 \text{ ksi} \qquad \textbf{Ans}$$

1–69. The frame is subjected to the load of 200 lb. Determine the average shear stress in the bolt at A as a function of the bar angle θ. Plot this function, $0 \leq \theta \leq 90°$, and indicate the values of θ for which this stress is a minimum. The bolt has a diameter of 0.25 in. and is subjected to single shear.

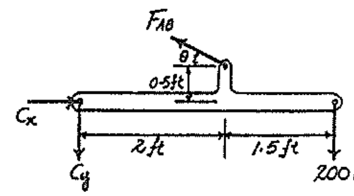


Support Reactions :

$\curvearrowleft + \Sigma M_C = 0;\quad F_{AB}\cos\theta\,(0.5) + F_{AB}\sin\theta\,(2) - 200(3.5) = 0$

$$F_{AB}(0.5\cos\theta + 2\sin\theta) = 700$$

$$F_{AB} = \frac{700}{0.5\cos\theta + 2\sin\theta}$$

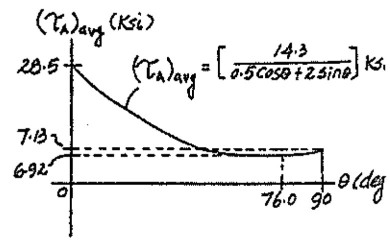


Average Shear Stress : Pin A is subjected to single shear. Hence, $V_A = F_{AB}$

$$(\tau_A)_{avg} = \frac{V_A}{A_A} = \frac{\left(\frac{700}{0.5\cos\theta + 2\sin\theta}\right)}{\frac{\pi}{4}(0.25^2)}$$

$$= \left\{\frac{14260}{0.5\cos\theta + 2\sin\theta}\right\}\text{ psi}$$

$$= \left\{\frac{14.3}{0.5\cos\theta + 2\sin\theta}\right\}\text{ ksi} \qquad \textbf{Ans}$$



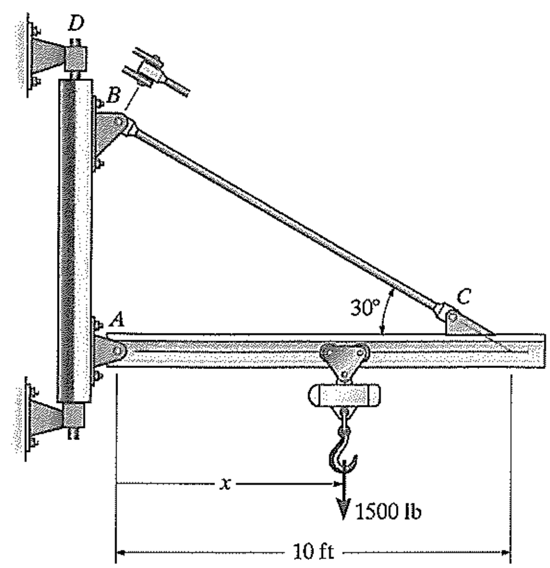
$$\frac{d\tau}{d\theta} = 0$$

$$\frac{(0.5\cos\theta + 2\sin\theta)(0) - (-0.5\sin\theta + 2\cos\theta)(14260)}{(0.5\cos\theta + 2\sin\theta)^2} = 0$$

$$0.5\sin\theta - 2\cos\theta = 0$$

$$\tan\theta = 4;\quad \theta_{min} = 76.0° \qquad \textbf{Ans}$$

1–70. The jib crane is pinned at A and supports a chain hoist that can travel along the bottom flange of the beam, $1\text{ ft} \leq x \leq 12\text{ ft}$. If the hoist is rated to support a maximum of 1500 lb, determine the maximum average normal stress in the $\frac{3}{4}$-in.-diameter tie rod BC and the maximum average shear stress in the $\frac{5}{8}$-in.-diameter pin at B.



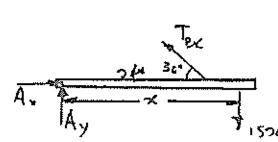
$\curvearrowleft + \Sigma M_A = 0;\quad T_{BC}\sin 30°(10) - 1500(x) = 0$

Maximum T_{BC} occurs when $x = 12$ ft

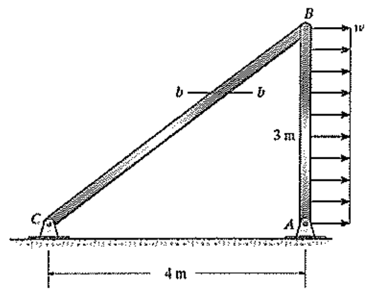
$$T_{BC} = 3600\text{ lb}$$

$$\sigma = \frac{P}{A} = \frac{3600}{\frac{\pi}{4}(0.75)^2} = 8.15\text{ ksi} \qquad \textbf{Ans}$$

$$\tau = \frac{V}{A} = \frac{3600/2}{\frac{\pi}{4}(5/8)^2} = 5.87\text{ ksi} \qquad \textbf{Ans}$$



*1–76. The two-member frame is subjected to the distributed loading shown. Determine the largest intensity w of the uniform loading that can be applied to the frame without causing either the average normal stress or the average shear stress at section b–b to exceed $\sigma = 15$ MPa and $\tau = 16$ MPa, respectively. Member CB has a square cross-section of 30 mm on each side.



Support Reactions : FBD (a)

$\circlearrowleft + \Sigma M_A = 0; \quad \frac{4}{5}F_{BC}(3) - 3w(1.5) = 0 \quad F_{BC} = 1.875w$

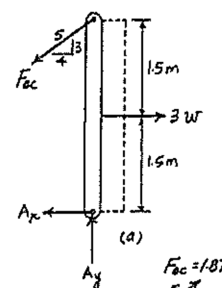
Equations of Equilibrium : For section b-b, FBD (b)

$\xrightarrow{+} \Sigma F_x = 0; \quad \frac{4}{5}(1.875w) - V_{b-b} = 0 \quad V_{b-b} = 1.50w$

$+\uparrow \Sigma F_y = 0; \quad \frac{3}{5}(1.875w) - N_{b-b} = 0 \quad N_{b-b} = 1.125w$

Average Normal Stress And Shear Sress : The cross-sectional area of section b-b, $A' = \frac{5A}{3}$; where $A = (0.03)(0.03) = 0.90(10^{-3})\ \text{m}^2$.

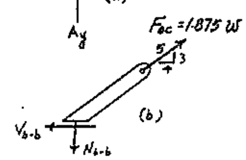
Then $A' = \frac{5}{3}(0.90)(10^{-3}) = 1.50(10^{-3})\ \text{m}^2$.



Assume failure due to normal stress.

$(\sigma_{b-b})_{\text{Allow}} = \frac{N_{b-b}}{A'}; \quad 15(10^6) = \frac{1.125w}{1.50(10^{-3})}$

$w = 20000\ \text{N/m} = 20.0\ \text{kN/m}$

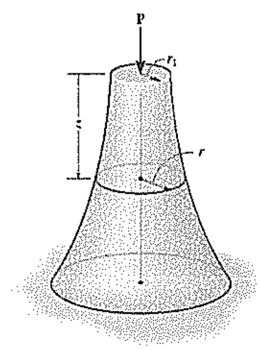


Assume failure due to shear stress.

$(\tau_{b-b})_{\text{Allow}} = \frac{V_{b-b}}{A'}; \quad 16(10^6) = \frac{1.50w}{1.50(10^{-3})}$

$w = 16000\ \text{N/m} = 16.0\ \text{kN/m}$ ***(Controls !)*** Ans

1–77. The pedestal supports a load **P** at its center. If the material has a mass density ρ, determine the radial dimension r as a function of z so that the average normal stress in the pedestal remains constant. The cross section is circular.



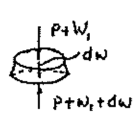
Require :

$\sigma = \frac{P + W_1}{A} = \frac{P + W_1 + dW}{A + dA}$

$P\,dA + W_1\,dA = A\,dW$

$\frac{dW}{dA} = \frac{P + W_1}{A} = \sigma \qquad (1)$

$dA = \pi(r + dr)^2 - \pi r^2 = 2\pi r\,dr$



$dW = \pi r^2(\rho g)\,dz$

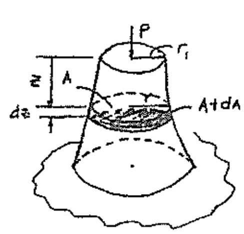
From Eq. (1),

$\frac{\pi r^2(\rho g)\,dz}{2\pi r\,dr} = \sigma$

$\frac{r\rho g\,dz}{2\,dr} = \sigma$

$\frac{\rho g}{2\sigma}\int_0^z dz = \int_{r_1}^{r}\frac{dr}{r}$

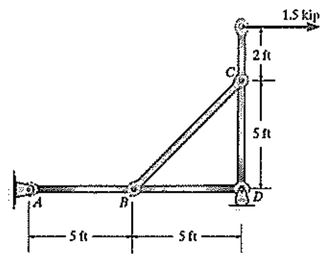
$\frac{\rho g z}{2\sigma} = \ln\frac{r}{r_1}; \qquad r = r_1 e^{(\frac{\rho g}{2\sigma})z}$



However, $\sigma = \frac{P}{\pi r_1^2}$

$r = r_1\,e^{(\frac{\pi r_1^2 \rho g}{2P})z}$ Ans

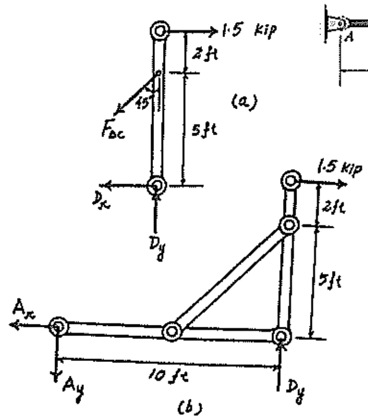
1–87. The frame is subjected to the load of 1.5 kip. Determine the required diameter of the pins at A and B if the allowable shear stress for the material is $\tau_{allow} = 6$ ksi. Pin A is subjected to double shear, whereas pin B is subjected to single shear.



Support Reactions : From FBD (a),

$\curvearrowleft + \Sigma M_D = 0; \quad F_{BC}(\sin 45°)(5) - 1.5(7) = 0$

$F_{BC} = 2.970$ kip



From FBD (b),

$\curvearrowleft + \Sigma M_A = 0; \quad D_y(10) - 1.5(7) = 0 \quad D_y = 1.05$ kip

$\overset{+}{\leftarrow} \Sigma F_x = 0; \quad A_x - 1.5 = 0 \quad A_x = 1.50$ kip

$+\uparrow \Sigma F_y = 0; \quad 1.05 - A_y = 0 \quad A_y = 1.05$ kip

Allowable Shear Stress : Design of pin sizes

For pin A

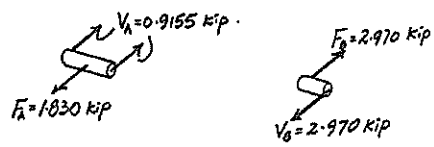
Pin A is subjected to double shear and

$F_A = \sqrt{1.50^2 + 1.05^2} = 1.831$ kip.

Therefore, $V_A = \frac{F_A}{2} = 0.9155$ kip

$\tau_{allow} = \frac{V_A}{A_A}; \quad 6 = \frac{0.9155}{\frac{\pi}{4} d_A^2}$

$d_A = 0.441$ in. **Ans**



For pin B

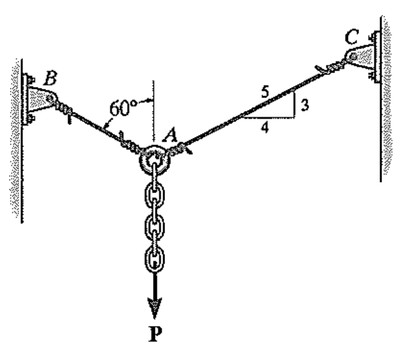
Pin B is subjected to single shear. Therefore,

$V_B = F_B = F_{BC} = 2.970$ kip

$\tau_{allow} = \frac{V_B}{A_B}; \quad 6 = \frac{2.970}{\frac{\pi}{4} d_B^2}$

$d_B = 0.794$ in. **Ans**

***1–88.** The two steel wires AB and AC are used to support the load. If both wires have an allowable tensile stress of $\sigma_{allow} = 200$ MPa, determine the required diameter of each wire if the applied load is $P = 5$ kN.



$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad \frac{4}{5} F_{AC} - F_{AB} \sin 60° = 0 \quad (1)$

$+\uparrow \Sigma F_y = 0; \quad \frac{3}{5} F_{AC} + F_{AB} \cos 60° - 5 = 0 \quad (2)$

Solving Eqs. (1) and (2) yields :

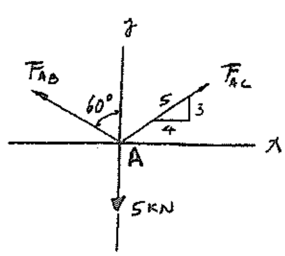
$F_{AB} = 4.3496$ kN; $\quad F_{AC} = 4.7086$ kN

Applying $\sigma_{allow} = \frac{P}{A}$

For wire AB,

$200(10^6) = \frac{4.3496(10^3)}{\frac{\pi}{4}(d_{AB})^2}$

$d_{AB} = 0.00526$ m $= 5.26$ mm **Ans**



For wire AC,

$200(10^6) = \frac{4.7086(10^3)}{\frac{\pi}{4}(d_{AC})^2}$

$d_{AC} = 0.00548$ m $= 5.48$ mm **Ans**