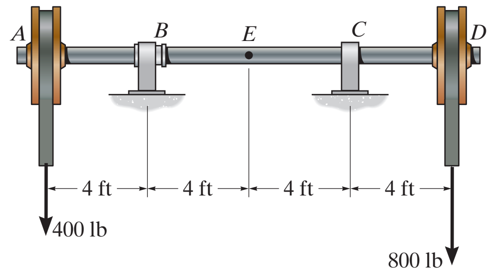
1–1.

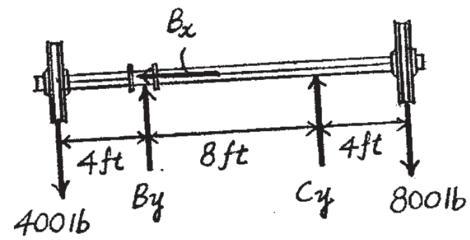
The shaft is supported by a smooth thrust bearing at B and a journal bearing at C. Determine the resultant internal loadings acting on the cross section at E.



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*.

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



(a)

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*,

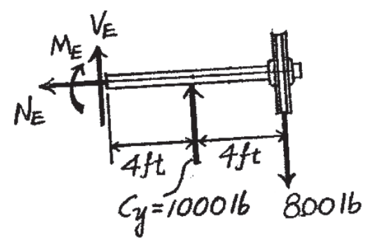
$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad N_E = 0$ **Ans.**

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

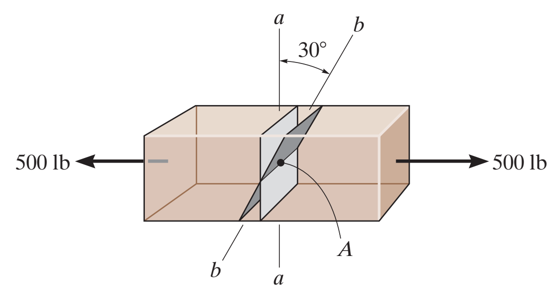


(b)

Ans:
$N_E = 0, V_E = -200 \text{ lb}, M_E = -2.40 \text{ kip} \cdot \text{ft}$

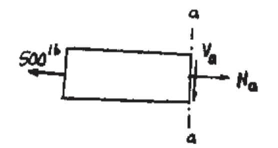
1–2.

Determine the resultant internal normal and shear force in the member at (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)

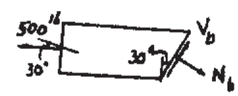


$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad N_a - 500 = 0$

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

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

(b)



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

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

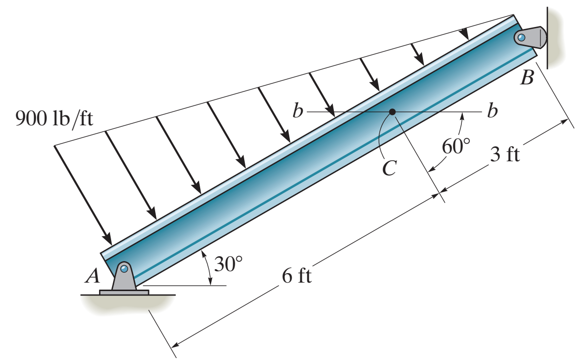
$\overset{+}{\nearrow} \Sigma F_y = 0; \qquad V_b - 500 \sin 30° = 0$

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

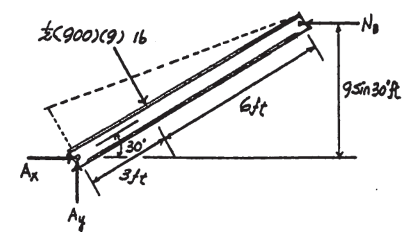
Ans:
(a) $N_a = 500$ lb, $V_a = 0$,
(b) $N_b = 433$ lb, $V_b = 250$ lb

1–3.

Determine the resultant internal loadings acting on section b–b through the centroid C on the beam.



SOLUTION



Support Reaction:

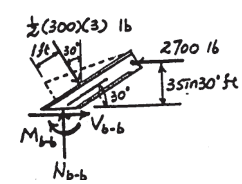
$$\circlearrowleft + \Sigma M_A = 0; \quad N_B(9 \sin 30°) - \frac{1}{2}(900)(9)(3) = 0$$

$$N_B = 2700 \text{ lb}$$

Equations of Equilibrium: For section b–b

$$\xrightarrow{+} \Sigma F_x = 0; \quad V_{b-b} + \frac{1}{2}(300)(3) \sin 30° - 2700 = 0$$

$$V_{b-b} = 2475 \text{ lb} = 2.475 \text{ kip} \qquad \textbf{Ans.}$$



$$+\uparrow \Sigma F_y = 0; \quad N_{b-b} - \frac{1}{2}(300)(3) \cos 30° = 0$$

$$N_{b-b} = 389.7 \text{ lb} = 0.390 \text{ kip} \qquad \textbf{Ans.}$$

$$\circlearrowleft + \Sigma M_C = 0; \quad 2700(3 \sin 30°)$$

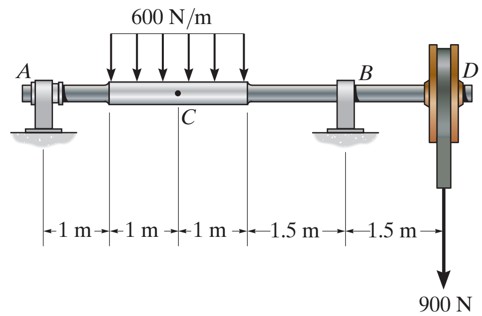
$$-\frac{1}{2}(300)(3)(1) - M_{b-b} = 0$$

$$M_{b-b} = 3600 \text{ lb} \cdot \text{ft} = 3.60 \text{ kip} \cdot \text{ft} \qquad \textbf{Ans.}$$

Ans:
$V_{b-b} = 2.475$ kip,
$N_{b-b} = 0.390$ kip,
$M_{b-b} = 3.60$ kip · ft

***1–4.**

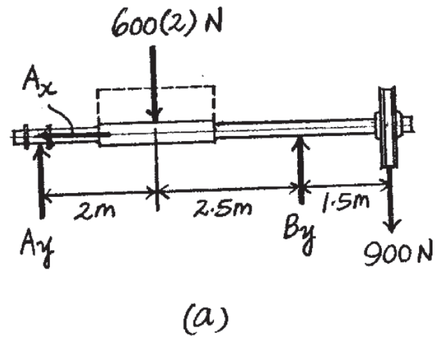
The shaft is supported by a smooth thrust bearing at A and a smooth journal bearing at B. Determine the resultant internal loadings acting on the cross section at C.



SOLUTION

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

$\circlearrowleft + \Sigma M_A = 0; \quad B_y(4.5) - 600(2)(2) - 900(6) = 0 \qquad B_y = 1733.33\text{ N}$



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

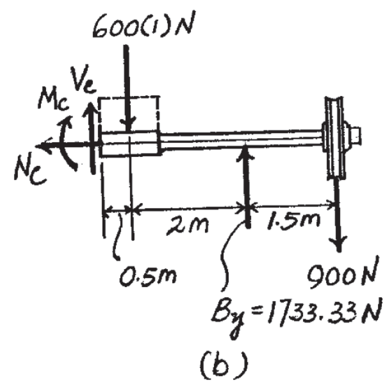
$\xrightarrow{+} \Sigma F_x = 0; \quad N_C = 0$ **Ans.**

$+\uparrow \Sigma F_y = 0; \quad V_C - 600(1) + 1733.33 - 900 = 0 \qquad V_C = -233\text{ N}$ **Ans.**

$\circlearrowleft + \Sigma M_C = 0; \quad 1733.33(2.5) - 600(1)(0.5) - 900(4) - M_C = 0$

$M_C = 433\text{ N}\cdot\text{m}$ **Ans.**

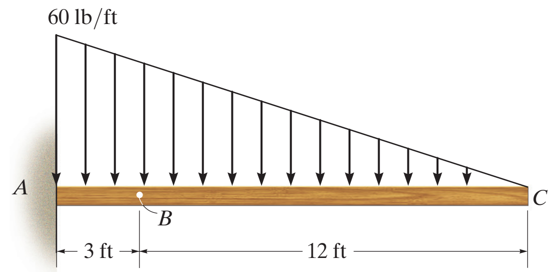
The negative sign indicates that $\mathbf{V}_C$ acts in the opposite sense to that shown on the free-body diagram.



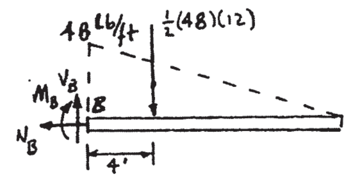
Ans:
$N_C = 0$,
$V_C = -233\text{ N}$,
$M_C = 433\text{ N}\cdot\text{m}$

1–5.

Determine the resultant internal loadings acting on the cross section at point B.



SOLUTION



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

$+\uparrow \Sigma F_y = 0;\qquad V_B - \frac{1}{2}(48)(12) = 0$

$V_B = 288 \text{ lb}$ **Ans.**

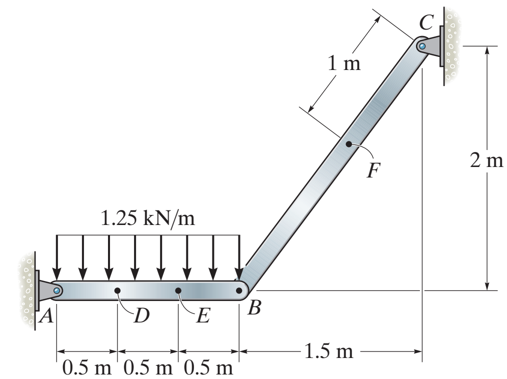
$\circlearrowleft + \Sigma M_B = 0;\qquad -M_B - \frac{1}{2}(48)(12)(4) = 0$

$M_B = -1152 \text{ lb} \cdot \text{ft} = -1.15 \text{ kip} \cdot \text{ft}$ **Ans.**

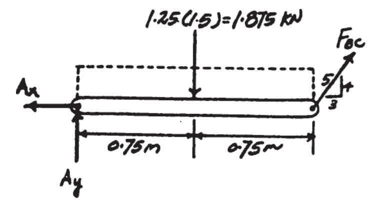
Ans:
$N_B = 0$,
$V_B = 288$ lb,
$M_B = -1.15$ kip · ft

1–6.

Determine the resultant internal loadings on the cross section at point D.



SOLUTION



Support Reactions: Member BC is the two force member.

$$\circlearrowleft + \Sigma M_A = 0; \quad \frac{4}{5}F_{BC}(1.5) - 1.875(0.75) = 0$$

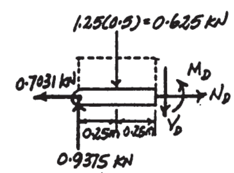
$$F_{BC} = 1.1719 \text{ kN}$$

$$+\uparrow \Sigma F_y = 0; \quad A_y + \frac{4}{5}(1.1719) - 1.875 = 0$$

$$A_y = 0.9375 \text{ kN}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad \frac{3}{5}(1.1719) - A_x = 0$$

$$A_x = 0.7031 \text{ kN}$$



Equations of Equilibrium: For point D

$$\xrightarrow{+} \Sigma F_x = 0; \quad N_D - 0.7031 = 0$$
$$N_D = 0.703 \text{ kN}$$ **Ans.**

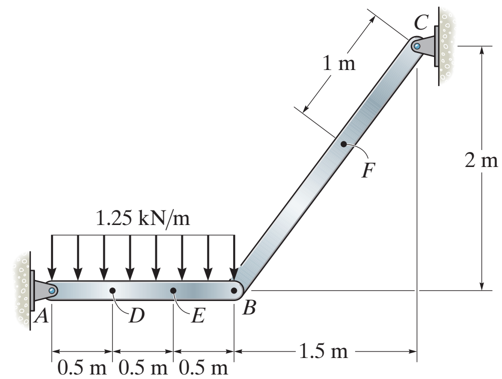
$$+\uparrow \Sigma F_y = 0; \quad 0.9375 - 0.625 - V_D = 0$$
$$V_D = 0.3125 \text{ kN}$$ **Ans.**

$$\circlearrowleft + \Sigma M_D = 0; \quad M_D + 0.625(0.25) - 0.9375(0.5) = 0$$
$$M_D = 0.3125 \text{ kN} \cdot \text{m}$$ **Ans.**

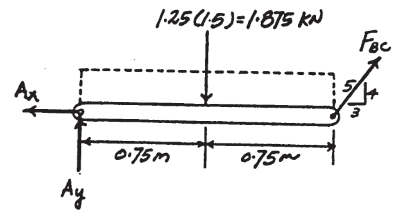
Ans:
$N_D = 0.703$ kN,
$V_D = 0.3125$ kN,
$M_D = 0.3125$ kN · m

1–7.

Determine the resultant internal loadings at cross sections at points E and F on the assembly.



SOLUTION



Support Reactions: Member BC is the two-force member.

$$\circlearrowleft+\Sigma M_A = 0; \quad \frac{4}{5}F_{BC}(1.5) - 1.875(0.75) = 0$$

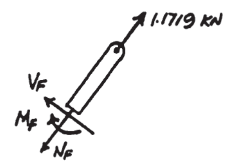
$$F_{BC} = 1.1719 \text{ kN}$$

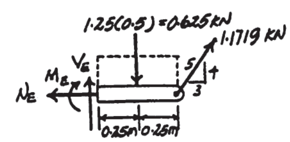
$$+\uparrow\Sigma F_y = 0; \quad A_y + \frac{4}{5}(1.1719) - 1.875 = 0$$

$$A_y = 0.9375 \text{ kN}$$

$$\overset{+}{\rightarrow}\Sigma F_x = 0; \quad \frac{3}{5}(1.1719) - A_x = 0$$

$$A_x = 0.7031 \text{ kN}$$





Equations of Equilibrium: For point F

$$+\swarrow\Sigma F_{x'} = 0; \quad N_F - 1.1719 = 0$$

$$N_F = 1.17 \text{ kN} \qquad \textbf{Ans.}$$

$$\nwarrow+\Sigma F_{y'} = 0; \quad V_F = 0 \qquad \textbf{Ans.}$$

$$\circlearrowleft+\Sigma M_F = 0; \quad M_F = 0 \qquad \textbf{Ans.}$$

Equations of Equilibrium: For point E

$$\overset{+}{\leftarrow}\Sigma F_x = 0; \quad N_E - \frac{3}{5}(1.1719) = 0$$

$$N_E = 0.703 \text{ kN} \qquad \textbf{Ans.}$$

$$+\uparrow\Sigma F_y = 0; \quad V_E - 0.625 + \frac{4}{5}(1.1719) = 0$$

$$V_E = -0.3125 \text{ kN} \qquad \textbf{Ans.}$$

$$\circlearrowleft+\Sigma M_E = 0; \quad -M_E - 0.625(0.25) + \frac{4}{5}(1.1719)(0.5) = 0$$

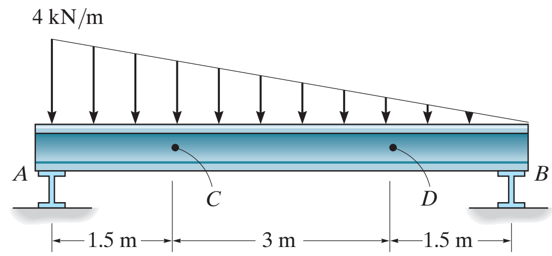
$$M_E = 0.3125 \text{ kN}\cdot\text{m} \qquad \textbf{Ans.}$$

Negative sign indicates that $\mathbf{V}_E$ acts in the opposite direction to that shown on FBD.

Ans:
$N_F = 1.17$ kN,
$V_F = 0$,
$M_F = 0$,
$N_E = 0.703$ kN,
$V_E = -0.3125$ kN,
$M_E = 0.3125$ kN·m

***1–8.**

The beam supports the distributed load shown. Determine the resultant internal loadings acting 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*,

$\circlearrowleft + \Sigma M_A = 0; \qquad B_y(6) - \frac{1}{2}(4)(6)(2) = 0 \qquad B_y = 4.00 \text{ kN}$

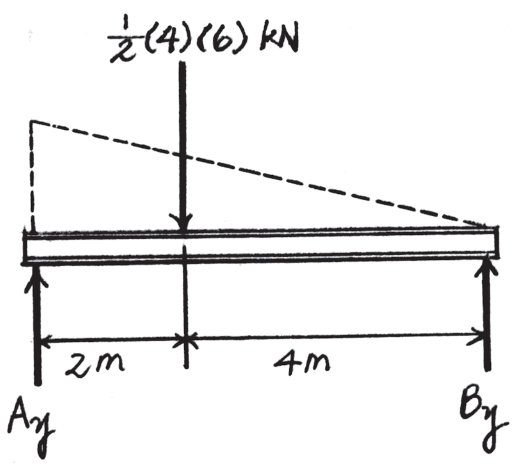
Internal Loadings: Referring to the FBD of the right segment of the beam sectioned through C, Fig. *b*,

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

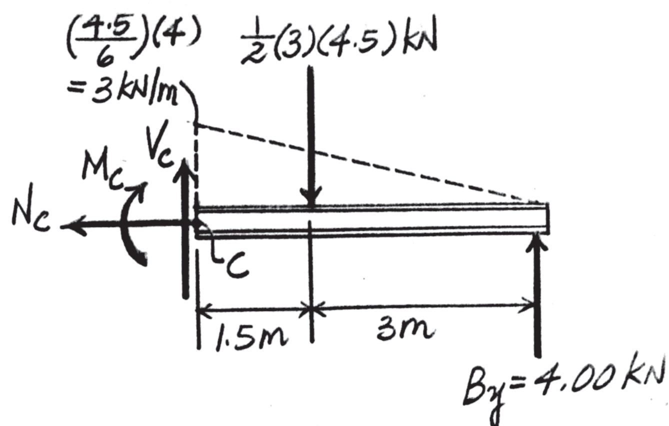
$+\uparrow \Sigma F_y = 0; \qquad V_C + 4.00 - \frac{1}{2}(3)(4.5) = 0 \qquad V_C = 2.75 \text{ kN}$ **Ans.**

$\circlearrowleft + \Sigma M_C = 0; \qquad 4.00(4.5) - \frac{1}{2}(3)(4.5)(1.5) - M_C = 0$

$M_C = 7.875 \text{ kN} \cdot \text{m}$ **Ans.**



(a)

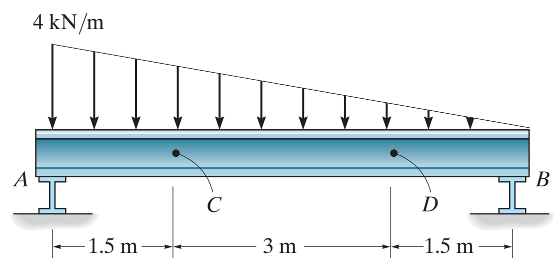


(b)

Ans:
$N_C = 0,$
$V_C = 2.75 \text{ kN},$
$M_C = 7.875 \text{ kN} \cdot \text{m}$

1–9.

The beam supports the distributed load shown. Determine the resultant internal loadings acting on the cross section at point D. Assume the reactions at the supports A and B are vertical.



SOLUTION

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

$$\circlearrowleft + \Sigma M_A = 0; \qquad B_y(6) - \frac{1}{2}(4)(6)(2) = 0 \qquad B_y = 4.00 \text{ kN}$$

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

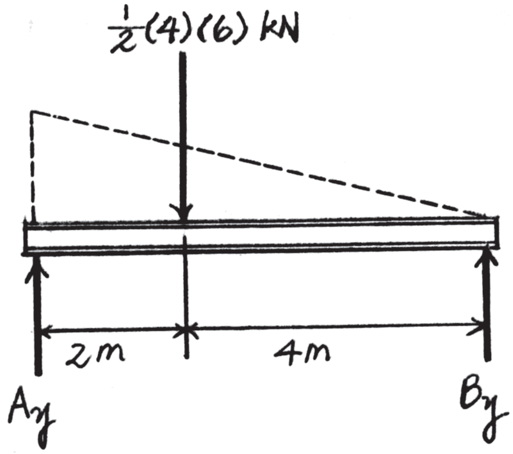
$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad N_D = 0 \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \qquad V_D + 4.00 - \frac{1}{2}(1.00)(1.5) = 0 \qquad V_D = -3.25 \text{ kN} \qquad \textbf{Ans.}$$

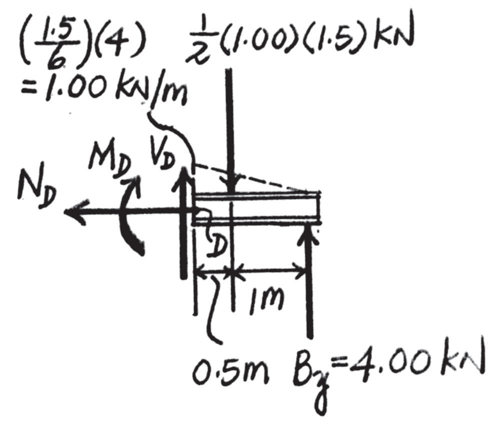
$$\circlearrowleft + \Sigma M_D = 0; \qquad 4.00(1.5) - \frac{1}{2}(1.00)(1.5)(0.5) - M_D = 0$$

$$M_D = 5.625 \text{ kN} \cdot \text{m} \qquad \textbf{Ans.}$$

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



(a)

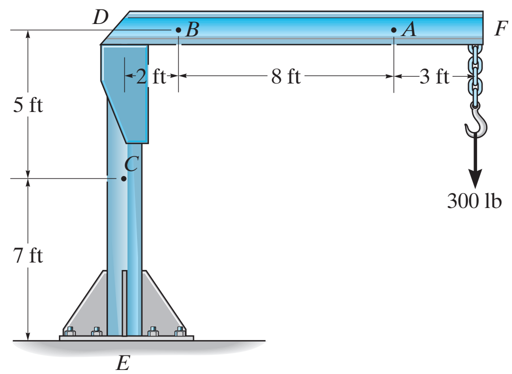


(b)

Ans:
$N_D = 0$,
$V_D = -3.25$ kN,
$M_D = 5.625$ kN·m

1–10.

The boom DF of the jib crane and the column DE have a uniform weight of 50 lb/ft. If the supported load is 300 lb, determine the resultant internal loadings in the crane on cross sections at points A, B, and C.



SOLUTION

Equations of Equilibrium: For point A

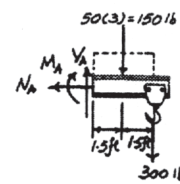
$\xleftarrow{+}\ \Sigma F_x = 0; \qquad N_A = 0$ **Ans.**

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

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

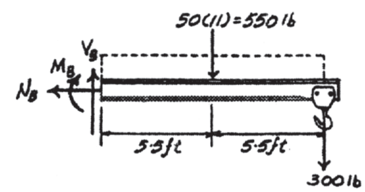
$\xleftarrow{+}\ \Sigma F_x = 0; \qquad N_B = 0$ **Ans.**

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

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

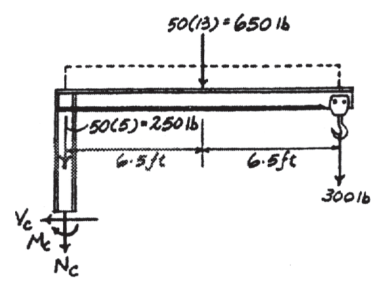
$\xleftarrow{+}\ \Sigma F_x = 0; \qquad V_C = 0$ **Ans.**

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

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

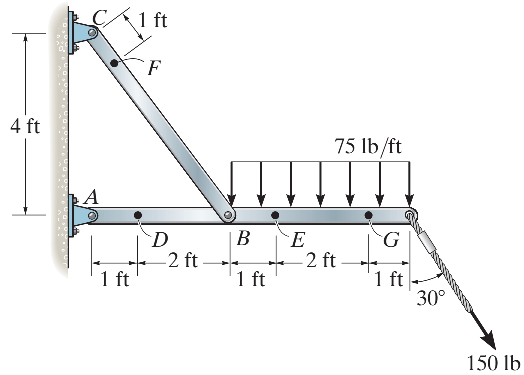


Negative signs indicate that N_C and M_C act in the opposite direction to that shown on FBD.

Ans:
$N_A = 0$, $V_A = 450$ lb, $M_A = -1.125$ kip · ft,
$N_B = 0$, $V_B = 850$ lb, $M_B = -6.325$ kip · ft,
$V_C = 0$, $N_C = -1.20$ kip, $M_C = -8.125$ kip · ft

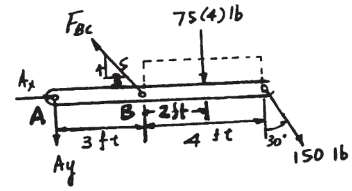
1–11.

Determine the resultant internal loadings acting on the cross sections at points D and E of the frame.



SOLUTION

Member AG:

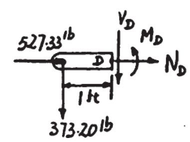


$\circlearrowleft + \Sigma M_A = 0; \quad \frac{4}{5}F_{BC}(3) - 75(4)(5) - 150 \cos 30°(7) = 0; \quad F_{BC} = 1003.89 \text{ lb}$

$\circlearrowleft + \Sigma M_B = 0; \quad A_y(3) - 75(4)(2) - 150 \cos 30°(4) = 0; \quad A_y = 373.20 \text{ lb}$

$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - \frac{3}{5}(1003.89) + 150 \sin 30° = 0; \quad A_x = 527.33 \text{ lb}$

For point D:



$\xrightarrow{+} \Sigma F_x = 0; \quad N_D + 527.33 = 0$

$N_D = -527 \text{ lb}$ **Ans.**

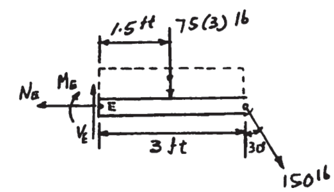
$+\uparrow \Sigma F_y = 0; \quad -373.20 - V_D = 0$

$V_D = -373 \text{ lb}$ **Ans.**

$\circlearrowleft + \Sigma M_D = 0; \quad M_D + 373.20(1) = 0$

$M_D = -373 \text{ lb} \cdot \text{ft}$ **Ans.**

For point E:



$\xrightarrow{+} \Sigma F_x = 0; \quad 150 \sin 30° - N_E = 0$

$N_E = 75.0 \text{ lb}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \quad V_E - 75(3) - 150 \cos 30° = 0$

$V_E = 355 \text{ lb}$ **Ans.**

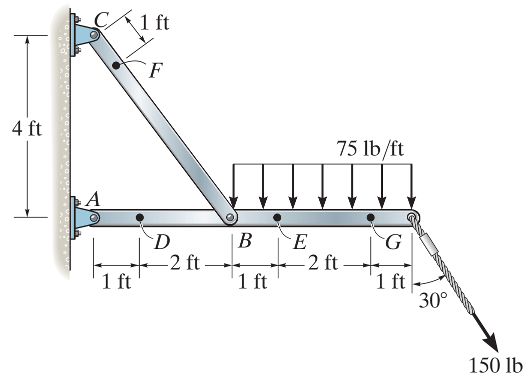
$\circlearrowleft + \Sigma M_E = 0; \quad -M_E - 75(3)(1.5) - 150 \cos 30°(3) = 0;$

$M_E = -727 \text{ lb} \cdot \text{ft}$ **Ans.**

Ans:
$N_D = -527$ lb,
$V_D = -373$ lb,
$M_D = -373$ lb · ft,
$N_E = 75.0$ lb,
$V_E = 355$ lb,
$M_E = -727$ lb · ft

***1–12.**

Determine the resultant internal loadings acting on the cross sections at points F and G of the frame.

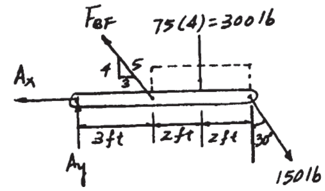


SOLUTION

Member AG:

$$\circlearrowleft+\Sigma M_A = 0; \qquad \frac{4}{5}F_{BF}(3) - 300(5) - 150\cos 30°(7) = 0$$

$$F_{BF} = 1003.9 \text{ lb}$$



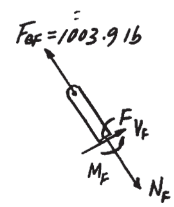
For point F:

$\nearrow^{+}\Sigma F_{x'} = 0; \qquad V_F = 0$ **Ans.**

$\nwarrow+\Sigma F_{y'} = 0; \qquad N_F - 1003.9 = 0$

$N_F = 1004 \text{ lb}$ **Ans.**

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



For point G:

$\overset{+}{\leftarrow}\Sigma F_x = 0; \qquad N_G - 150\sin 30° = 0$

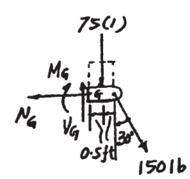
$N_G = 75.0 \text{ lb}$ **Ans.**

$+\uparrow\Sigma F_y = 0; \qquad V_G - 75(1) - 150\cos 30° = 0$

$V_G = 205 \text{ lb}$ **Ans.**

$\circlearrowleft+\Sigma M_G = 0; \qquad -M_G - 75(1)(0.5) - 150\cos 30°(1) = 0$

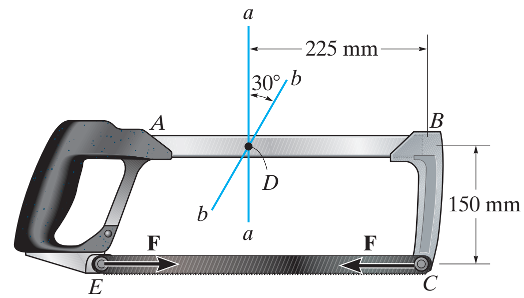
$M_G = -167 \text{ lb}\cdot\text{ft}$ **Ans.**



Ans:
$V_F = 0$,
$N_F = 1004$ lb,
$M_F = 0$,
$N_G = 75.0$ lb,
$V_G = 205$ lb,
$M_G = -167$ lb·ft

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

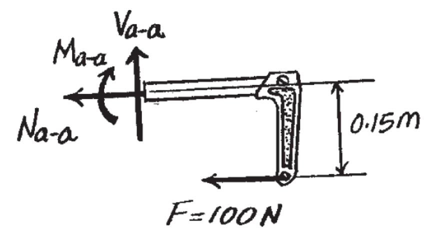
Internal Loadings: Referring to the free-body diagram of the section of the hacksaw shown in Fig. *a*,

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

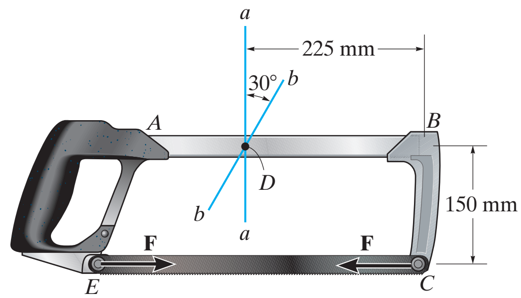


(a)

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.

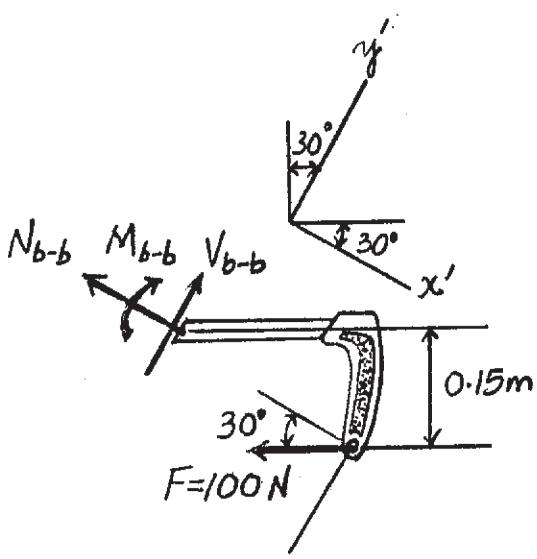


SOLUTION

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

$\Sigma F_{x'} = 0;$	$N_{b-b} + 100 \cos 30° = 0$	$N_{b-b} = -86.6 \text{ N}$	**Ans.**
$\Sigma F_{y'} = 0;$	$V_{b-b} - 100 \sin 30° = 0$	$V_{b-b} = 50 \text{ N}$	**Ans.**
$\circlearrowleft + \Sigma M_D = 0;$	$-M_{b-b} - 100(0.15) = 0$	$M_{b-b} = -15 \text{ N} \cdot \text{m}$	**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.

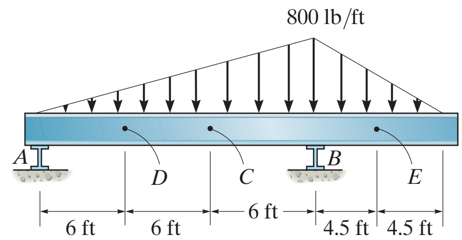


(a)

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

1–15.

The beam supports the triangular distributed load shown. 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,

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

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

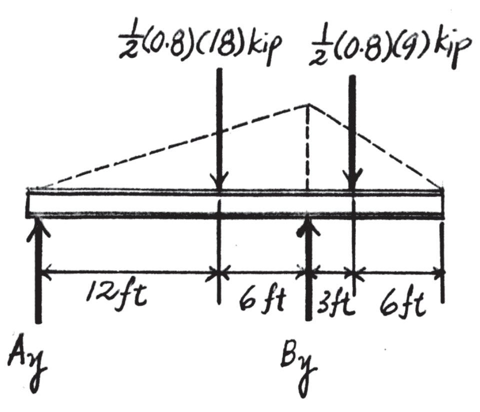
$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad N_C = 0 \qquad \textbf{Ans.}$$

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

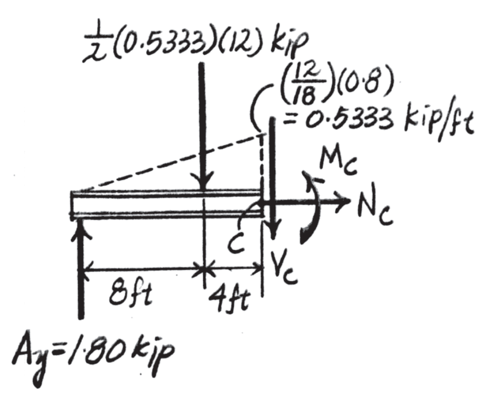
$$\circlearrowleft + \Sigma M_C = 0; \qquad M_C + \frac{1}{2}(0.5333)(12)(4) - 1.80(12) = 0$$

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

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



(a)

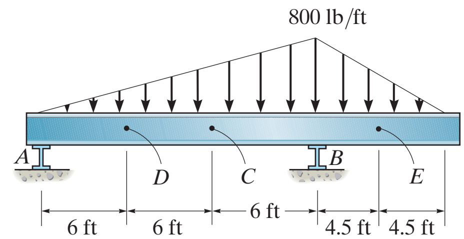


(b)

Ans:
$N_C = 0$,
$V_C = -1.40$ kip,
$M_C = 8.80$ kip · ft

***1–16.**

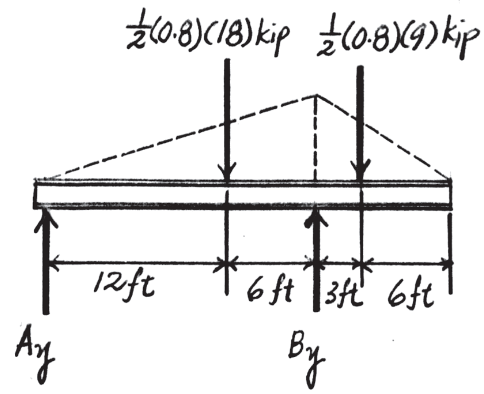
The beam supports the distributed load shown. Determine the resultant internal loadings on the cross section at points D and E. Assume the reactions at the supports A and B are vertical.



SOLUTION

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

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



(a)

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

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

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

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

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

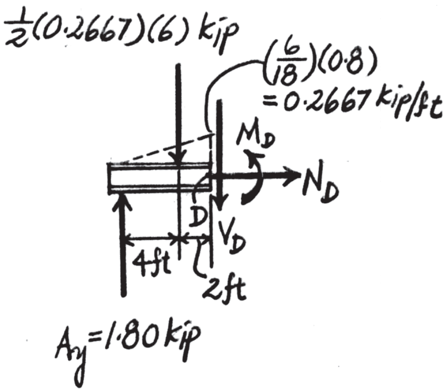
Referring to the FBD of the right segment of the beam sectioned through E, Fig. c,

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

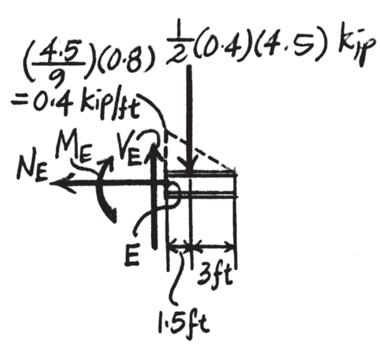
$+\uparrow \Sigma F_y = 0; \quad V_E - \frac{1}{2}(0.4)(4.5) = 0 \qquad V_E = 0.900 \text{ kip}$ **Ans.**

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

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



(b)

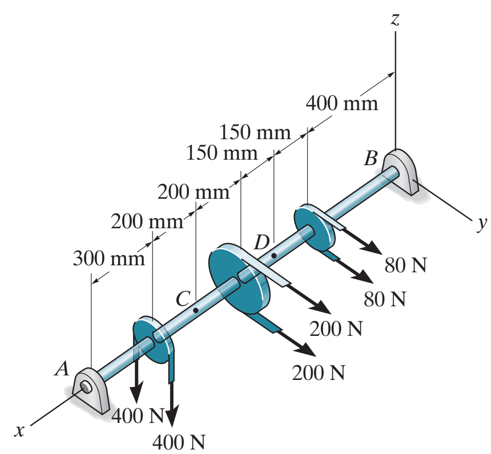


(c)

Ans:
$N_D = 0$,
$V_D = 1.00$ kip,
$M_D = 9.20 \text{ kip} \cdot \text{ft}$,
$N_E = 0$,
$V_E = 0.900$ kip,
$M_E = -1.35 \text{ kip} \cdot \text{ft}$

1–17.

The shaft is supported at its ends by two bearings A and B and is subjected to the forces applied to the pulleys fixed to the shaft. Determine the resultant internal loadings acting on the cross section at point D. The 400-N forces act in the $-z$ direction and the 200-N and 80-N forces act in the $+y$ direction. The journal bearings at A and B exert only y and z components of force on the shaft.



SOLUTION

Support Reactions:

$\Sigma M_z = 0; \qquad 160(0.4) + 400(0.7) - A_y(1.4) = 0$

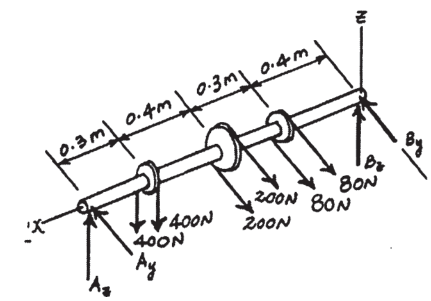
$A_y = 245.71 \text{ N}$

$\Sigma F_y = 0; \qquad -245.71 - B_y + 400 + 160 = 0$

$B_y = 314.29 \text{ N}$

$\Sigma M_y = 0; \qquad 800(1.1) - A_z(1.4) = 0 \qquad A_z = 628.57 \text{ N}$

$\Sigma F_z = 0; \qquad B_z + 628.57 - 800 = 0 \qquad B_z = 171.43 \text{ N}$



Equations of Equilibrium: For point D

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

$\Sigma F_y = 0; \qquad (V_D)_y - 314.29 + 160 = 0$

$(V_D)_y = 154 \text{ N}$ **Ans.**

$\Sigma F_z = 0; \qquad 171.43 + (V_D)_z = 0$

$(V_D)_z = -171 \text{ N}$ **Ans.**

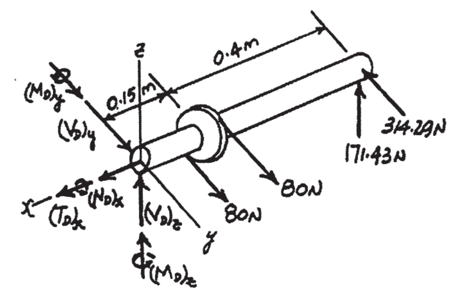
$\Sigma M_x = 0; \qquad (T_D)_x = 0$ **Ans.**

$\Sigma M_y = 0; \qquad 171.43(0.55) + (M_D)_y = 0$

$(M_D)_y = -94.3 \text{ N} \cdot \text{m}$ **Ans.**

$\Sigma M_z = 0; \qquad 314.29(0.55) - 160(0.15) + (M_D)_z = 0$

$(M_D)_z = -149 \text{ N} \cdot \text{m}$ **Ans.**

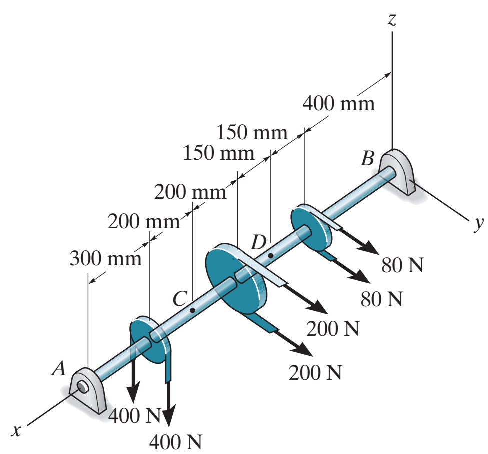


Ans:

$(N_D)_x = 0$,
$(V_D)_y = 154 \text{ N}$,
$(V_D)_z = -171 \text{ N}$,
$(T_D)_x = 0$,
$(M_D)_y = -94.3 \text{ N} \cdot \text{m}$,
$(M_D)_z = -149 \text{ N} \cdot \text{m}$

1–18.

The shaft is supported at its ends by two bearings A and B and is subjected to the forces applied to the pulleys fixed to the shaft. Determine the resultant internal loadings acting on the cross section at point C. The 400-N forces act in the $-z$ direction and the 200-N and 80-N forces act in the $+y$ direction. The journal bearings at A and B exert only y and z components of force on the shaft.



SOLUTION

Support Reactions:

$\Sigma M_z = 0;\qquad 160(0.4) + 400(0.7) - A_y(1.4) = 0$

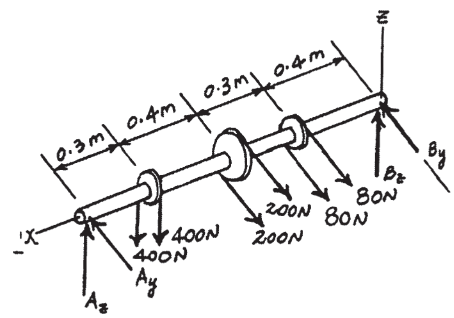
$A_y = 245.71 \text{ N}$

$\Sigma F_y = 0;\qquad -245.71 - B_y + 400 + 160 = 0$

$B_y = 314.29 \text{ N}$

$\Sigma M_y = 0;\qquad 800(1.1) - A_z(1.4) = 0 \qquad A_z = 628.57 \text{ N}$

$\Sigma F_z = 0;\qquad B_z + 628.57 - 800 = 0 \qquad B_z = 171.43 \text{ N}$



Equations of Equilibrium: For point C

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

$\Sigma F_y = 0;\qquad -245.71 + (V_C)_y = 0$

$(V_C)_y = -246 \text{ N}$ **Ans.**

$\Sigma F_z = 0;\qquad 628.57 - 800 + (V_C)_z = 0$

$(V_C)_z = -171 \text{ N}$ **Ans.**

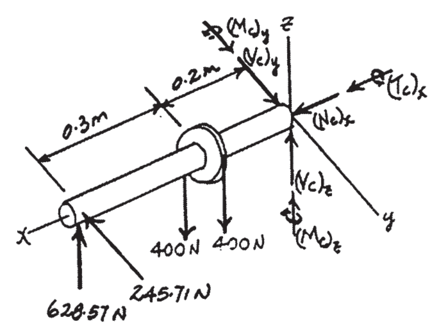
$\Sigma M_x = 0;\qquad (T_C)_x = 0$ **Ans.**

$\Sigma M_y = 0;\qquad (M_C)_y - 628.57(0.5) + 800(0.2) = 0$

$(M_C)_y = -154 \text{ N}\cdot\text{m}$ **Ans.**

$\Sigma M_z = 0;\qquad (M_C)_z - 245.71(0.5) = 0$

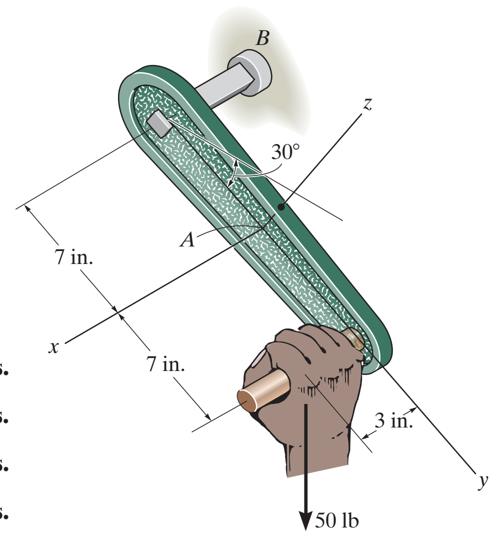
$(M_C)_z = -123 \text{ N}\cdot\text{m}$ **Ans.**



Ans:
$(N_C)_x = 0,$
$(V_C)_y = -246 \text{ N},$
$(V_C)_z = -171 \text{ N},$
$(T_C)_x = 0,$
$(M_C)_y = -154 \text{ N}\cdot\text{m},$
$(M_C)_z = -123 \text{ N}\cdot\text{m}$

1–19.

The hand crank that is used in a press has the dimensions shown. Determine the resultant internal loadings acting on the cross section at point A if a vertical force of 50 lb is applied to the handle as shown. Assume the crank is fixed to the shaft at B.



SOLUTION

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

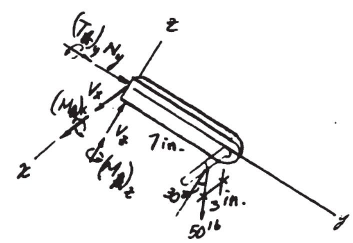
$\Sigma F_y = 0; \quad (N_A)_y + 50 \sin 30° = 0; \quad (N_A)_y = -25 \text{ lb}$ **Ans.**

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

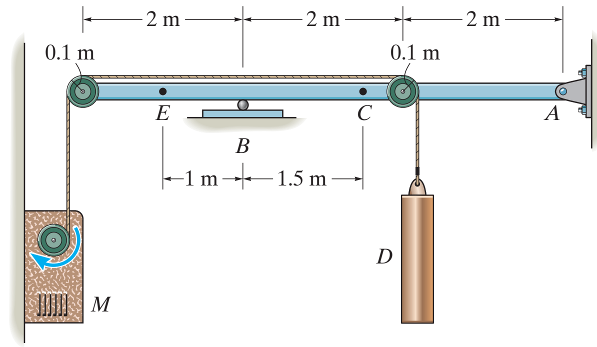


Ans:

$(V_A)_x = 0$,
$(N_A)_y = -25$ lb,
$(V_A)_z = 43.3$ lb,
$(M_A)_x = 303$ lb · in.,
$(T_A)_y = -130$ lb · in.,
$(M_A)_z = -75$ lb · in.

***1–20.**

Determine the resultant internal loadings acting on the cross section at point C in the beam. The load D has a mass of 300 kg and is being hoisted by the motor M with constant velocity.



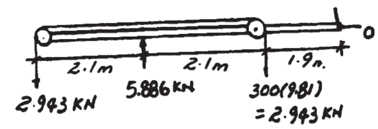
SOLUTION

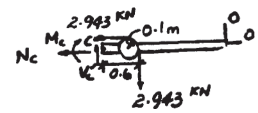
$\overset{+}{\leftarrow} \Sigma F_x = 0; \qquad N_C + 2.943 = 0; \qquad N_C = -2.94 \text{ kN}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \qquad V_C - 2.943 = 0; \qquad V_C = 2.94 \text{ kN}$ **Ans.**

$\circlearrowleft + \Sigma M_C = 0; \qquad -M_C - 2.943(0.6) + 2.943(0.1) = 0$

$M_C = -1.47 \text{ kN} \cdot \text{m}$ **Ans.**



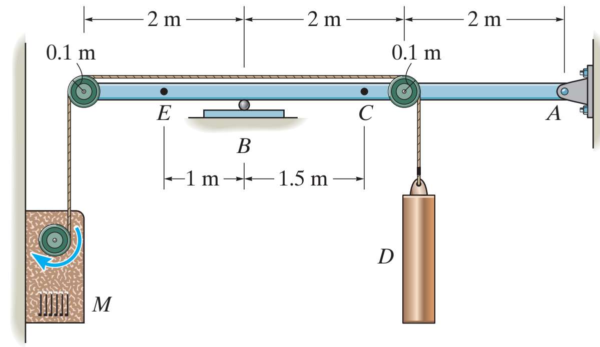


Ans:

$N_C = -2.94$ kN,
$V_C = 2.94$ kN,
$M_C = -1.47$ kN $\cdot$ m

1–21.

Determine the resultant internal loadings acting on the cross section at point E. The load D has a mass of 300 kg and is being hoisted by the motor M with constant velocity.



SOLUTION

$\overset{+}{\rightarrow}\Sigma F_x = 0;\qquad N_E + 2943 = 0$

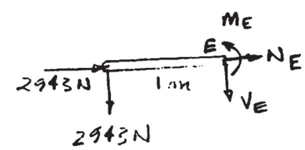
$N_E = -2.94\text{ kN}$ **Ans.**

$+\uparrow\Sigma F_y = 0;\qquad -2943 - V_E = 0$

$V_E = -2.94\text{ kN}$ **Ans.**

$\circlearrowleft + \Sigma M_E = 0;\qquad M_E + 2943(1) = 0$

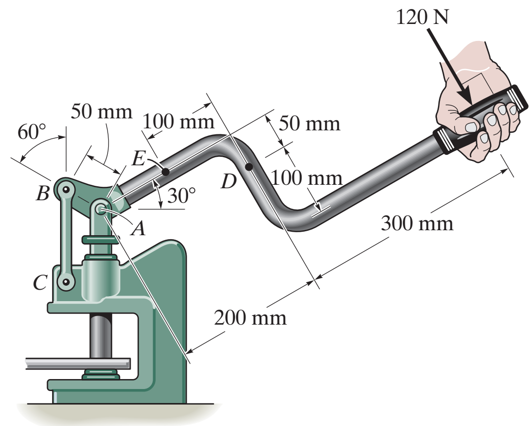
$M_E = -2.94\text{ kN}\cdot\text{m}$ **Ans.**



Ans:
$N_E = -2.94\text{ kN}$,
$V_E = -2.94\text{ kN}$,
$M_E = -2.94\text{ kN}\cdot\text{m}$

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.

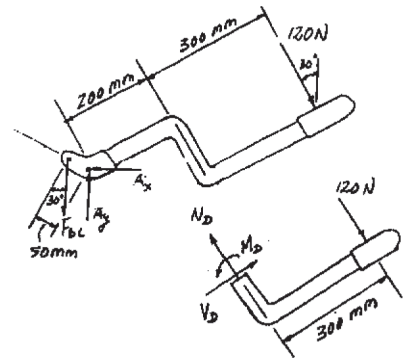


SOLUTION

Member:

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

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

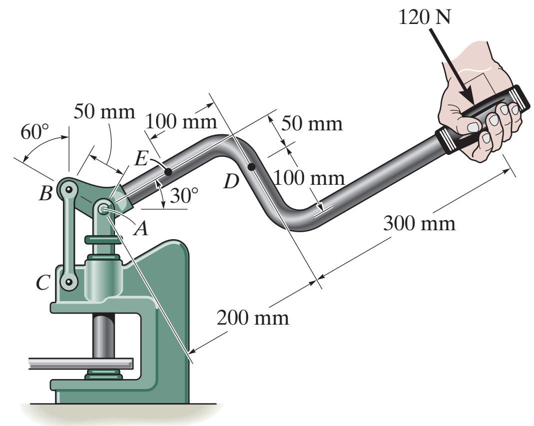
$\circlearrowleft + \Sigma M_D = 0;$ $\qquad M_D - 120(0.3) = 0$

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

Determine the resultant internal loadings acting on the cross section at point E of the handle arm, and on the cross section of the short link BC.

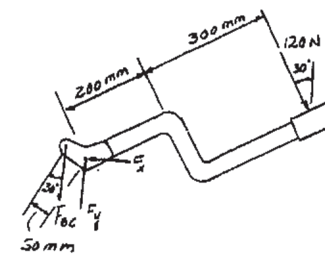


SOLUTION

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:

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

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

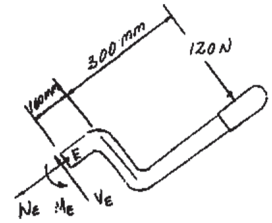
$\circlearrowleft + \Sigma M_E = 0; \qquad M_E - 120(0.4) = 0; \qquad M_E = 48.0 \text{ N} \cdot \text{m}$ **Ans.**

Short link:

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

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

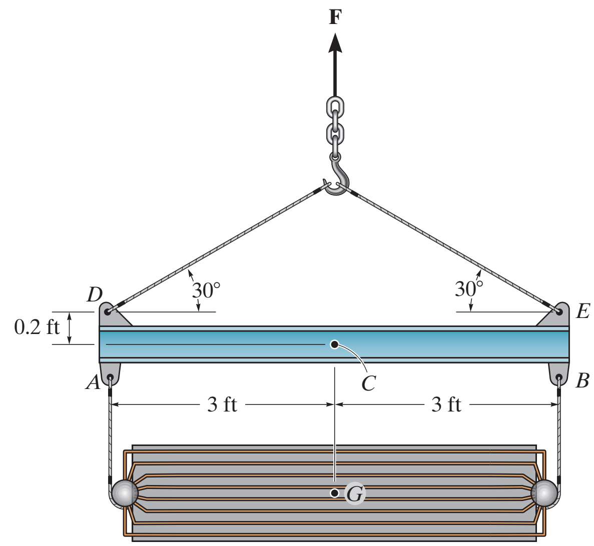
$\circlearrowleft + \Sigma M_H = 0; \qquad M = 0$ **Ans.**



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)

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

From FBD (b)

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

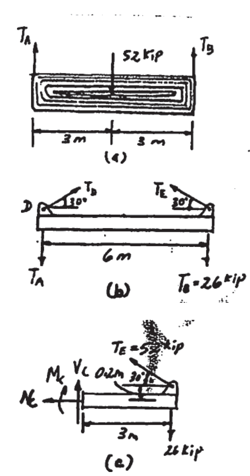
From FBD (c)

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

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

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

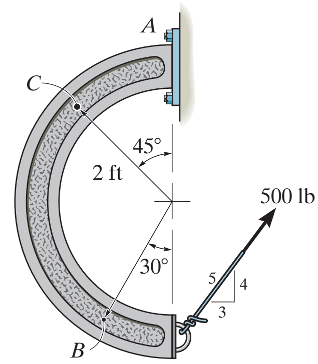
$M_C = 9.00 \text{ kip} \cdot \text{ft}$ **Ans.**



Ans:
$N_C = -45.0$ kip,
$V_C = 0$,
$M_C = 9.00$ kip $\cdot$ ft

1–25.

Determine the resultant internal loadings acting on the cross section at points B and C of the curved member.



SOLUTION

From FBD (a)

$$\nearrow + \Sigma F_{x'} = 0; \qquad 400 \cos 30° + 300 \cos 60° - V_B = 0$$

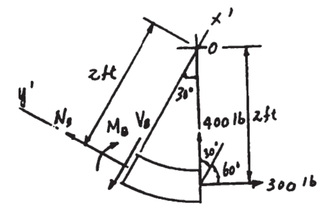
$$V_B = 496 \text{ lb} \qquad \textbf{Ans.}$$

$$\nwarrow + \Sigma F_{y'} = 0; \qquad N_B + 400 \sin 30° - 300 \sin 60° = 0$$

$$N_B = 59.80 = 59.8 \text{ lb} \qquad \textbf{Ans.}$$

$$\circlearrowleft + \Sigma M_O = 0; \qquad 300(2) - 59.80(2) - M_B = 0$$

$$M_B = 480 \text{ lb} \cdot \text{ft} \qquad \textbf{Ans.}$$



(a)

From FBD (b)

$$\nearrow + \Sigma F_{x'} = 0; \qquad 400 \cos 45° + 300 \cos 45° - N_C = 0$$

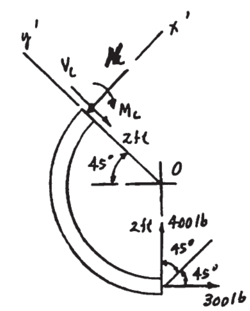
$$N_C = 495 \text{ lb} \qquad \textbf{Ans.}$$

$$\nwarrow + \Sigma F_{y'} = 0; \qquad -V_C + 400 \sin 45° - 300 \sin 45° = 0$$

$$V_C = 70.7 \text{ lb} \qquad \textbf{Ans.}$$

$$\circlearrowleft + \Sigma M_O = 0; \qquad 300(2) + 495(2) - M_C = 0$$

$$M_C = 1590 \text{ lb} \cdot \text{ft} = 1.59 \text{ kip} \cdot \text{ft} \qquad \textbf{Ans.}$$



(b)

Ans:
$V_B = 496$ lb,
$N_B = 59.8$ lb,
$M_B = 480$ lb · ft,
$N_C = 495$ lb,
$V_C = 70.7$ lb,
$M_C = 1.59$ kip · ft