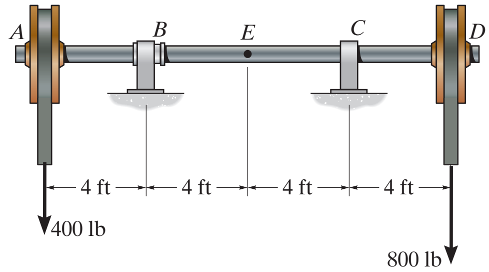
1–1.

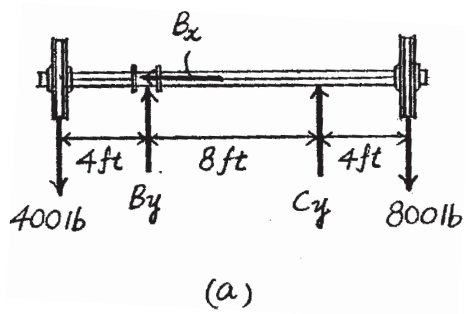
The shaft is supported by a smooth thrust bearing at B and a journal bearing at C. Determine the resultant internal loadings acting on the cross section at E.



SOLUTION

Support Reactions: We will only need to compute $\mathbf{C}_y$ by writing the moment equation of equilibrium about B with reference to the free-body diagram of the entire shaft, Fig. *a*.

$\circlearrowleft + \Sigma M_B = 0; \qquad C_y(8) + 400(4) - 800(12) = 0 \qquad C_y = 1000 \text{ lb}$



Internal Loadings: Using the result for $\mathbf{C}_y$, section DE of the shaft will be considered. Referring to the free-body diagram, Fig. *b*,

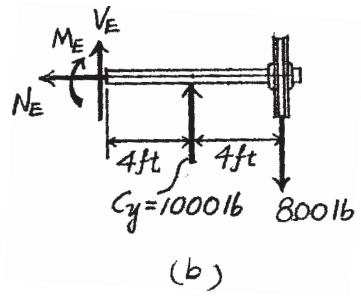
$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad N_E = 0$ **Ans.**

$+\uparrow \Sigma F_y = 0; \qquad V_E + 1000 - 800 = 0 \qquad V_E = -200 \text{ lb}$ **Ans.**

$\circlearrowleft + \Sigma M_E = 0; \; 1000(4) - 800(8) - M_E = 0$

$M_E = -2400 \text{ lb} \cdot \text{ft} = -2.40 \text{ kip} \cdot \text{ft}$ **Ans.**

The negative signs indicates that $\mathbf{V}_E$ and $\mathbf{M}_E$ act in the opposite sense to that shown on the free-body diagram.

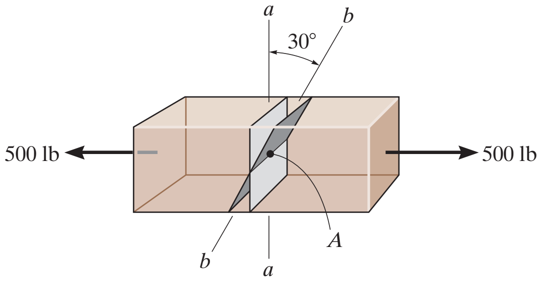


Ans:

$C_y = 1000 \text{ lb}, N_E = 0, V_E = 200\text{lb}, M_E = 2.40\text{kip} \cdot \text{ft}$

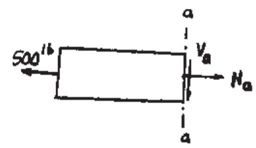
1–2.

Determine the resultant internal normal and shear force in the member on (a) section *a–a* and (b) section *b–b*, each of which passes through the centroid *A*. The 500-lb load is applied along the centroidal axis of the member.



SOLUTION

(a)

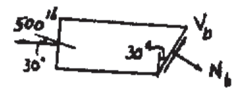


$\xrightarrow{+} \Sigma F_x = 0; \quad N_a - 500 = 0$

$N_a = 500 \text{ lb}$ **Ans.**

$+\downarrow \Sigma F_y = 0; \quad V_a = 0$ **Ans.**

(b)



$\searrow^{+} \Sigma F_x = 0; \quad N_b - 500 \cos 30° = 0$

$N_b = 433 \text{ lb}$ **Ans.**

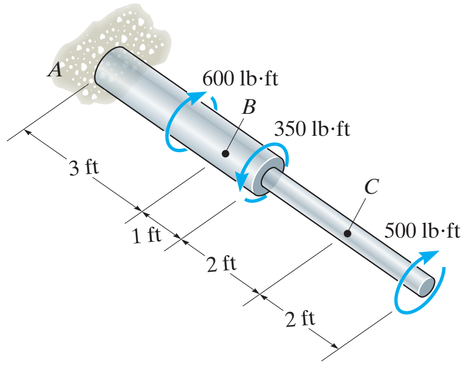
$+\nearrow \Sigma F_y = 0; \quad V_b - 500 \sin 30° = 0$

$V_b = 250 \text{ lb}$ **Ans.**

Ans:
(a) $N_a = 500$ lb, $V_a = 0$,
(b) $N_b = 433$ lb, $V_b = 250$ lb

1–3.

Determine the resultant internal torque acting on the cross sections through points B and C.



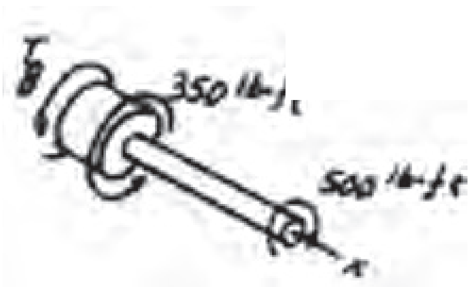
SOLUTION

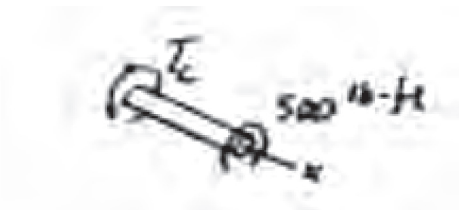
$\Sigma M_x = 0; \qquad T_B + 350 - 500 = 0$

$T_B = 150 \text{ lb} \cdot \text{ft}$ **Ans.**

$\Sigma M_x = 0; \qquad T_C - 500 = 0$

$T_C = 500 \text{ lb} \cdot \text{ft}$ **Ans.**

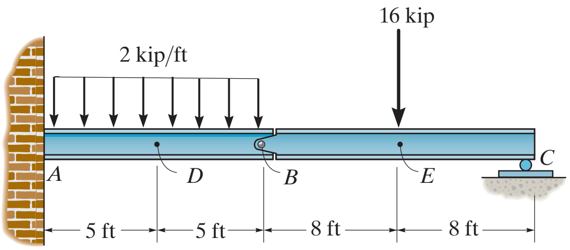




Ans:
$T_B = 150 \text{ lb} \cdot \text{ft}$
$T_C = 500 \text{ lb} \cdot \text{ft}$

***1–4.**

Determine the resultant internal loadings in the beam at cross sections through points D and E. Point E is just to the left of the 16-kip load.



SOLUTION

Support Reactions: We will only need to calculate B_x, B_y and C_y by consider the equilibrium of member BC with reference to its FBD shown in Fig. b.

$$\circlearrowleft + \Sigma M_B = 0; \quad C_y(16) - 16(8) = 0 \quad C_y = 8 \text{ kip}$$

$$\circlearrowleft + \Sigma M_C = 0; \quad 16(8) - B_y(16) = 0 \quad B_y = 8 \text{ kip}$$

$$\xrightarrow{+} \Sigma F_X = 0 \quad B_x = 0$$

Internal Loadings: For point D, consider segment BD of member AB. Using the results of B_x and B_y, the FBD of this segment shown in Fig. c is refered.

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

$$+\uparrow \Sigma F_y = 0; \quad V_D - 10 - 8 = 0 \quad V_D = 18.0 \text{ kip} \qquad \textbf{Ans.}$$

$$\circlearrowleft + \Sigma M_D = 0; \quad -M_D - 10(2.5) - 8(5) = 0 \quad M_D = -65.0 \text{ kip} \cdot \text{ft} \qquad \textbf{Ans.}$$

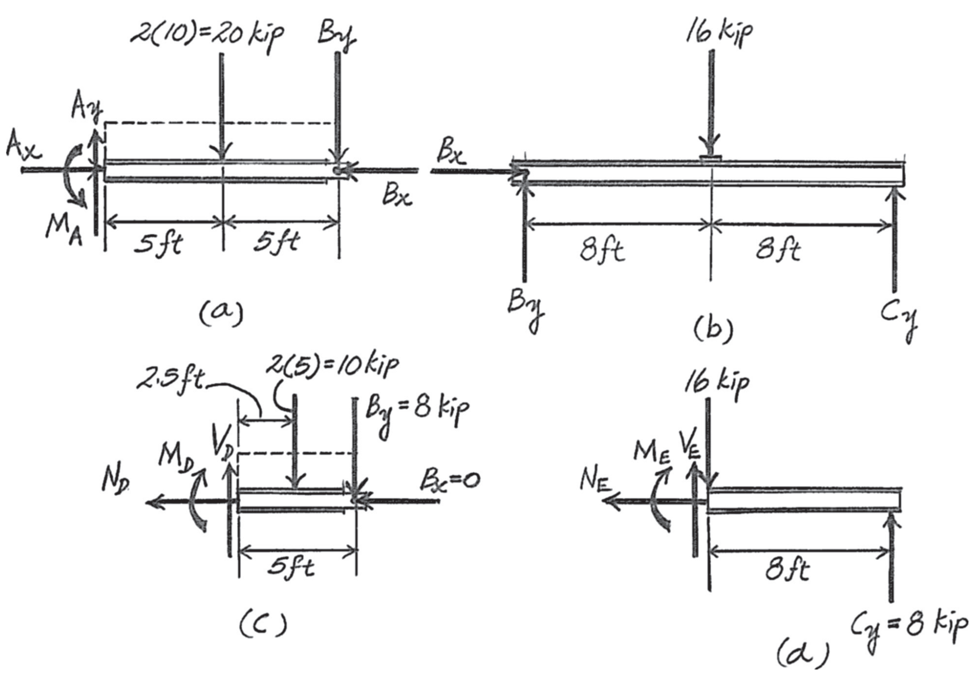
The negative sign indicates that $\mathbf{M}_D$ acts in the sense opposite to that shown in FBD.

For point E, segment CE of member BC using the result of C_y will be considered. Referring to its FBD, Fig. d

$$\xrightarrow{+} \Sigma F_x = 0; \quad N_E = 0 \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \quad V_E + 8 - 16 = 0 \quad V_E = 8.00 \text{ kip} \qquad \textbf{Ans.}$$

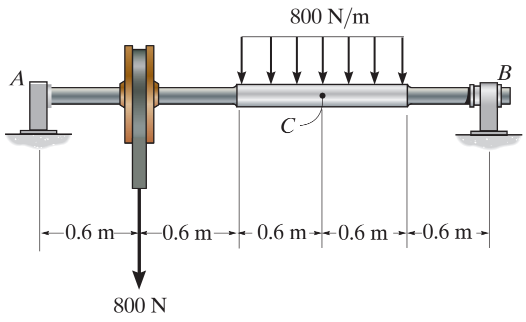
$$\circlearrowleft + \Sigma M_E = 0; \quad 8(8) - M_E = 0 \quad M_E = 64.0 \text{ kip} \cdot \text{ft} \qquad \textbf{Ans.}$$



Ans:
$N_D = 0$
$V_D = 18.0$ kip
$M_D = 65.0$ kip · ft
$N_E = 0$
$V_E = 8.00$ kip
$M_E = 64.0$ kip · ft

1–5.

The shaft is supported by a smooth thrust bearing at B and a smooth journal bearing at A. Determine the resultant internal loadings acting on the cross section at C.



SOLUTION

Support Reactions: We will only need to compute B_y by writing the moment equation of equilibrium about A with reference to the FBD of the entire shaft, Fig. *a*.

$$\circlearrowleft + \Sigma M_A = 0; \quad B_y(3) - 800(0.6) - 960(1.8) = 0 \qquad B_y = 736\text{ N}$$

Internal Loadings: Using the result of B_y, segment BC of the shaft will be considered. Referring to its FBD, Fig. *b*,

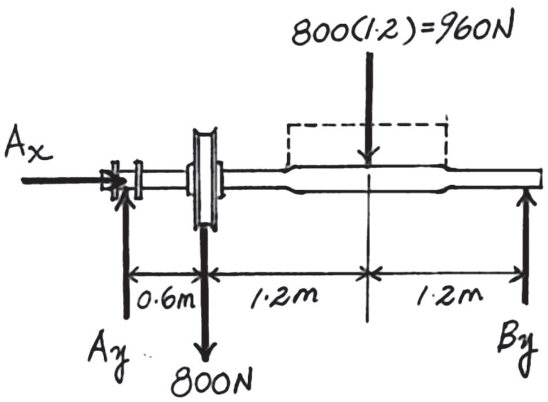
$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad N_C = 0 \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \quad V_C + 736 - 480 = 0 \quad V_C = -256\text{ N} \qquad \textbf{Ans.}$$

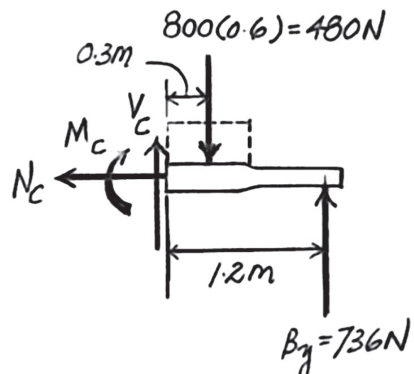
$$\circlearrowleft + \Sigma M_C = 0; \quad 736(1.2) - 480(0.3) - M_C = 0$$

$$M_C = 739.2\text{ N}\cdot\text{m} = 739\text{ N}\cdot\text{m} \qquad \textbf{Ans.}$$

The negative sign indicates that $\mathbf{V}_C$ acts in the opposite sense to that shown in FBD.



(a)

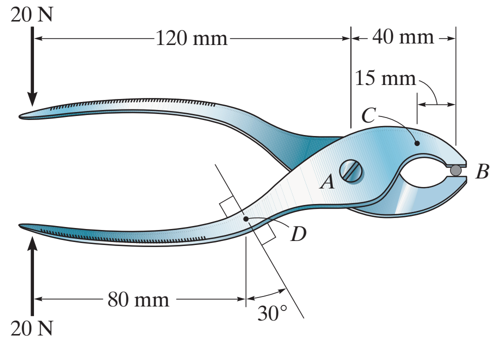


(b)

Ans:
$B_y = 736$ N
$N_C = 0$
$V_C = 256$ N
$M_C = 739$ N · m

1–6.

Determine the resultant internal loading on the cross section through point C of the pliers. There is a pin at A, and the jaws at B are smooth.

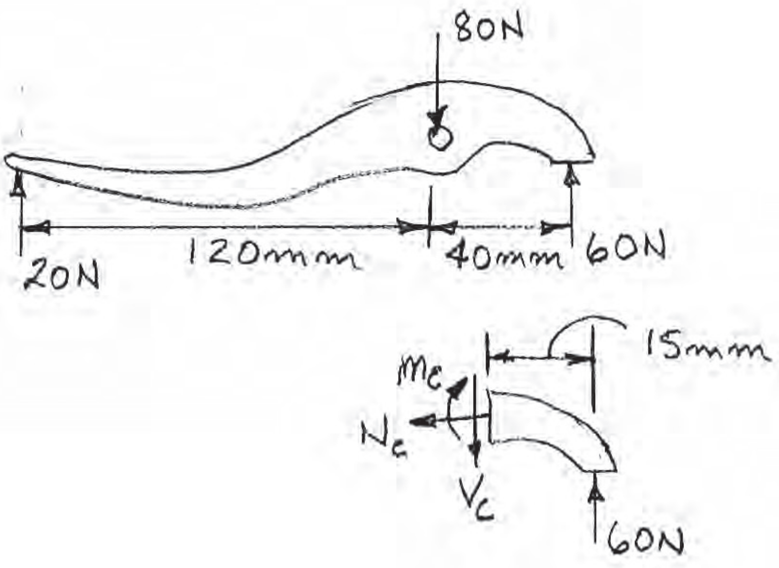


SOLUTION

$+\uparrow \Sigma F_y = 0; \qquad -V_C + 60 = 0; \qquad V_C = 60\text{ N}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0; \qquad N_C = 0$ **Ans.**

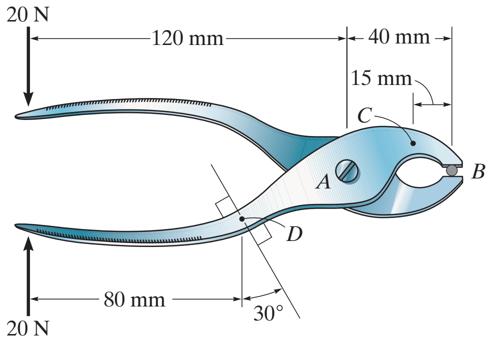
$+\circlearrowleft \Sigma M_C = 0; \qquad -M_C + 60(0.015) = 0; \qquad M_C = 0.9\text{ N.m}$ **Ans.**



Ans:
$V_C = 60$ N
$N_C = 0$
$M_C = 0.9$ N · m

1–7.

Determine the resultant internal loading on the cross section through point D of the pliers. There is a pin at A, and the jaws at B are smooth.

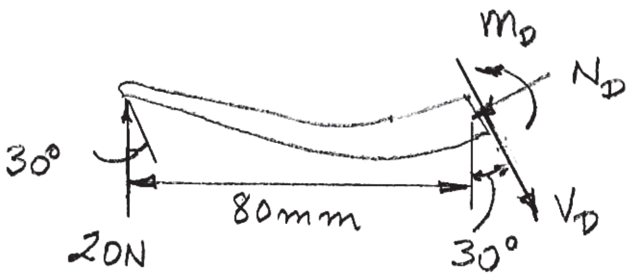


SOLUTION

$\searrow + \Sigma F_y = 0; \quad V_D - 20 \cos 30° = 0; \quad V_D = 17.3 \text{ N}$ **Ans.**

$+\swarrow \Sigma F_x = 0; \quad N_D - 20 \sin 30° = 0; \quad N_D = 10 \text{ N}$ **Ans.**

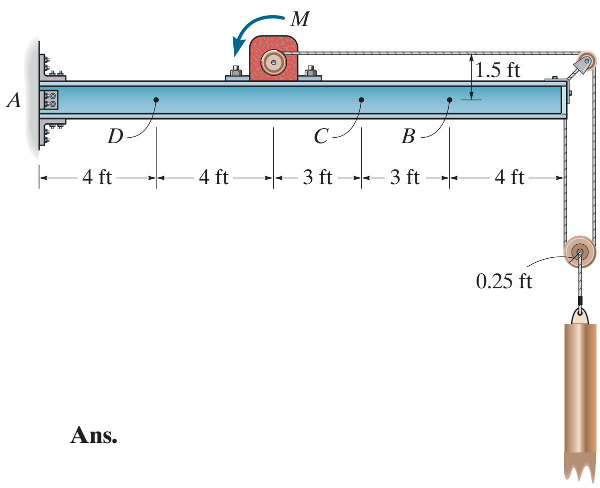
$+\circlearrowleft \Sigma M_D = 0; \quad M_D - 20(0.08) = 0; \quad M_D = 1.60 \text{ N} \cdot \text{m}$ **Ans.**



Ans:
$V_D = 17.3$ N
$N_D = 10$ N
$M_D = 1.60$ N · m

***1–8.**

The 800-lb load is being hoisted at a constant speed using the motor M, which has a weight of 90 lb. Determine the resultant internal loadings acting on the cross section through point B in the beam. The beam has a weight of 40 lb/ft and is fixed to the wall at A.



SOLUTION

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad -N_B - 0.4 = 0$$

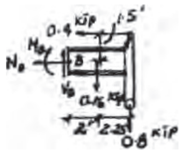
$$N_B = -0.4\,\text{kip} \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \qquad V_B - 0.8 - 0.16 = 0$$

$$V_B = 0.960\text{ kip} \qquad \textbf{Ans.}$$

$$\circlearrowleft + \ \Sigma M_B = 0; \qquad -M_B - 0.16(2) - 0.8(4.25) + 0.4(1.5) = 0$$

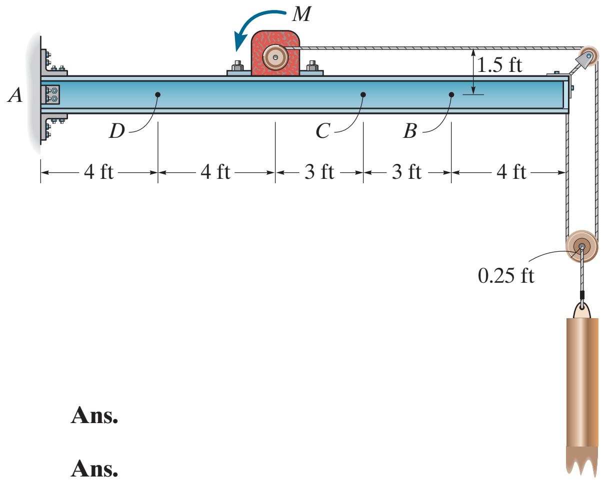
$$M_B = -3.12\text{ kip}\cdot\text{ft} \qquad \textbf{Ans.}$$



Ans:
$N_B = 0.4$ kip
$V_B = 0.960$ kip
$M_B = 3.12$ kip · ft

1–9.

Determine the resultant internal loadings acting on the cross section through points C and D of the beam.



SOLUTION

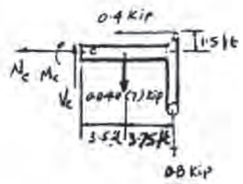
For point C:

$\overset{+}{\leftarrow}\ \Sigma F_x = 0;\qquad N_C + 0.4 = 0;\qquad N_C = -0.4\text{kip}$ **Ans.**

$+\uparrow \Sigma F_y = 0;\qquad V_C - 0.8 - 0.04\,(7) = 0;\qquad V_C = 1.08\text{ kip}$ **Ans.**

$\circlearrowleft +\ \Sigma M_C = 0;\qquad -M_C - 0.8(7.25) - 0.04(7)(3.5) + 0.4(1.5) = 0$

$M_C = -6.18\text{ kip}\cdot\text{ft}$ **Ans.**



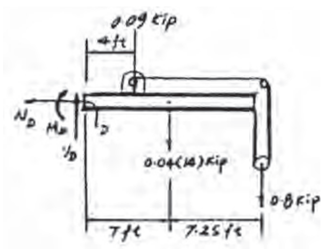
For point D:

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

$+\uparrow \Sigma F_y = 0;\qquad V_D - 0.09 - 0.04(14) - 0.8 = 0;\qquad V_D = 1.45\text{ kip}$ **Ans.**

$\circlearrowleft +\Sigma M_D = 0;\qquad -M_D - 0.09(4) - 0.04(14)(7) - 0.8(14.25) = 0$

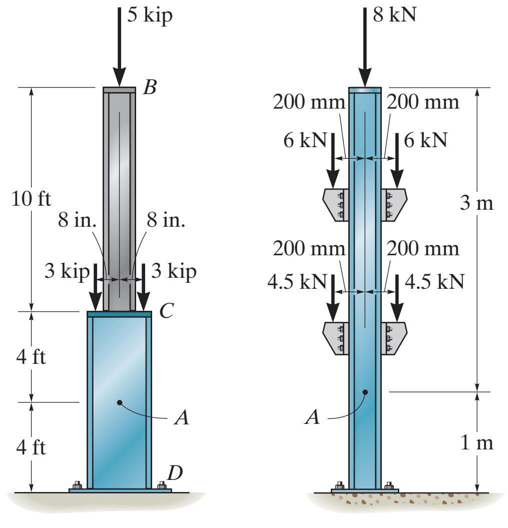
$M_D = -15.7\text{ kip}\cdot\text{ft}$ **Ans.**



Ans:
$N_C = -0.4$ kip
$V_C = 1.08$ kip
$M_C = -6.18$ kip $\cdot$ ft
$N_D = 0$
$V_D = 1.45$ kip
$M_D = -15.7$ kip $\cdot$ ft

1–10.

Determine the resultant internal normal force acting on the cross section through point A in each column. In (a), segment BC weighs 180 lb/ft and segment CD weighs 250 lb/ft. In (b), the column has a mass of 200 kg/m.



(a) (b)

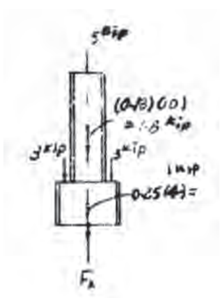
SOLUTION

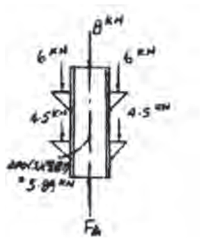
(a) $+\uparrow \Sigma F_y = 0; \qquad F_A - 1.0 - 3 - 3 - 1.8 - 5 = 0$

$$F_A = 13.8 \text{ kip}$$

(b) $+\uparrow \Sigma F_y = 0; \qquad F_A - 4.5 - 4.5 - 5.89 - 6 - 6 - 8 = 0$

$$F_A = 34.9 \text{ kN}$$

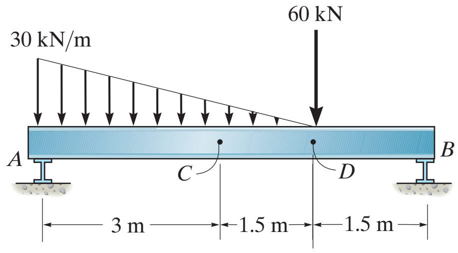




Ans:
(a) $F_A = 13.8$ kip
(b) $F_A = 34.9$ kN

1–11.

Determine the resultant internal loadings on the cross section at point C. Assume the support reactions at A and B are vertical.



SOLUTION

Support Reactions: Only B_y needs to be computed. Referring to the FBD of the entire beam and writing the moment equation of equilibrium about A, Fig. *a*,

$$\circlearrowleft + \Sigma M_A = 0; \quad B_y(6) - 67.5(1.5) - 60(4.5) = 0 \qquad B_y = 61.875 \text{ kN}$$

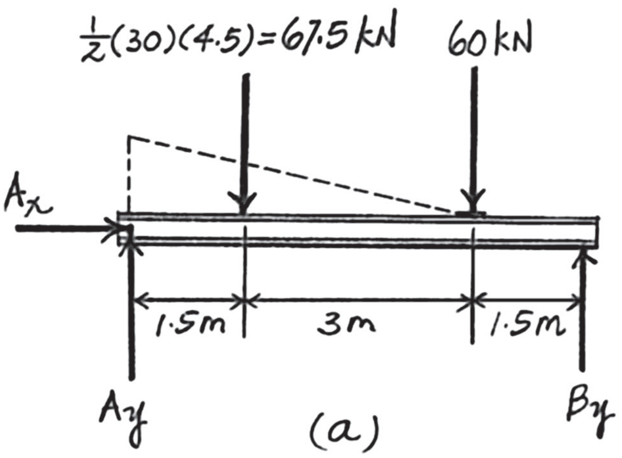
Internal Loadings: Using the result of B_y and referring to the FBD of segment BC of the beam, Fig. *b*.

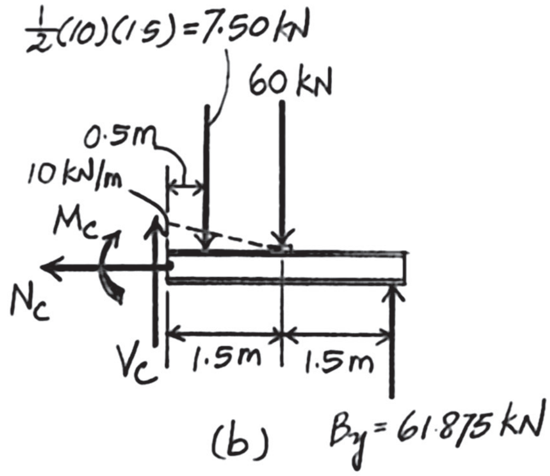
$$\xrightarrow{+} \Sigma F_x = 0; \qquad N_C = 0 \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \quad V_C + 61.875 - 7.50 - 60 = 0 \quad V_C = 5.625 \text{ kN} \qquad \textbf{Ans.}$$

$$\circlearrowleft + \Sigma M_C = 0; \quad 61.875(3) - 7.50(0.5) - 60(1.5) - M_C = 0$$

$$M_C = 91.875 \text{ kN}\cdot\text{m} = 91.9 \text{ kN}\cdot\text{m} \qquad \textbf{Ans.}$$

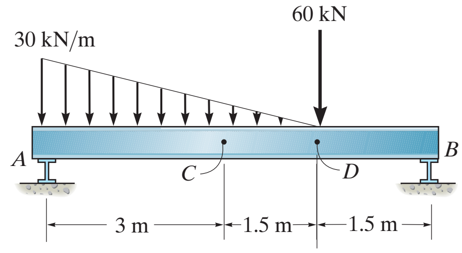




Ans:
$B_y = 61.875$ kN
$N_C = 0$
$V_C = 5.625$ kN
$M_C = 91.9$ kN · m

***1–12.**

Determine the resultant internal loadings on the cross section at point D. Assume point D is just to the left of the 60-kN force. Assume the support reactions at A and B vertical.



SOLUTION

Support Reactions: Only B_y needs to be computed. Referring to the FBD of the entire beam and writing the moment equation of equilibrium about A, Fig. a,

$$\circlearrowleft + \Sigma M_A = 0; \quad B_y(6) - 67.5(1.5) - 60(4.5) = 0 \quad B_y = 61.875 \text{ kN}$$

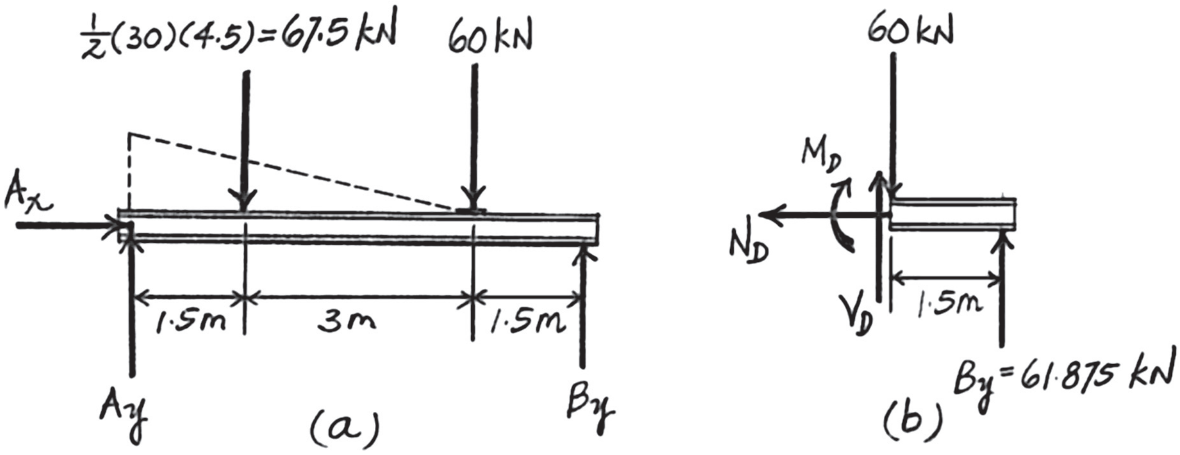
Internal Loadings: using the result of B_y and referring to the FBD of segment BD of the beam, Fig. b,

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

$$+\uparrow \Sigma F_y = 0; \quad V_D + 61.875 - 60 = 0 \quad V_D = -1.875 \text{ kN} \qquad \textbf{Ans.}$$

$$\circlearrowleft + \Sigma M_D = 0; \quad 61.875(1.5) - M_D = 0 \quad M_D = 92.8125 \text{ kN} \cdot \text{m} = 92.8 \text{ kN} \cdot \text{m} \qquad \textbf{Ans.}$$

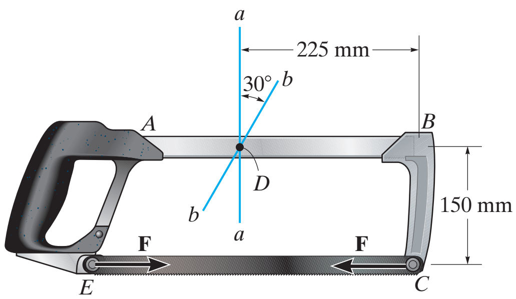
The negative sign indicates that $\mathbf{V}_D$ acts in the sense that opposite to that shown in the FBD.



Ans:
$B_y = 61.875$ kN
$N_D = 0$
$V_D = -1.875$ kN
$M_D = 92.8$ kN · m

1–13.

The blade of the hacksaw is subjected to a pretension force of $F = 100$ N. Determine the resultant internal loadings acting on section a–a that passes through point D.



SOLUTION

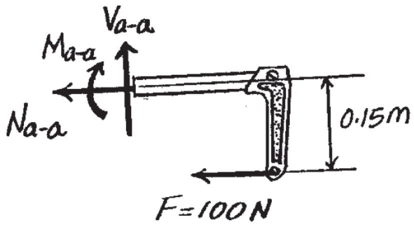
Internal Loadings: Referring to the free-body diagram of the section of the hacksaw shown in Fig. a,

$\overset{+}{\leftarrow} \Sigma F_x = 0; \quad N_{a-a} + 100 = 0 \quad N_{a-a} = -100 \text{ N}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \quad V_{a-a} = 0$ **Ans.**

$\circlearrowleft + \Sigma M_D = 0; \quad -M_{a-a} - 100(0.15) = 0 \quad M_{a-a} = -15 \text{ N} \cdot \text{m}$ **Ans.**

The negative sign indicates that $\mathbf{N}_{a-a}$ and $\mathbf{M}_{a-a}$ act in the opposite sense to that shown on the free-body diagram.

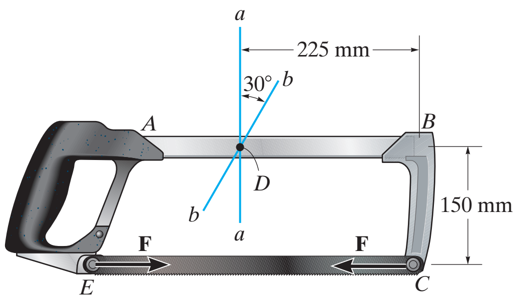


(a)

Ans:
$N_{a-a} = -100$ N, $V_{a-a} = 0$, $M_{a-a} = -15$ N · m

1–14.

The blade of the hacksaw is subjected to a pretension force of $F = 100$ N. Determine the resultant internal loadings acting on section b–b that passes through point D.



SOLUTION

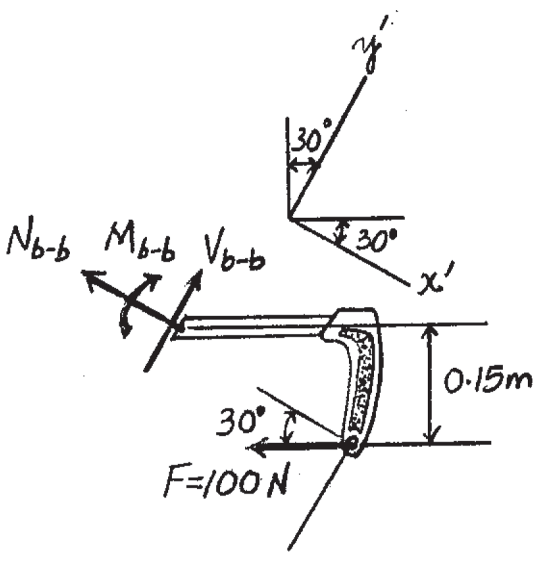
Internal Loadings: Referring to the free-body diagram of the section of the hacksaw shown in Fig. *a*,

$\Sigma F_{x'} = 0;$ $\quad N_{b-b} + 100 \cos 30° = 0 \quad N_{b-b} = -86.6 \text{ N}$ **Ans.**

$\Sigma F_{y'} = 0;$ $\quad V_{b-b} - 100 \sin 30° = 0 \quad V_{b-b} = 50 \text{ N}$ **Ans.**

$\circlearrowleft + \Sigma M_D = 0;$ $\quad -M_{b-b} - 100(0.15) = 0 \quad M_{b-b} = -15 \text{ N} \cdot \text{m}$ **Ans.**

The negative sign indicates that $\mathbf{N}_{b-b}$ and $\mathbf{M}_{b-b}$ act in the opposite sense to that shown on the free-body diagram.

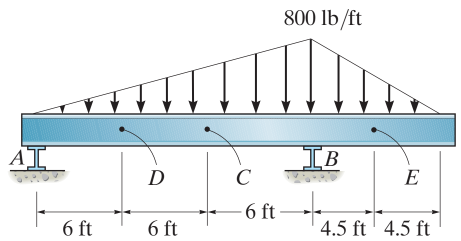


(a)

Ans:
$N_{b-b} = -86.6$ N, $V_{b-b} = 50$ N
$M_{b-b} = -15$ N · m

1–15.

Determine the resultant internal loadings on the cross section at point C. Assume the reactions at the supports A and B are vertical.



SOLUTION

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

$$\circlearrowleft + \Sigma M_B = 0; \quad \frac{1}{2}(0.8)(18)(6) - \frac{1}{2}(0.8)(9)(3) - A_y(18) = 0 \quad A_y = 1.80 \text{ kip}$$

Internal Loadings: Referring to the FBD of the left beam segment sectioned through point C, Fig. *b*,

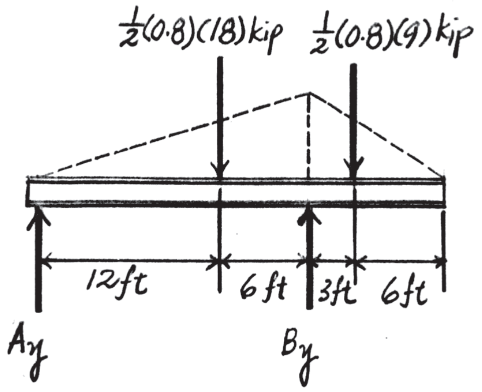
$$\xrightarrow{+} \Sigma F_x = 0; \quad N_C = 0 \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \quad 1.80 - \frac{1}{2}(0.5333)(12) - V_C = 0 \quad V_C = -1.40 \text{ kip} \qquad \textbf{Ans.}$$

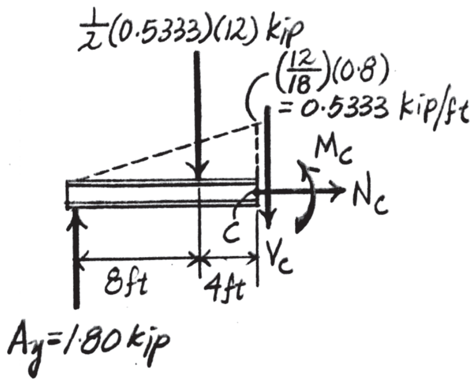
$$\circlearrowleft + \Sigma M_C = 0; \quad M_C + \frac{1}{2}(0.5333)(12)(4) - 1.80(12) = 0$$

$$M_C = 8.80 \text{ kip} \cdot \text{ft} \qquad \textbf{Ans.}$$

The negative sign indicates that $\mathbf{V}_C$ acts in the sense opposite to that shown on the FBD.



(a)

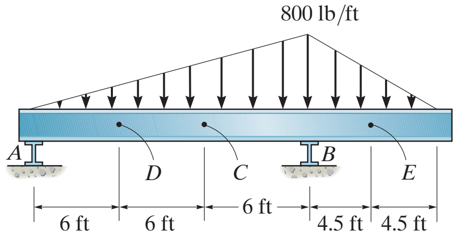


(b)

Ans:
$A_y = 1.80$ kip
$N_C = 0$
$V_C = 1.40$ kip
$M_C = 8.80$ kip · ft

***1–16.**

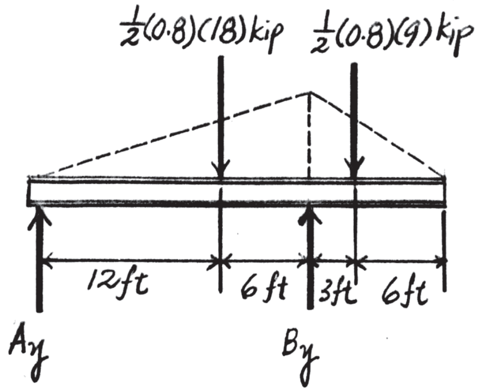
Determine the resultant internal loadings on the cross section at points D and E. Assume the reactions at the supports A and B are vertical.



SOLUTION

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

$$\zeta+\Sigma M_B = 0; \quad \frac{1}{2}(0.8)(18)(6) - \frac{1}{2}(0.8)(9)(3) - A_y(18) = 0 \qquad A_y = 1.80 \text{ kip}$$



(a)

Internal Loadings: Referring to the FBD of the left segment of the beam section through D, Fig. *b*,

$$\xrightarrow{+} \Sigma F_x = 0; \qquad N_D = 0 \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \qquad 1.80 - \frac{1}{2}(0.2667)(6) - V_D = 0 \qquad V_D = 1.00 \text{ kip} \qquad \textbf{Ans.}$$

$$\zeta+\Sigma M_D = 0; \qquad M_D + \frac{1}{2}(0.2667)(6)(2) - 1.80(6) = 0$$

$$M_D = 9.20 \text{ kip} \cdot \text{ft} \qquad \textbf{Ans.}$$

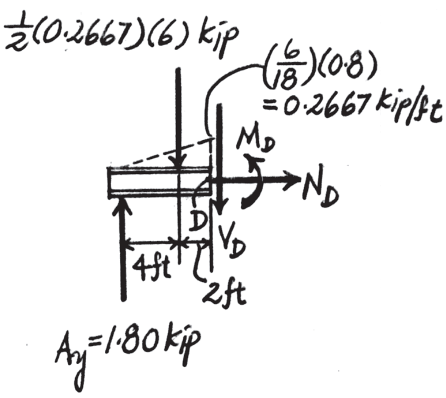
Referring to the FBD of the right segment of the beam sectioned through E, Fig. *c*,

$$\xrightarrow{+} \Sigma F_x = 0; \qquad N_E = 0 \qquad \textbf{Ans.}$$

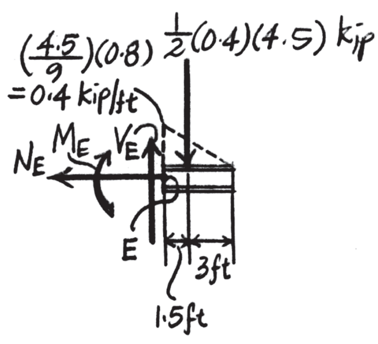
$$+\uparrow \Sigma F_y = 0; \qquad V_E - \frac{1}{2}(0.4)(4.5) = 0 \qquad V_E = 0.900 \text{ kip} \qquad \textbf{Ans.}$$

$$\zeta+\Sigma M_E = 0; \qquad -M_E - \frac{1}{2}(0.4)(4.5)(1.5) = 0 \qquad M_E = -1.35 \text{ kip} \cdot \text{ft} \qquad \textbf{Ans.}$$

The negative sign indicates that $\mathbf{M}_E$ act in the sense opposite to that shown in Fig. *c*.



(b)

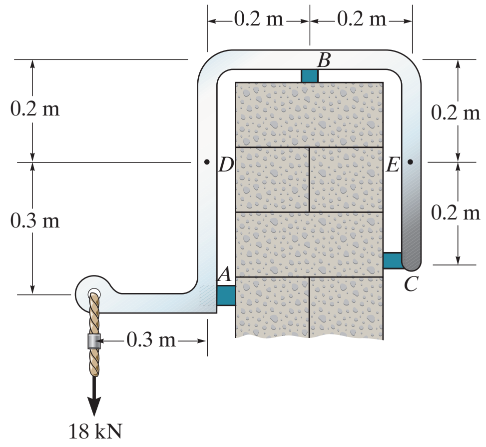


(c)

Ans:
$A_y = 1.80$ kip,
$N_D = 0$,
$V_D = 1.00$ kip,
$M_D = 9.20$ kip · ft
$N_E = 0$,
$V_E = 0.900$ kip,
$M_E = -1.35$ kip · ft

1–17.

The sky hook is used to support the cable of a scaffold over the side of a building. If it consists of a smooth rod that contacts the parapet of a wall at points A, B, and C, determine the normal force, shear force, and moment on the cross section at points D and E.



SOLUTION

Support Reactions:

$+\uparrow \Sigma F_y = 0;\qquad N_B - 18 = 0 \qquad N_B = 18.0 \text{ kN}$

$\circlearrowleft + \Sigma M_C = 0;\qquad 18(0.7) - 18.0(0.2) - N_A(0.1) = 0$

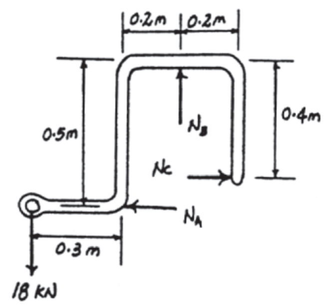
$N_A = 90.0 \text{ kN}$

$\overset{+}{\rightarrow} \Sigma F_x = 0;\qquad N_C - 90.0 = 0 \qquad N_C = 90.0 \text{ kN}$

Equations of Equilibrium: For point D

$\overset{+}{\rightarrow} \Sigma F_x = 0;\qquad V_D - 90.0 = 0$

$V_D = 90.0 \text{ kN}$ **Ans.**



$+\uparrow \Sigma F_y = 0;\qquad N_D - 18 = 0$

$N_D = 18.0 \text{ kN}$ **Ans.**

$\circlearrowleft + \Sigma M_D = 0;\qquad M_D + 18(0.3) - 90.0(0.3) = 0$

$M_D = 21.6 \text{ kN} \cdot \text{m}$ **Ans.**

Equations of Equilibrium: For point E

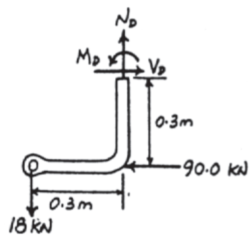
$\overset{+}{\rightarrow} \Sigma F_x = 0;\qquad 90.0 - V_E = 0$

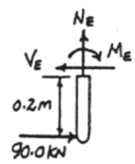
$V_E = 90.0 \text{ kN}$ **Ans.**

$+\uparrow \Sigma F_y = 0;\qquad N_E = 0$ **Ans.**

$\circlearrowleft + \Sigma M_E = 0;\qquad 90.0(0.2) - M_E = 0$

$M_E = 18.0 \text{ kN} \cdot \text{m}$ **Ans.**

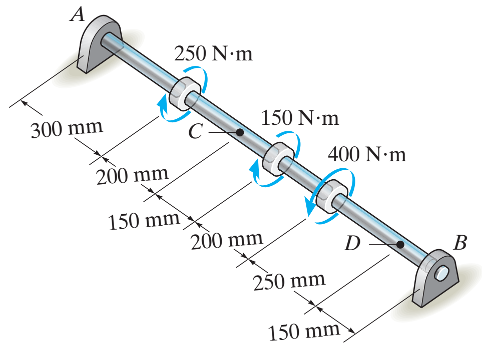




Ans:
$V_D = 90.0$ kN
$N_D = 18.0$ kN
$M_D = 21.6$ kN · m
$V_E = 90.0$ kN
$N_E = 0$
$M_E = 18.0$ kN · m

1–18.

Determine the resultant internal torque acting on the cross section through points C and D. The support bearings at A and B allow free turning of the shaft.

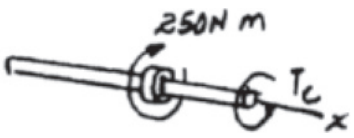


SOLUTION

$\Sigma M_x = 0; \qquad T_C - 250 = 0$

$T_C = 250 \text{ N} \cdot \text{m}$ **Ans.**

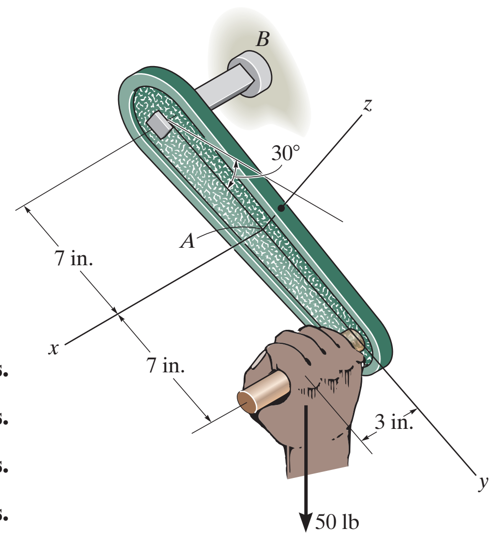
$\Sigma M_x = 0; \qquad T_D = 0$ **Ans.**



Ans:
$T_C = 250 \text{ N} \cdot \text{m}$
$T_D = 0$

1–19.

Determine the resultant internal loadings acting on the cross section of the hand crank at point A if a vertical force of 50 lb is applied to the handle. Assume the crank is fixed to the shaft at B.



SOLUTION

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

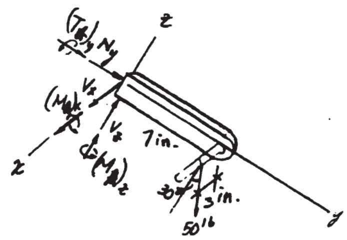
$\Sigma F_y = 0;\quad (N_A)_y + 50 \sin 30° = 0;\quad (N_A)_y = -25\text{ lb}$ **Ans.**

$\Sigma F_z = 0;\quad (V_A)_z - 50 \cos 30° = 0;\quad (V_A)_z = 43.3\text{ lb}$ **Ans.**

$\Sigma M_x = 0;\quad (M_A)_x - 50 \cos 30°(7) = 0;\quad (M_A)_x = 303\text{ lb} \cdot \text{in.}$ **Ans.**

$\Sigma M_y = 0;\quad (T_A)_y + 50 \cos 30°(3) = 0;\quad (T_A)_y = -130\text{ lb} \cdot \text{in.}$ **Ans.**

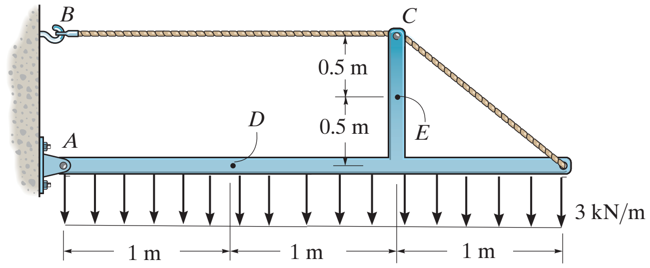
$\Sigma M_z = 0;\quad (M_A)_z + 50 \sin 30°(3) = 0;\quad (M_A)_z = -75\text{ lb} \cdot \text{in.}$ **Ans.**



Ans:
$(V_A)_x = 0$,
$(N_A)_y = -25\text{ lb}$
$(V_A)_z = 43.3\text{ lb}$
$(M_A)_x = 303\text{ lb} \cdot \text{in.}$
$(T_A)_y = -130\text{ lb} \cdot \text{in.}$
$(M_A)_z = -75\text{ lb} \cdot \text{in.}$

***1–20.**

Determine the resultant internal loadings on the cross section at point D. The cable passes over a smooth peg at C.



SOLUTION

Support Reactions: Referring to the FBD of the entire assembly shown in Fig. *a*,

$$\circlearrowleft + \Sigma M_A = 0; \quad T(1) - 9(1.5) = 0 \qquad T = 13.5 \text{ kN}$$

$$+\uparrow \Sigma F_y = 0; \quad A_y - 9 = 0 \qquad A_y = 9 \text{ kN}$$

$$\underset{\rightarrow}{+} \Sigma F_x = 0; \quad A_x - 13.5 \text{ kN} = 0 \qquad A_x = 13.5 \text{ kN}$$

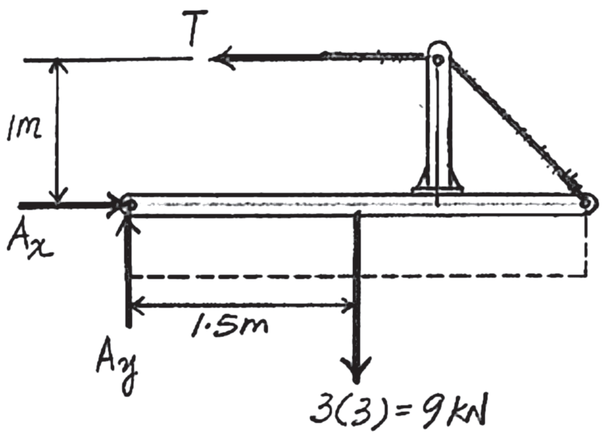
Internal Loadings: Using the results of A_x and A_y, segment AD will be considered. Referring to its FBD, Fig. *b*,

$$\underset{\rightarrow}{+} \Sigma F_x = 0; \quad N_D + 13.5 = 0 \qquad N_D = -13.5 \text{ kN} \qquad \textbf{Ans.}$$

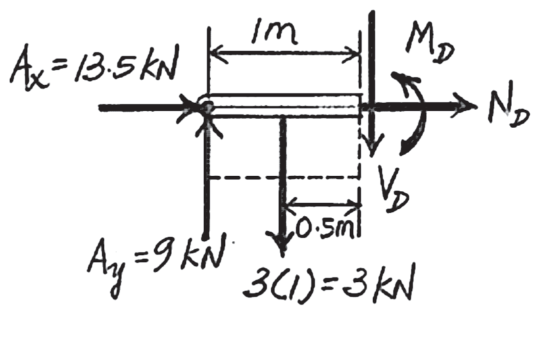
$$+\uparrow \Sigma F_y = 0; \quad 9 - 3 - V_D = 0 \qquad V_D = 6.00 \text{ kN} \qquad \textbf{Ans.}$$

$$\circlearrowleft + \Sigma M_D = 0; \quad M_D + 3(0.5) - 9(1) = 0 \quad M_D = 7.50 \text{ kN} \cdot \text{m} \qquad \textbf{Ans.}$$

The negative sign indicates $\mathbf{N}_D$ acts in the sense opposite to that shown in FBD.



(a)

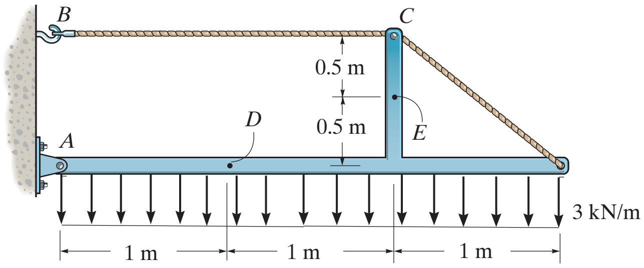


(b)

Ans:
$N_D = -13.5$ kN
$V_D = 6.00$ kN
$M_D = 7.50$ kN · m

1–21.

Determine the resultant internal loadings on the cross section at point E. The cable passes over a smooth peg at C.



SOLUTION

Support Reactions: Only Tension T in the cable needs to be calculated. Referring to the FBD of the entire assembley shown in Fig. *a* and writing the moment equation of equilibrium about A,

$$\circlearrowleft + \Sigma M_A = 0; \quad T(1) - 9(1.5) = 0 \qquad T = 13.5 \text{ kN}$$

Internal Loadings: Using the result of T and referring to the FBD of segment CE, Fig. *b*,

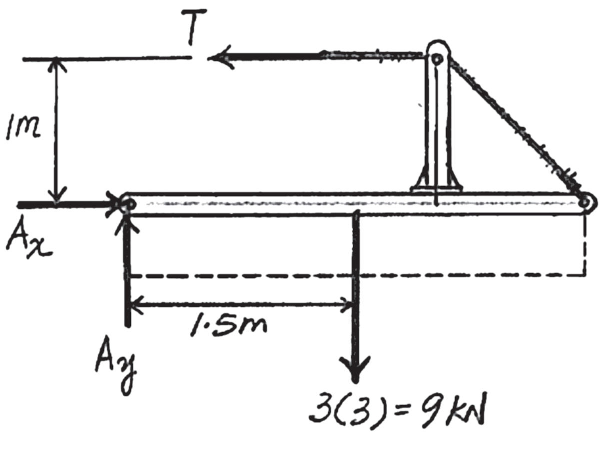
$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad V_E + 13.5\left(\frac{1}{\sqrt{2}}\right) - 13.5 = 0 \quad V_E = 3.954 \text{ kN} = 3.95 \text{ kN} \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \quad -N_E - 13.5\left(\frac{1}{\sqrt{2}}\right) = 0 \quad N_E = -9.546 \text{ kN} = -9.55 \text{ kN} \qquad \textbf{Ans.}$$

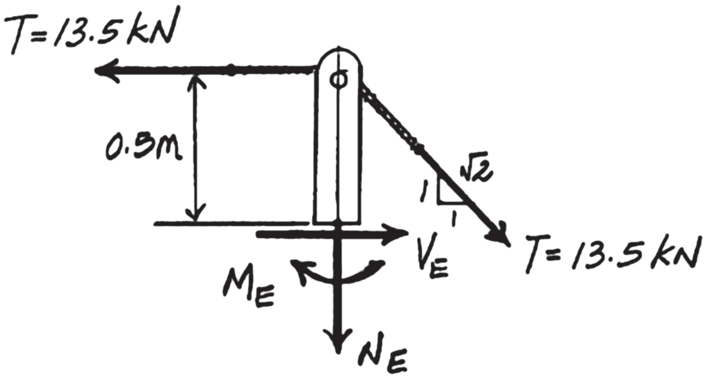
$$\circlearrowleft + \Sigma M_E = 0; \quad 13.5(0.5) - 13.5\left(\frac{1}{\sqrt{2}}\right)(0.5) - M_E = 0$$

$$M_E = 1.977 \text{ kN} \cdot \text{m} = 1.98 \text{ kN} \cdot \text{m} \qquad \textbf{Ans.}$$

The negative sign indicates that $\mathbf{N}_E$ acts in the sense that opposite to that shown in the FBD.



(a)

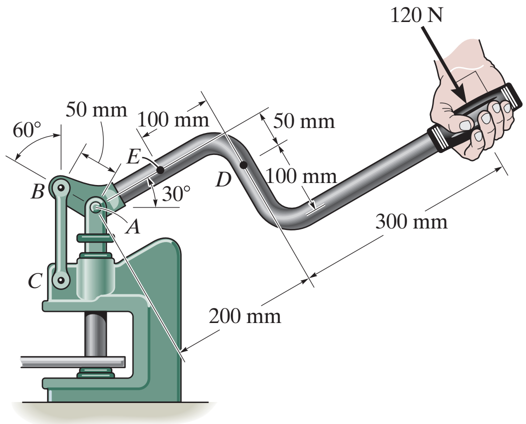


(b)

Ans:
$V_E = 3.95$ kN
$N_E = -9.55$ kN
$M_E = 1.98$ kN · m

1–22.

The metal stud punch is subjected to a force of 120 N on the handle. Determine the magnitude of the reactive force at the pin A and in the short link BC. Also, determine the resultant internal loadings acting on the cross section at point D.

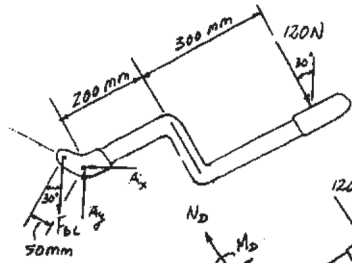


SOLUTION

Member:

$\curvearrowleft + \Sigma M_A = 0;$ $\qquad F_{BC} \cos 30°(50) - 120(500) = 0$

$F_{BC} = 1385.6 \text{ N} = 1.39 \text{ kN}$ **Ans.**



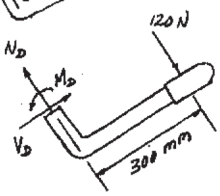
$+\uparrow \Sigma F_y = 0;$ $\qquad A_y - 1385.6 - 120 \cos 30° = 0$

$A_y = 1489.56 \text{ N}$

$\overset{+}{\leftarrow} \Sigma F_x = 0;$ $\qquad A_x - 120 \sin 30° = 0;$ $\qquad A_x = 60 \text{ N}$

$F_A = \sqrt{1489.56^2 + 60^2}$

$= 1491 \text{ N} = 1.49 \text{ kN}$ **Ans.**



Segment:

$\nwarrow^{+} \Sigma F_{x'} = 0;$ $\qquad N_D - 120 = 0$

$N_D = 120 \text{ N}$ **Ans.**

$+\nearrow \Sigma F_{y'} = 0;$ $\qquad V_D = 0$ **Ans.**

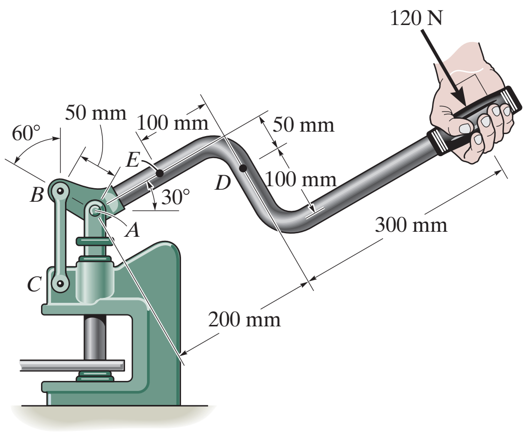
$\curvearrowleft + \Sigma M_D = 0;$ $\qquad M_D - 120(0.3) = 0$

$M_D = 36.0 \text{ N} \cdot \text{m}$ **Ans.**

Ans:
$F_{BC} = 1.39 \text{ kN}, F_A = 1.49 \text{ kN}, N_D = 120 \text{ N},$
$V_D = 0, M_D = 36.0 \text{ N} \cdot \text{m}$

1–23.

The metal stud punch is subjected to a force of 120 N on the handle. Determine the resultant internal loadings acting on the cross section of the handle arm at point E, and on the cross section of the short link BC.



SOLUTION

Member:

$\circlearrowleft + \Sigma M_A = 0; \qquad F_{BC}\cos 30°(50) - 120(500) = 0$

$F_{BC} = 1385.6 \text{ N} = 1.3856 \text{ kN}$

Segment:

$\searrow + \Sigma F_{x'} = 0; \qquad N_E = 0$ **Ans.**

$\nwarrow + \Sigma F_{y'} = 0; \qquad V_E - 120 = 0; \qquad V_E = 120 \text{ N}$ **Ans.**

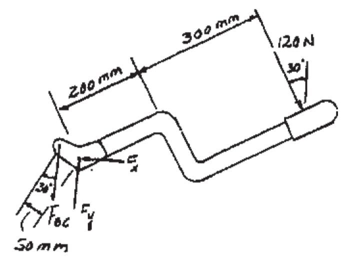
$\circlearrowleft + \Sigma M_E = 0; \qquad M_E - 120(0.4) = 0; \qquad M_E = 48.0 \text{ N}\cdot\text{m}$ **Ans.**

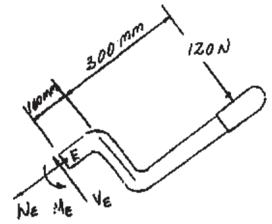
Short link:

$\xrightarrow{+} \Sigma F_x = 0; \qquad V = 0$ **Ans.**

$+\uparrow \Sigma F_y = 0; \qquad 1.3856 - N = 0; \qquad N = 1.39 \text{ kN}$ **Ans.**

$\circlearrowleft + \Sigma M_H = 0; \qquad M = 0$ **Ans.**

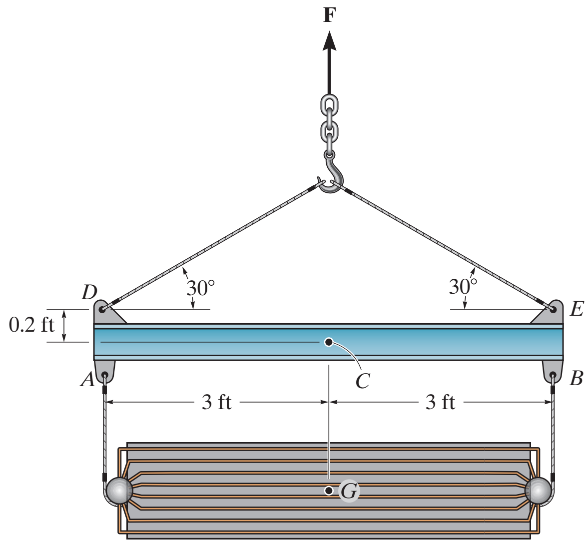




Ans:
$N_E = 0, V_E = 120 \text{ N}, M_E = 48.0 \text{ N}\cdot\text{m},$
Short link: $V = 0, N = 1.39 \text{ kN}, M = 0$

***1–24.**

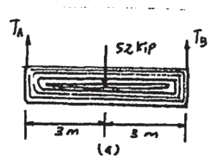
Determine the resultant internal loadings acting on the cross section at point C. The cooling unit has a total weight of 52 kip and a center of gravity at G.



SOLUTION

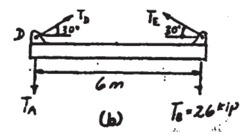
From FBD (a)

$\circlearrowleft + \Sigma M_A = 0; \qquad T_B(6) - 52(3) = 0; \qquad T_B = 26 \text{ kip}$ **Ans.**



From FBD (b)

$\circlearrowleft + \Sigma M_D = 0; \qquad T_E \sin 30°(6) - 26(6) = 0; \qquad T_E = 52 \text{ kip}$ **Ans.**



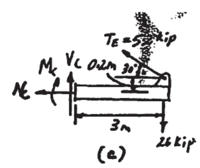
From FBD (c)

$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad -N_C - 52 \cos 30° = 0; \qquad N_C = -45.0 \text{ kip}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \qquad V_C + 52 \sin 30° - 26 = 0; \qquad V_C = 0$ **Ans.**

$\circlearrowleft + \Sigma M_C = 0; \qquad 52 \cos 30°(0.2) + 52 \sin 30°(3) - 26(3) - M_C = 0$

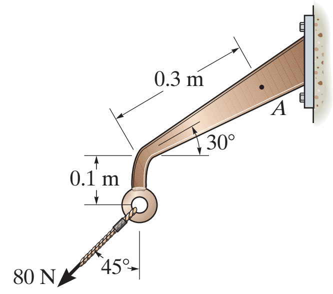
$M_C = 9.00 \text{ kip} \cdot \text{ft}$ **Ans.**



Ans:
$T_B = 26$ kip
$T_E = 52$ kip
$N_C = 45.0$ kip,
$V_C = 0$
$M_C = 9.00$ kip · ft

1–25.

A force of 80 N is supported by the bracket. Determine the resultant internal loadings acting on the cross section at point A.



SOLUTION

Equations of Equilibrium:

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

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

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

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

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

$-80\sin 45°(0.1 + 0.3\sin 30°) = 0$

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

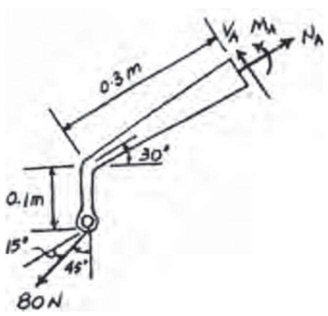
or

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

$-80\cos 15°(0.1\cos 30°) = 0$

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

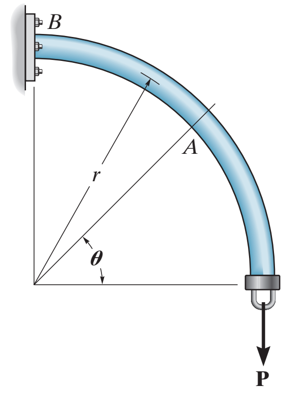
Negative sign indicates that M_A acts in the opposite direction to that shown on FBD.



Ans:
$N_A = 77.3\text{ N}$
$V_A = 20.7\text{ N}$
$M_A = -0.555\text{ N}\cdot\text{m}$

1–26.

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 at point A which is located at an angle θ from the horizontal.



SOLUTION

Equations of Equilibrium: For point A

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

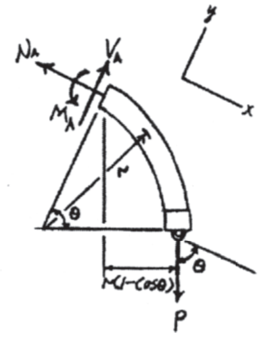
$$N_A = P\cos\theta \qquad \textbf{Ans.}$$

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

$$V_A = P\sin\theta \qquad \textbf{Ans.}$$

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

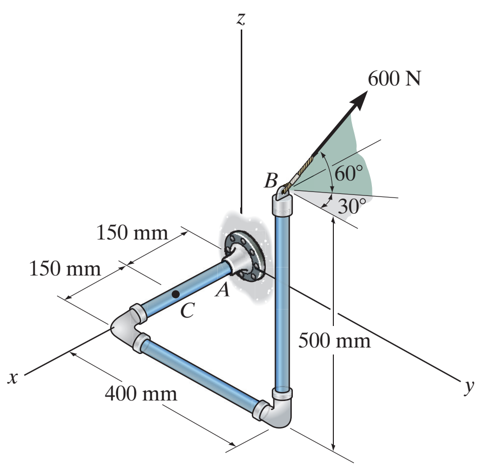
$$M_A = Pr(1 - \cos\theta) \qquad \textbf{Ans.}$$



Ans:
$N_A = P\cos\theta$
$V_A = P\sin\theta$
$M_A = Pr(1 - \cos\theta)$

1–27.

The pipe assembly is subjected to a force of 600 N at *B*. Determine the resultant internal loading acting on the cross section at point *C*.



SOLUTION

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

$\Sigma F_x = 0;\quad (N_C)_x - 600\cos 60^\circ \sin 30^\circ = 0 \qquad (N_C)_x = 150\text{ N}$ **Ans.**

$\Sigma F_y = 0;\quad (V_C)_y + 600\cos 60^\circ \cos 30^\circ = 0 \qquad (V_C)_y = -260\text{ N}$ **Ans.**

$\Sigma F_z = 0;\quad (V_C)_z + 600\sin 60^\circ = 0 \qquad (V_C)_z = -520\text{ N}$ **Ans.**

$\Sigma M_x = 0;\quad (T_C)_x + 600\sin 60^\circ(0.4) - 600\cos 60^\circ \cos 30^\circ(0.5) = 0$

$(T_C)_x = -77.9\text{ N}\cdot\text{m}$ **Ans.**

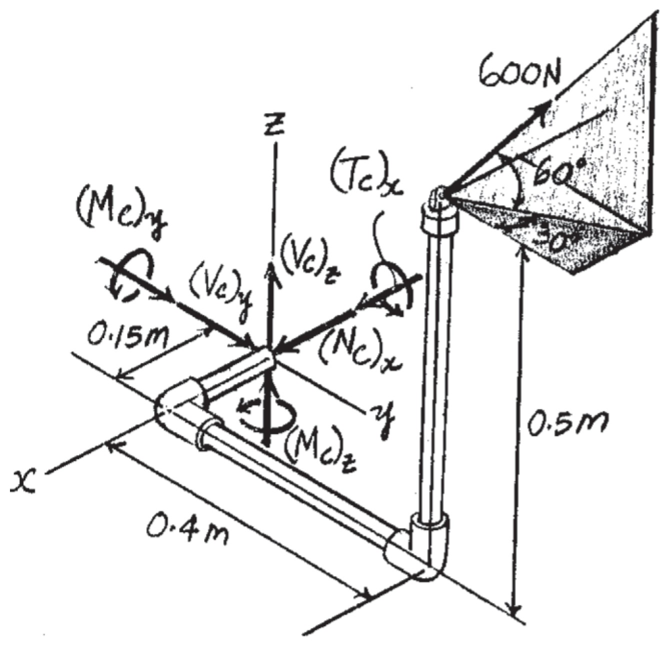
$\Sigma M_y = 0;\quad (M_C)_y - 600\sin 60^\circ\,(0.15) - 600\cos 60^\circ \sin 30^\circ(0.5) = 0$

$(M_C)_y = 153\text{ N}\cdot\text{m}$ **Ans.**

$\Sigma M_z = 0;\quad (M_C)_z + 600\cos 60^\circ \cos 30^\circ(0.15) + 600\cos 60^\circ \sin 30^\circ(0.4) = 0$

$(M_C)_z = -99.0\text{ N}\cdot\text{m}$ **Ans.**

The negative signs indicate that $(\mathbf{V}_C)_y$, $(\mathbf{V}_C)_z$, $(\mathbf{T}_C)_x$, and $(\mathbf{M}_C)_z$ act in the opposite sense to that shown on the free-body diagram.

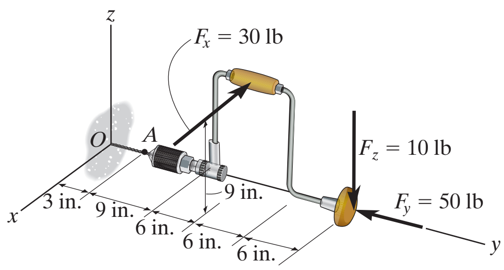


(a)

Ans:
$(N_C)_x = 150\text{ N}$, $(V_C)_y = -260\text{ N}$,
$(V_C)_z = -520\text{ N}$, $(T_C)_x = -77.9\text{ N}\cdot\text{m}$,
$(M_C)_y = 153\text{ N}\cdot\text{m}$, $(M_C)_z = -99.0\text{ N}\cdot\text{m}$

***1–28.**

If the drill bit jams when the handle of the hand drill is subjected to the forces shown, determine the resultant internal loadings acting on the cross section of the drill bit at A.

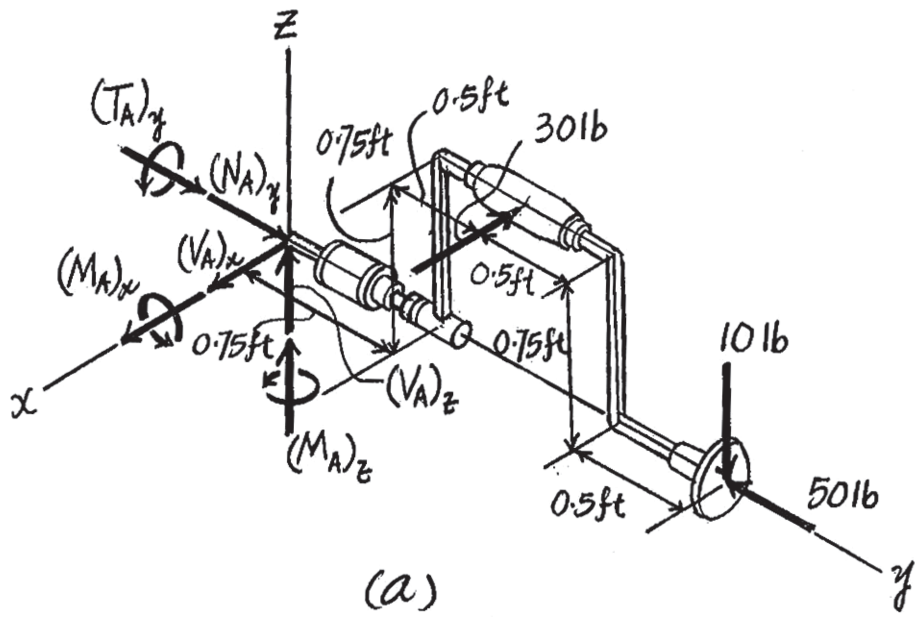


SOLUTION

Internal Loading: Referring to the free-body diagram of the section of the drill and brace shown in Fig. *a*,

$\Sigma F_x = 0;$	$(V_A)_x - 30 = 0$	$(V_A)_x = 30 \text{ lb}$	**Ans.**
$\Sigma F_y = 0;$	$(N_A)_y - 50 = 0$	$(N_A)_y = 50 \text{ lb}$	**Ans.**
$\Sigma F_z = 0;$	$(V_A)_z - 10 = 0$	$(V_A)_z = 10 \text{ lb}$	**Ans.**
$\Sigma M_x = 0;$	$(M_A)_x - 10(2.25) = 0$	$(M_A)_x = 22.5 \text{ lb}\cdot\text{ft}$	**Ans.**
$\Sigma M_y = 0;$	$(T_A)_y - 30(0.75) = 0$	$(T_A)_y = 22.5 \text{ lb}\cdot\text{ft}$	**Ans.**
$\Sigma M_z = 0;$	$(M_A)_z + 30(1.25) = 0$	$(M_A)_z = -37.5 \text{ lb}\cdot\text{ft}$	**Ans.**

The negative sign indicates that $(M_A)_z$ acts in the opposite sense to that shown on the free-body diagram.

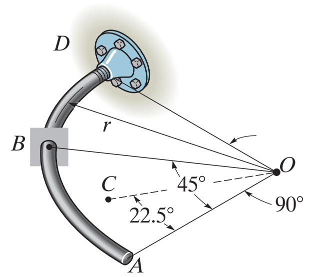


(a)

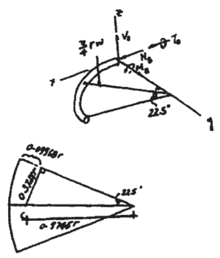
Ans:
$(V_A)_x = 30 \text{ lb}$,
$(N_A)_y = 50 \text{ lb}$,
$(V_A)_z = 10 \text{ lb}$,
$(M_A)_x = 22.5 \text{ lb}\cdot\text{ft}$,
$(T_A)_y = 22.5 \text{ lb}\cdot\text{ft}$,
$(M_A)_z = -37.5 \text{ lb}\cdot\text{ft}$

1–29.

The curved rod AD of radius r has a weight per length of w. If it lies in the horizontal plane, determine the resultant internal loadings acting on the cross section at point B. *Hint*: The distance from the centroid C of segment AB to point O is $CO = 0.9745r$.



SOLUTION



$\Sigma F_z = 0;\quad V_B - \frac{\pi}{4} rw = 0;\quad V_B = 0.785\, w\, r$ **Ans.**

$\Sigma F_x = 0;\quad N_B = 0$ **Ans.**

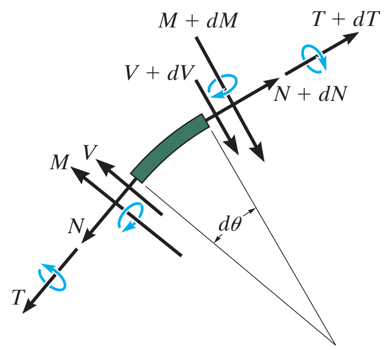
$\Sigma M_x = 0;\quad T_B - \frac{\pi}{4} rw(0.09968r) = 0;\quad T_B = 0.0783\, w\, r^2$ **Ans.**

$\Sigma M_y = 0;\quad M_B + \frac{\pi}{4} rw(0.3729\, r) = 0;\quad M_B = -0.293\, w\, r^2$ **Ans.**

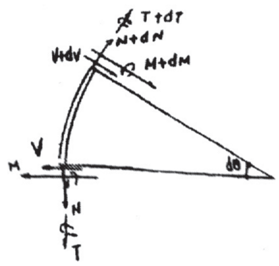
Ans:
$V_B = 0.785wr$,
$N_B = 0$,
$T_B = 0.0783wr^2$,
$M_B = -0.293wr^2$

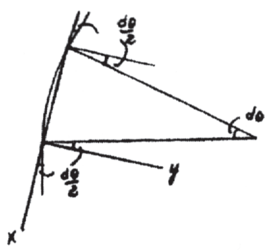
1–30.

A differential element taken from a curved bar is shown in the figure. Show that $dN/d\theta = V$, $dV/d\theta = -N$, $dM/d\theta = -T$, and $dT/d\theta = M$.



SOLUTION





$\Sigma F_x = 0;$

$$N\cos\frac{d\theta}{2} + V\sin\frac{d\theta}{2} - (N + dN)\cos\frac{d\theta}{2} + (V + dV)\sin\frac{d\theta}{2} = 0 \qquad \textbf{(1)}$$

$\Sigma F_y = 0;$

$$N\sin\frac{d\theta}{2} - V\cos\frac{d\theta}{2} + (N + dN)\sin\frac{d\theta}{2} + (V + dV)\cos\frac{d\theta}{2} = 0 \qquad \textbf{(2)}$$

$\Sigma M_x = 0;$

$$T\cos\frac{d\theta}{2} + M\sin\frac{d\theta}{2} - (T + dT)\cos\frac{d\theta}{2} + (M + dM)\sin\frac{d\theta}{2} = 0 \qquad \textbf{(3)}$$

$\Sigma M_y = 0;$

$$T\sin\frac{d\theta}{2} - M\cos\frac{d\theta}{2} + (T + dT)\sin\frac{d\theta}{2} + (M + dM)\cos\frac{d\theta}{2} = 0 \qquad \textbf{(4)}$$

Since $\frac{d\theta}{2}$ is can add, then $\sin\frac{d\theta}{2} = \frac{d\theta}{2}$, $\cos\frac{d\theta}{2} = 1$

Eq. (1) becomes $Vd\theta - dN + \frac{dVd\theta}{2} = 0$

Neglecting the second order term, $Vd\theta - dN = 0$

$\frac{dN}{d\theta} = V$ **QED**

Eq. (2) becomes $Nd\theta + dV + \frac{dNd\theta}{2} = 0$

Neglecting the second order term, $Nd\theta + dV = 0$

$\frac{dV}{d\theta} = -N$ **QED**

Eq. (3) becomes $Md\theta - dT + \frac{dMd\theta}{2} = 0$

Neglecting the second order term, $Md\theta - dT = 0$

$\frac{dT}{d\theta} = M$ **QED**

Eq. (4) becomes $Td\theta + dM + \frac{dTd\theta}{2} = 0$

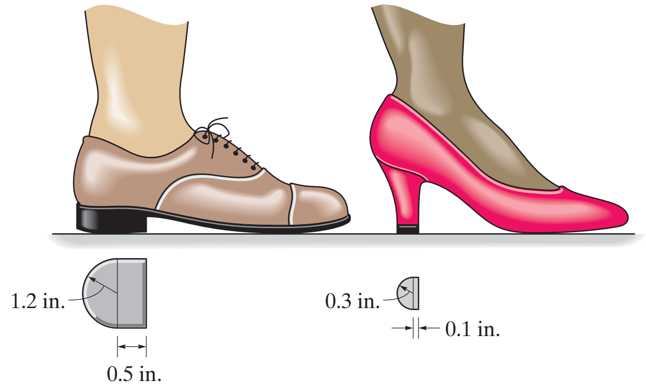
Neglecting the second order term, $Td\theta + dM = 0$

$\frac{dM}{d\theta} = -T$ **QED**

Ans:
N/A

1–31.

A 175-lb woman stands on a vinyl floor wearing stiletto high-heel shoes. If the heel has the dimensions shown, determine the average normal stress she exerts on the floor and compare it with the average normal stress developed when a man having the same weight is wearing flat-heeled shoes. Assume the entire weight is supported only by the heel of one shoe.



SOLUTION

Stiletto shoes:

$$A = \frac{1}{2}(\pi)(0.3)^2 + (0.6)(0.1) = 0.2014 \text{ in}^2$$

$$\sigma = \frac{P}{A} = \frac{175 \text{ lb}}{0.2014 \text{ in}^2} = 869 \text{ psi}$$ **Ans.**

Flat-heeled shoes:

$$A = \frac{1}{2}(\pi)(1.2)^2 + 2.4(0.5) = 3.462 \text{ in}^2$$

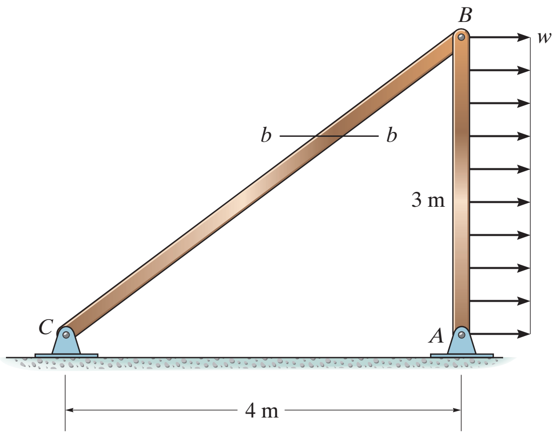
$$\sigma = \frac{P}{A} = \frac{175 \text{ lb}}{3.462 \text{ in}^2} = 50.5 \text{ psi}$$ **Ans.**

Ans:
Stiletto shoes:
$\sigma = 869$ psi

Flat-heeled shoes:
$\sigma = 50.5$ psi

***1–32.**

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.



SOLUTION

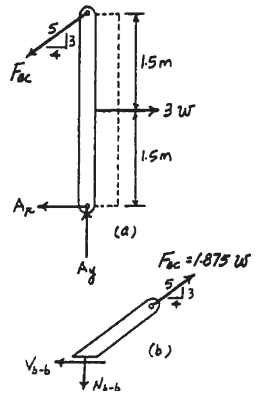
Support Reactions: FBD(a)

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

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

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

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



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

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

Assume failure due to normal stress.

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

$$w = 20000\text{ N/m} = 20.0\text{ kN/m} \qquad \textbf{Ans.}$$

Assume failure due to shear stress.

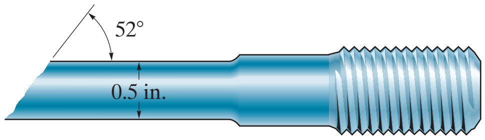
$$(\tau_{b-b})_{\text{Allow}} = \frac{V_{b-b}}{A'}; \qquad 16(10^6) = \frac{1.50w}{1.50(10^{-3})}$$

$$w = 16000\text{ N/m} = 16.0\text{ kN/m }(\textit{Controls}) \qquad \textbf{Ans.}$$

Ans:
$w = 20.0$ kN/m
$w = 16.0$ kN/m (*Controls*)

1–33.

The specimen failed in a tension test at an angle of 52° when the axial load was 19.80 kip. If the diameter of the specimen is 0.5 in., determine the average normal and average shear stress acting on the area of the inclined failure plane. Also, what is the average normal stress acting on the *cross section* when failure occurs?



SOLUTION

$$+\swarrow \Sigma F_x = 0; \qquad V - 19.80 \cos 52° = 0$$

$$V = 12.19 \text{ kip}$$

$$+\nwarrow \Sigma F_y = 0; \qquad N - 19.80 \sin 52° = 0$$

$$N = 15.603 \text{ kip}$$

Inclined plane:

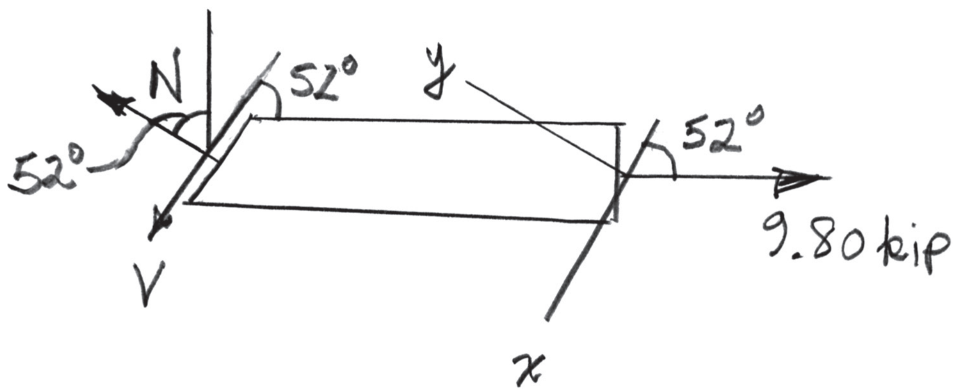
$$\sigma' = \frac{P}{A}; \qquad \sigma' = \frac{15.603}{\frac{\pi(0.25)^2}{\sin 52°}} = 62.6 \text{ ksi} \qquad \textbf{Ans.}$$

$$\tau'_{avg} = \frac{V}{A}; \qquad \tau'_{avg} = \frac{12.19}{\frac{\pi(0.25)^2}{\sin 52°}} = 48.9 \text{ ksi} \qquad \textbf{Ans.}$$

Cross section:

$$\sigma = \frac{P}{A}; \qquad \sigma = \frac{19.80}{\pi(0.25)^2} = 101 \text{ ksi} \qquad \textbf{Ans.}$$

$$\tau_{avg} = \frac{V}{A}; \qquad \tau_{avg} = 0 \qquad \textbf{Ans.}$$

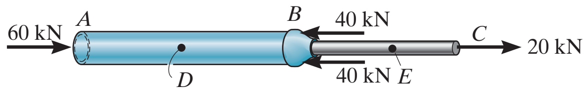


Ans:
Inclined plane:
$\sigma' = 62.6$ ksi
$\tau'_{avg} = 48.9$ ksi

Cross section:
$\sigma = 101$ ksi
$\tau_{avg} = 0$

1–34.

The built-up shaft consists of a pipe AB and solid rod BC. The pipe has an inner diameter of 25 mm and outer diameter of 30 mm. The rod has a diameter of 15 mm. Determine the average normal stress at points D and E and represent the stress on a volume element located at each of these points.



SOLUTION

Internal Loadings: Referring to the FBD of the rod and the pipe shown in Fig. *a* and *b* respectively,

$$\Sigma F_x = 0; \quad 20 - F_E = 0 \quad F_E = 20 \text{ kN}$$

$$\Sigma F_x = 0; \quad 60 - F_D = 0 \quad F_D = 60 \text{ kN}$$

Normal stress: The cross-sectional area of the rod and the pipe are

$$A_r = \frac{\pi}{4}(0.015^2) = 56.25(10^{-6})\pi \text{ m}^2$$

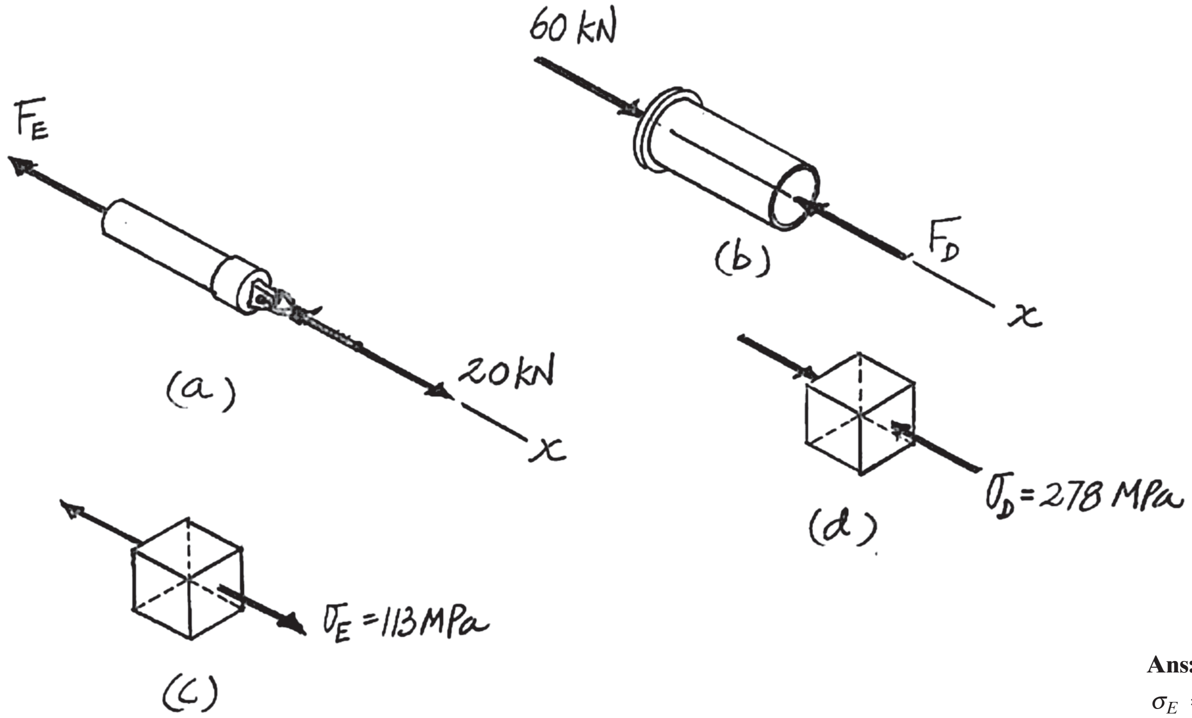
$$A_p = \frac{\pi}{4}(0.03^2 - 0.025^2) = 68.75(10^{-6})\pi \text{ m}^2$$

Then

$$\sigma_E = \frac{F_E}{A_r} = \frac{20(10^3)}{56.25(10^{-6})\pi} = 113.18(10^6)\text{Pa(T)} = 113 \text{ MPa (T)} \qquad \textbf{Ans.}$$

$$\sigma_D = \frac{F_D}{A_p} = \frac{60(10^3)}{68.75(10^{-6})\pi} = 277.80(10^6)\text{Pa(C)} = 278 \text{ MPa (C)} \qquad \textbf{Ans.}$$

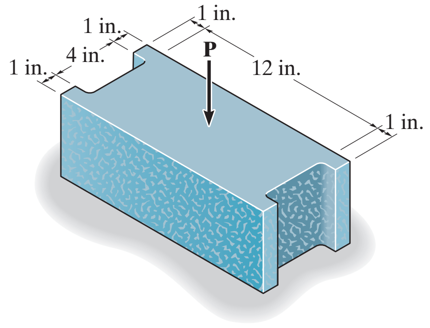
The state of stress at points D and E can be represented by the volume element shown in Fig. *d* and *c* respectively.



Ans:
$\sigma_E = 113$ MPa (T)
$\sigma_D = 278$ MPa (C)

1–35.

If the material fails when the average normal stress reaches 120 psi, determine the largest centrally applied vertical load **P** the block can support.



SOLUTION

Average Normal Stress: The cross-sectional area of the block is

$$A = 14(6) - 2\left[4(1)\right] = 76 \text{ in}^2$$

Thus,

$$\sigma_{\text{allow}} = \frac{N_{\text{allow}}}{A}; \qquad 120 = \frac{P_{\text{allow}}}{76}$$

$$P_{\text{allow}} = 9120 \text{ lb} = 9.12 \text{ kip} \qquad \textbf{Ans.}$$

Ans:
$P_{\text{allow}} = 9.12$ kip