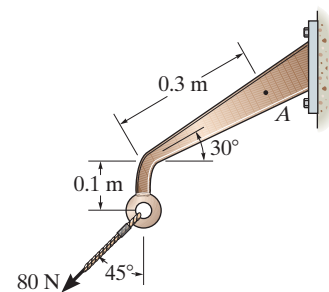**1–1.** A force of 80 N is supported by the bracket as shown. Determine the resultant internal loadings acting on the section through point A.

SOLUTION

Equations of Equilibrium:

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

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

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

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

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

$\qquad\qquad\qquad - 80 \sin 45°(0.1 + 0.3 \sin 30°) = 0$

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

or

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

$\qquad\qquad\qquad - 80 \cos 15°(0.1 \cos 30°) = 0$

$\qquad\qquad\qquad M_A = -0.555 \text{ N} \cdot \text{m}$ **Ans.**
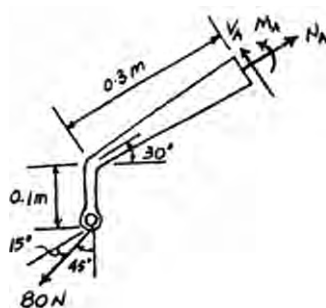
Negative sign indicates that M_A acts in the opposite direction to that shown on FBD.

Ans:

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

1

1–2.

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

SOLUTION

Support Reactions: Member BC is the two force member.

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

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

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

$A_y = 0.9375 \text{ kN}$

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

$A_x = 0.7031 \text{ kN}$

Equations of Equilibrium: For point D

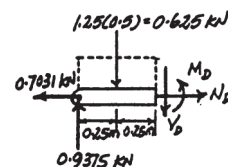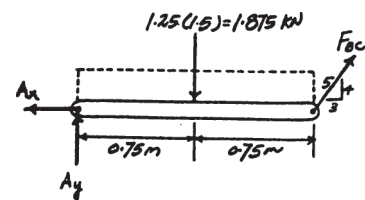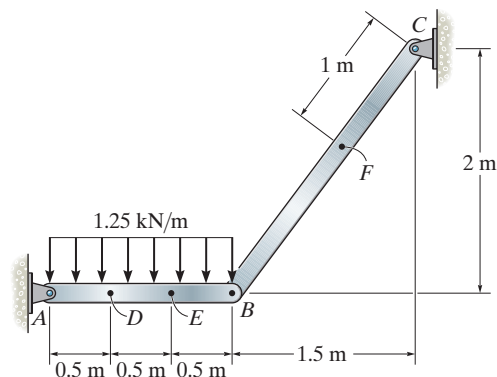$\xrightarrow{+} \Sigma F_x = 0; \quad N_D - 0.7031 = 0$

$N_D = 0.703 \text{ kN}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \quad 0.9375 - 0.625 - V_D = 0$

$V_D = 0.3125 \text{ kN}$ **Ans.**

$\zeta + \Sigma M_D = 0; \quad M_D + 0.625(0.25) - 0.9375(0.5) = 0$

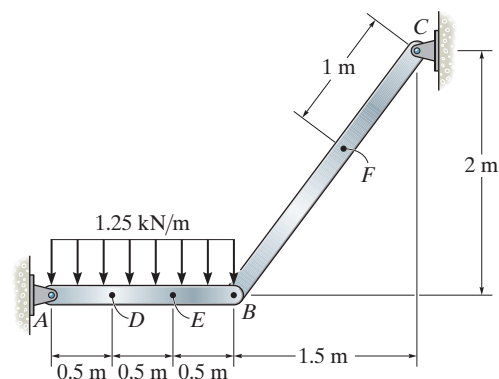$M_D = 0.3125 \text{ kN} \cdot \text{m}$ **Ans.**

Ans:
$N_D = 0.703 \text{ kN},$
$V_D = 0.3125 \text{ kN},$
$M_D = 0.3125 \text{ kN} \cdot \text{m}$

1–3.

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.

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

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

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

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

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

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

Equations of Equilibrium: For point F

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

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

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

$$\zeta + \Sigma M_F = 0; \quad M_F = 0 \qquad \text{Ans.}$$

Equations of Equilibrium: For point E

$$\xleftarrow{+} \Sigma F_x = 0; \quad N_E - \frac{3}{5}(1.1719) = 0$$
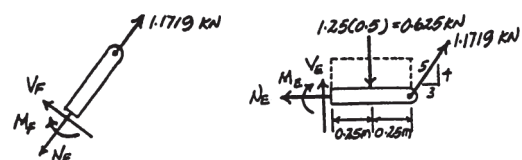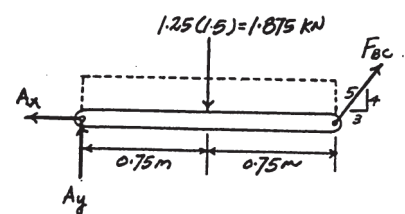
$$N_E = 0.703 \text{ kN} \qquad \text{Ans.}$$

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

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

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

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

Negative sign indicates that $\mathbf{V}_E$ acts in the opposite direction to that shown on FBD.
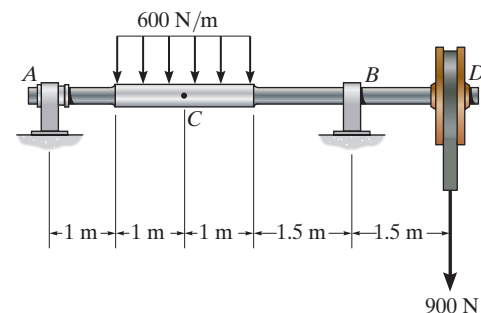
Ans:
$N_F = 1.17 \text{ kN},$
$V_F = 0,$
$M_F = 0,$
$N_E = 0.703 \text{ kN},$
$V_E = -0.3125 \text{ kN},$
$M_E = 0.3125 \text{ kN} \cdot \text{m}$

*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.

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

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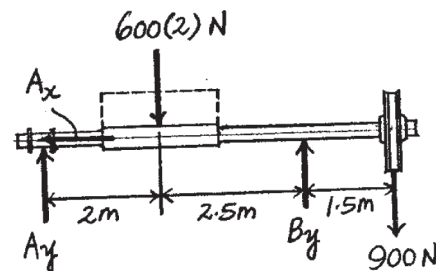
$$\xrightarrow{+} \Sigma F_x = 0; \qquad N_C = 0 \qquad\qquad\qquad\qquad\qquad\qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \qquad V_C - 600(1) + 1733.33 - 900 = 0 \qquad V_C = -233 \text{ N} \qquad \textbf{Ans.}$$
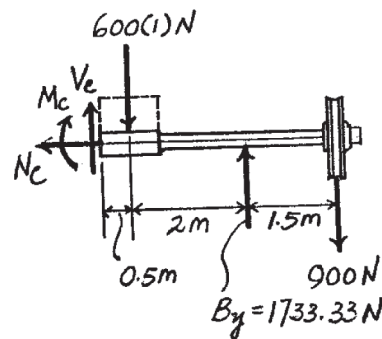
$$\zeta + \Sigma M_C = 0; \qquad 1733.33(2.5) - 600(1)(0.5) - 900(4) - M_C = 0$$

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

The negative sign indicates that $\mathbf{V}_C$ acts in the opposite sense to that shown on the free-body diagram.
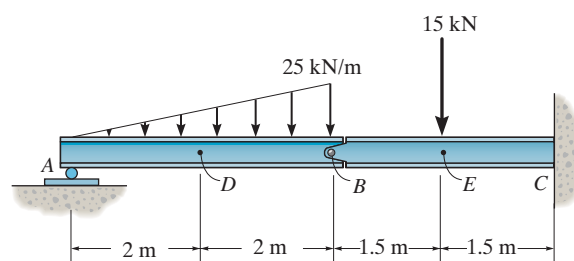
1–5. Determine the resultant internal loadings in the beam at cross sections through points D and E. Point E is just to the right of the 15-kN load.

SOLUTION

Support Reactions: For member AB

$\zeta + \Sigma M_B = 0;$ $\qquad 50(4/3) - A_y(4) = 0$ $\qquad A_y = 16.67$ kN

$\xrightarrow{+} \Sigma F_x = 0;$ $\qquad B_x = 0$

$+\uparrow \Sigma F_y = 0;$ $\qquad B_y + 16.67 - 50 = 0$ $\qquad B_y = 33.33$ kN

Equations of Equilibrium: For point D

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

$+\uparrow \Sigma F_y = 0;$ $\qquad 16.67 - 12.5 - V_D = 0$

$\qquad\qquad V_D = 4.17$ kN **Ans.**

$\zeta + \Sigma M_D = 0;$ $\qquad M_D + 12.25(\frac{2}{3}) - 16.67(2) = 0$

$\qquad\qquad M_D = 25.17$ kN $\cdot$ m **Ans.**

Equations of Equilibrium: For point E

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

$+\uparrow \Sigma F_y = 0;$ $\qquad -33.33 - 15 - V_E = 0$

$\qquad\qquad V_E = -48.33$ kN **Ans.**

$\zeta + \Sigma M_E = 0;$ $\qquad M_E + 33.33(1.5) = 0$
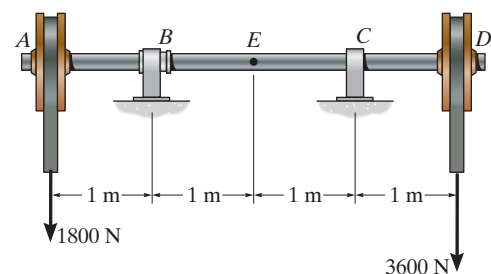
$\qquad\qquad M_E = -50.00$ kN $\cdot$ m **Ans.**

Negative signs indicate that M_E and V_E act in the opposite direction to that shown on FBD.
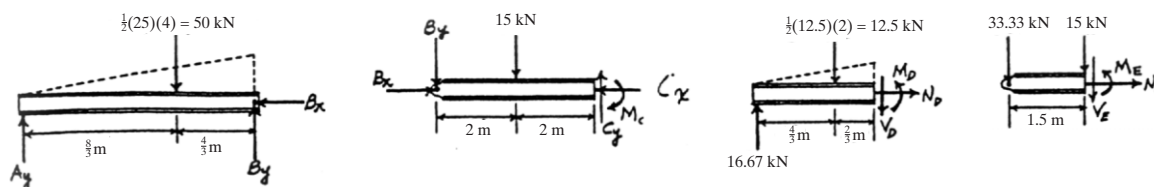
Ans:
$N_D = 0, V_D = 4.17$ kN,
$M_D = 25.0$ kN $\cdot$ m, $N_E = 0, V_E = -48.3$ kN,
$M_E = -50.0$ kN $\cdot$ m

1–6. 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 C_y by writing the moment equation of equilibrium about B with reference to the free-body diagram of the entire shaft, Fig. a.

$\zeta + \Sigma M_B = 0;$ $C_y(2) + 1800(1) - 3600(3) = 0$ $C_y = 4500$ N

(a)

Internal Loadings: Using the result for C_y, section DE of the shaft will be considered. Referring to the free-body diagram, Fig. b,
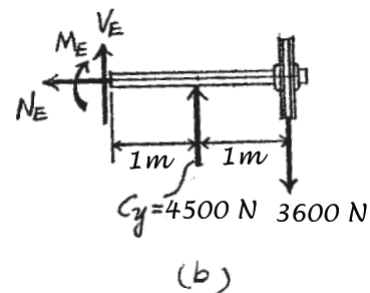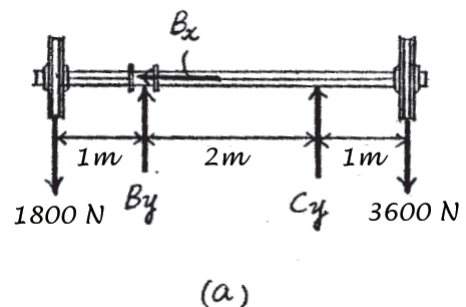
$\xrightarrow{+} \Sigma F_x = 0;$ $N_E = 0$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $V_E + 4500 - 3600 = 0$ $V_E = -900$ N   **Ans.**

$\zeta + \Sigma M_E = 0; 4500(1) - 3600(2) - M_E = 0$
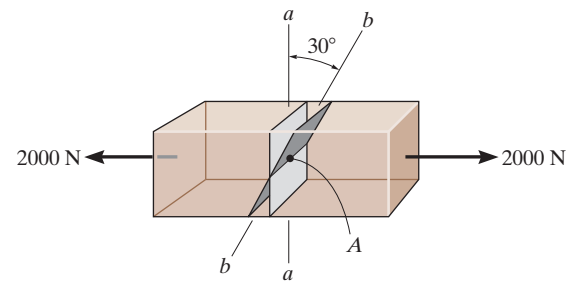
$M_E = -2700$ N·m $= -2.70$ kN·m   **Ans.**

The negative signs indicates that V_E and M_E act in the opposite sense to that shown on the free-body diagram.

(b)

Ans:

$N_E = 0,\ V_E = -900$ N, $M_E = -2.7$ kN·m

6

1–7. 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 point A. The 2000-N load is applied along the centroidal axis of the member.
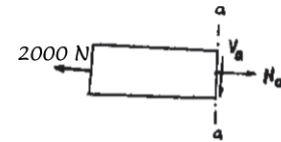

(a)

$\xrightarrow{+} \Sigma F_x = 0; \qquad N_a - 2000 = 0$

$\qquad\qquad\qquad N_a = 2000 \text{ N}$ **Ans.**

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

(b)

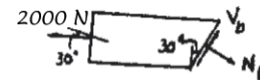$\searrow^{+} \Sigma F_x = 0; \qquad N_b - 2000 \cos 30° = 0$

$\qquad\qquad\qquad N_b = 1732 \text{ N}$ **Ans.**

$+\nearrow \Sigma F_y = 0; \qquad V_b - 2000 \sin 30° = 0$

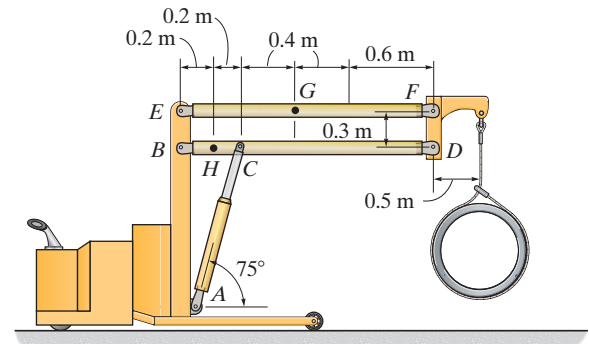$\qquad\qquad\qquad V_b = 1000 \text{ N}$ **Ans.**

Ans:
$N_a = 2000 \text{ N}, V_a = 0,$
$N_b = 1732 \text{ N}, V_b = 1000 \text{ N}$

*1–8.

The floor crane is used to lift a 600-kg concrete pipe. Determine the resultant internal loadings acting on the cross section at G.

SOLUTION

Support Reactions: We will only need to compute $\mathbf{F}_{EF}$ by writing the moment equation of equilibrium about D with reference to the free-body diagram of the hook, Fig. a.
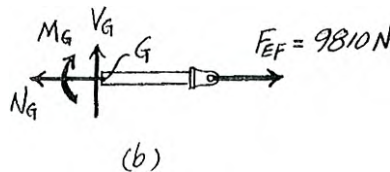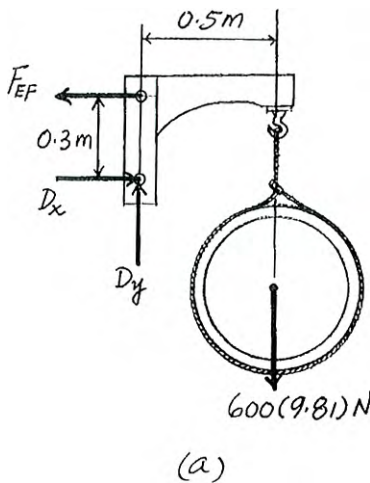
$\zeta + \Sigma M_D = 0;$ $F_{EF}(0.3) - 600(9.81)(0.5) = 0$ $F_{EF} = 9810$ N

Internal Loadings: Using the result for $\mathbf{F}_{EF}$, section FG of member EF will be considered. Referring to the free-body diagram, Fig. b,

$\xrightarrow{+} \Sigma F_x = 0;$ $9810 - N_G = 0$ $N_G = 9810$ N $= 9.81$ kN   **Ans.**

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

$\zeta + \Sigma M_G = 0;$ $M_G = 0$ **Ans.**

(a)

(b)

Ans:

$N_G = 9.81$ kN, $V_G = 0$, $M_G = 0$

8

1–9. The floor crane is used to lift a 600-kg concrete pipe. Determine the resultant internal loadings acting on the cross section at H.
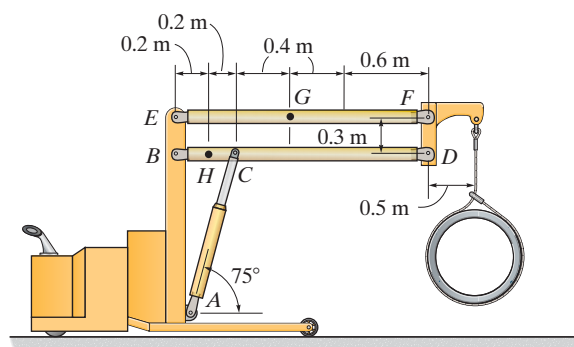
SOLUTION

Support Reactions: Referring to the free-body diagram of the hook, Fig. *a*.

$\zeta + \Sigma M_F = 0;$ $D_x(0.3) - 600(9.81)(0.5) = 0$ $D_x = 9810$ N

$+\uparrow \Sigma F_y = 0;$ $D_y - 600(9.81) = 0$ $D_y = 5886$ N

Subsequently, referring to the free-body diagram of member BCD, Fig. *b*,

$\zeta + \Sigma M_B = 0;$ $F_{AC} \sin 75°(0.4) - 5886(1.8) = 0$ $F_{AC} = 27\,421.36$ N

$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $B_x + 27\,421.36 \cos 75° - 9810 = 0$ $B_x = 2712.83$ N

$+\uparrow \Sigma F_y = 0;$ $27\,421.36 \sin 75° - 5886 - B_y = 0$ $B_y = 20\,601$ N

Internal Loadings: Using the results of $\mathbf{B}_x$ and $\mathbf{B}_y$, section BH of member BCD will be considered. Referring to the free-body diagram of this part shown in Fig. *c*,

$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $N_H + 2712.83 = 0$ $N_H = -2712.83$ N $= -2.71$ kN   **Ans.**

$+\uparrow \Sigma F_y = 0;$ $-V_H - 2060 = 0$ $V_H = -20601$ N $= -20.6$ kN   **Ans.**

$\zeta + \Sigma M_D = 0;$ $M_H + 20601(0.2) = 0$ $M_H = -4120.2$ N $\cdot$ m

$$= -4.12 \text{ kN} \cdot \text{m} \quad \textbf{Ans.}$$

The negative signs indicates that N_H, V_H, and M_H act in the opposite sense to that shown on the free-body diagram.
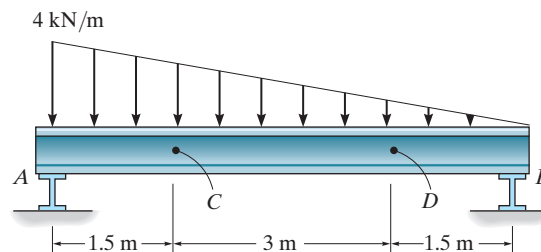
(a)

(b)

(c)
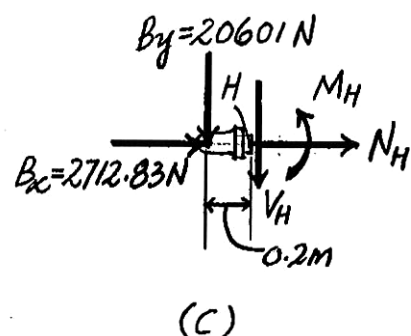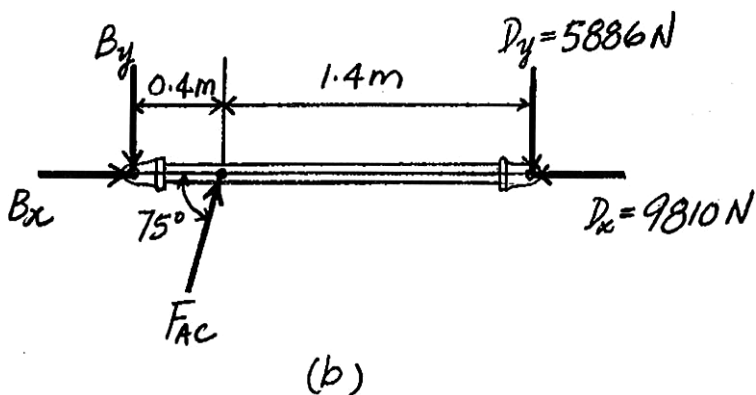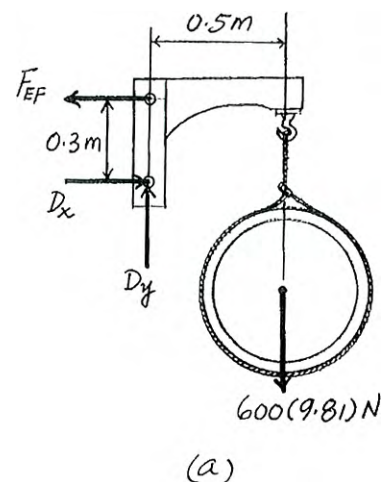
Ans:
$N_H = -2.71$ kN, $V_H = -20.6$ kN,
$M_H = -4.12$ kN $\cdot$ m

9

1–10.

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.

4 kN/m

A C D B

|←1.5 m→|←— 3 m —→|←1.5 m→|

SOLUTION

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

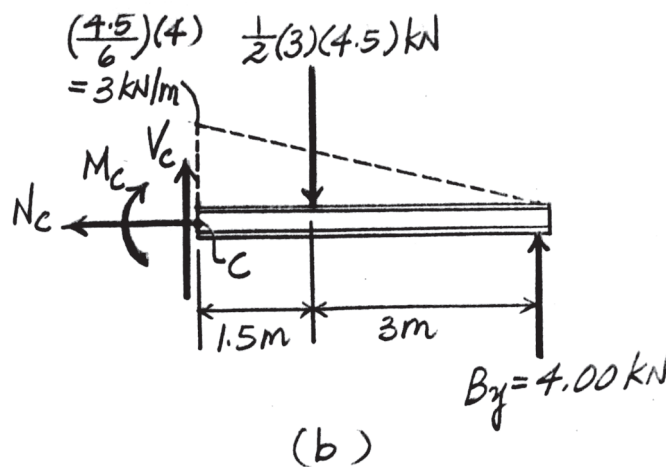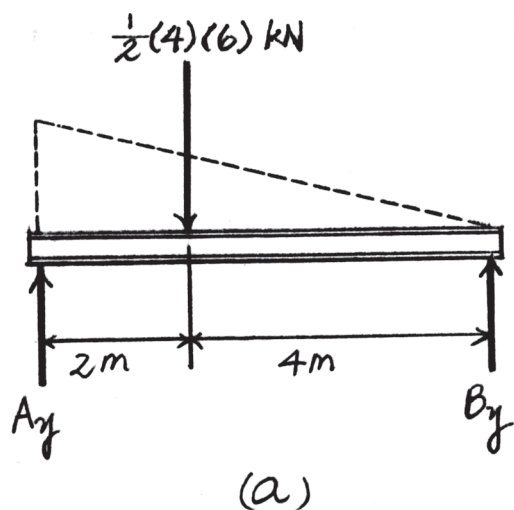$$\zeta+\Sigma M_A = 0; \qquad B_y(6) - \frac{1}{2}(4)(6)(2) = 0 \qquad B_y = 4.00 \text{ kN}$$

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

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

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

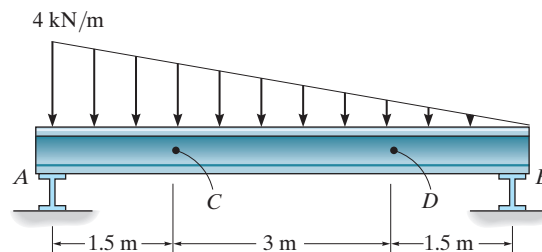$$\zeta+\Sigma M_C = 0; \qquad 4.00(4.5) - \frac{1}{2}(3)(4.5)(1.5) - M_C = 0$$

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

(a)

(b)

1–11.

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.

4 kN/m

A C D B

—1.5 m— —— 3 m —— —1.5 m—

SOLUTION

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

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

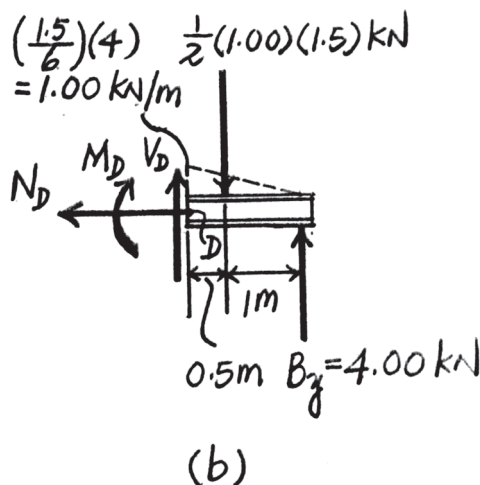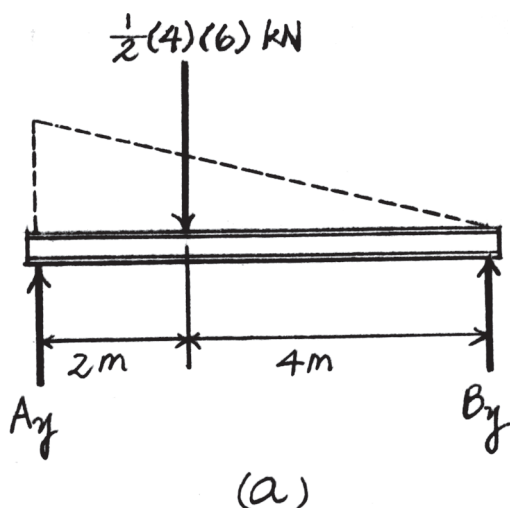**Internal Loadings:** Referring to the FBD of the right segment of the beam sectioned through D, Fig. b,

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

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

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

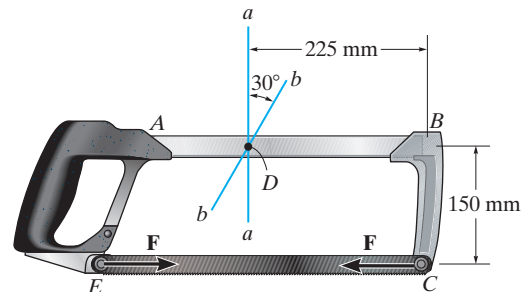$$M_D = 5.625 \text{ kN} \cdot \text{m} \qquad \textbf{Ans.}$$

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 $\cdot$ m

11

*1–12.

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.
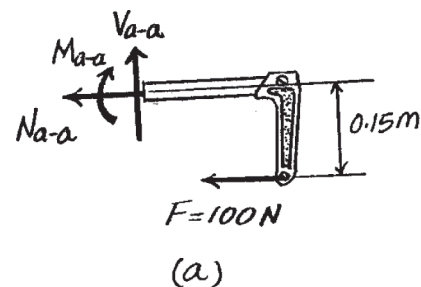
SOLUTION

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

$$\xrightarrow{+}\ \Sigma F_x = 0; \qquad N_{a-a} + 100 = 0 \qquad\qquad N_{a-a} = -100 \text{ N} \qquad\qquad \textbf{Ans.}$$

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

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

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.
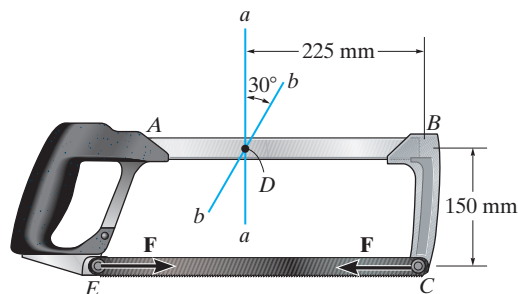

(a)

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

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 b–b that passes through point D.
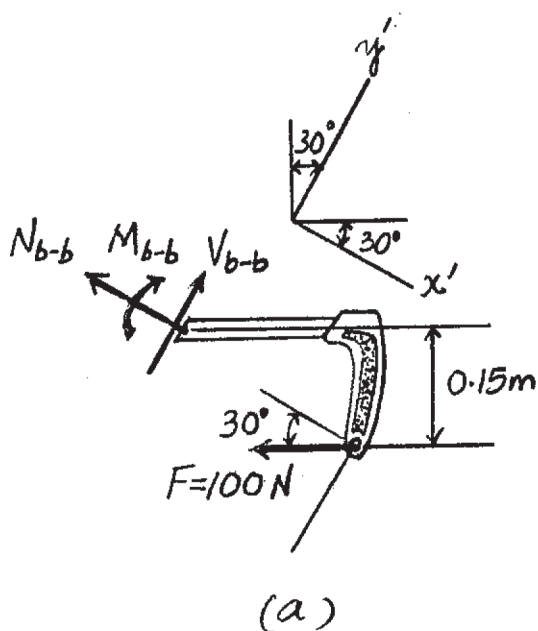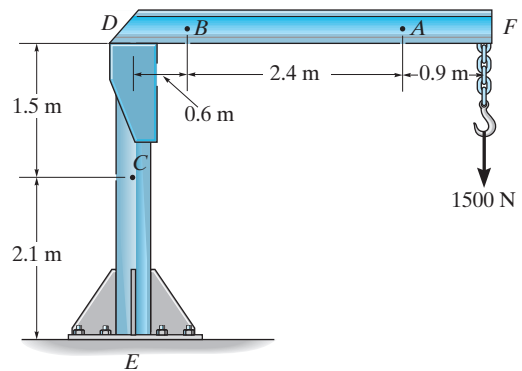
SOLUTION

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

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

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

$\zeta + \Sigma M_D = 0;$ $-M_{b-b} - 100(0.15) = 0$ $M_{b-b} = -15$ N · 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

1–14. The boom DF of the jib crane and the column DE have a uniform wieght of 750 N/m. If the hoist and load weigh 1500 N, determine the resultant internal loadings in the crane on cross sections through points A, B, and C.

SOLUTION

Equations of Equilibrium: For point A

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

$+\uparrow \Sigma F_y = 0;$ $\qquad V_A - 0.675 - 1.500 = 0$

$\qquad\qquad V_A = 2.175$ kN **Ans.**

$\zeta + \Sigma M_A = 0;$ $\qquad -M_A - 0.675(0.45) - 1.500(0.9) = 0$

$\qquad\qquad M_A = -1.65$ kN $\cdot$ m **Ans.**

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

Equations of Equilibrium: For point B

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

$+\uparrow \Sigma F_y = 0;$ $\qquad V_B - 2.475 - 1.5 = 0$

$\qquad\qquad V_B = 3.975$ kN **Ans.**

$\zeta + \Sigma M_B = 0;$ $\qquad -M_B - 2.475(1.65) - 1.500(3.3) = 0$

$\qquad\qquad M_B = -9.03$ kN $\cdot$ m **Ans.**

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

Equations of Equilibrium: For point C

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

$+\uparrow \Sigma F_y = 0;$ $\qquad -N_C - 1.125 - 2.925 - 1.500 = 0$

$\qquad\qquad N_C = -5.55$ kN **Ans.**

$\zeta + \Sigma M_C = 0;$ $\qquad -M_C - 2.925(1.95) - 1.500(3.9) = 0$

$\qquad\qquad M_C = -11.6$ kN $\cdot$ m **Ans.**

Negative signs indicate that N_C and M_C act in the opposite direction to that shown on FBD.
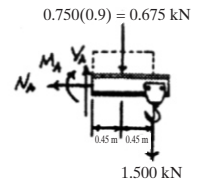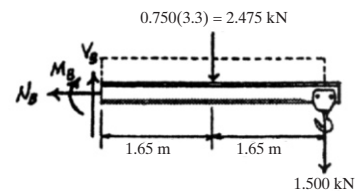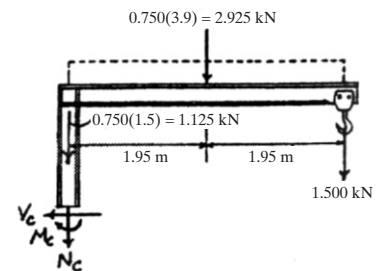
Ans:
$N_A = 0$, $V_A = 2.175$ kN, $M_A = -1.65$ kN $\cdot$ m,
$N_B = 0$, $V_B = 3.975$ kN, $M_B = -9.03$ kN $\cdot$ m,
$V_C = 0$, $N_C = -5.55$ kN, $M_C = -11.6$ kN $\cdot$ m

1–15.

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.
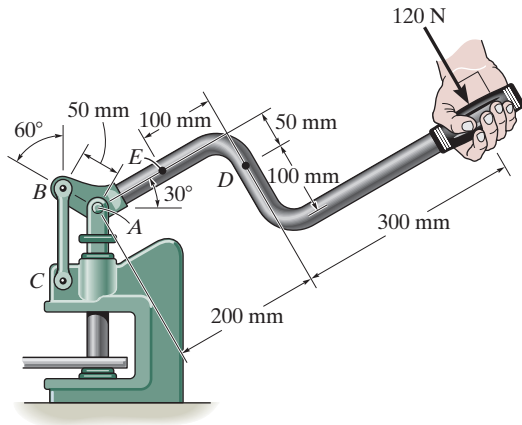
SOLUTION

Member:

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

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

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

$$A_y = 1489.56 \text{ N}$$

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

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

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

Segment:

$$\nwarrow^{+} \Sigma F_{x'} = 0; \qquad N_D - 120 = 0$$
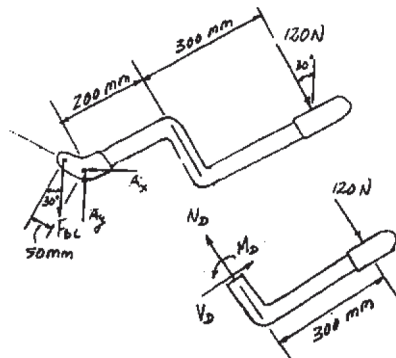
$$N_D = 120 \text{ N} \qquad \textbf{Ans.}$$

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

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

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

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

*1–16.

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:

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

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

Segment:

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

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

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

Short link:

$\pm \Sigma F_x = 0;$ $V = 0$ **Ans.**

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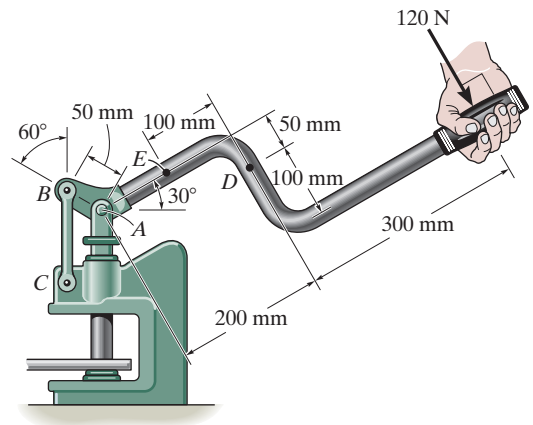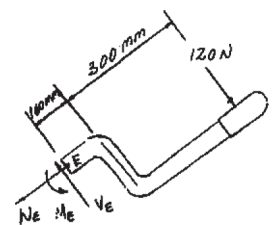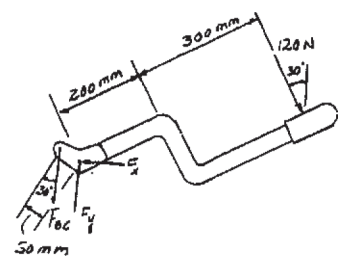
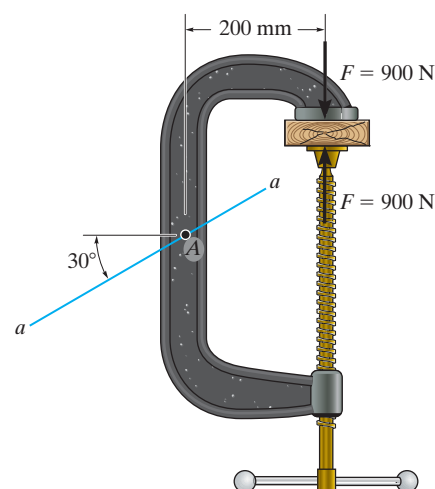$\zeta + \Sigma M_H = 0;$ $M = 0$ **Ans.**

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

1–17. The forged steel clamp exerts a force of $F = 900$ N on the wooden block. Determine the resultant internal loadings acting on section a–a passing through point A.
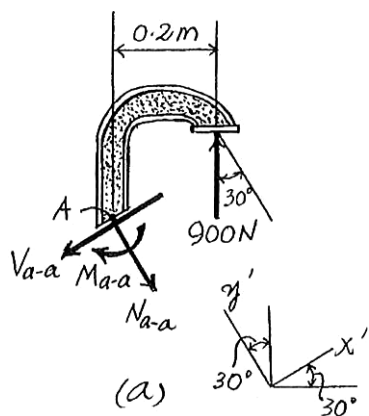
SOLUTION

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

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

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

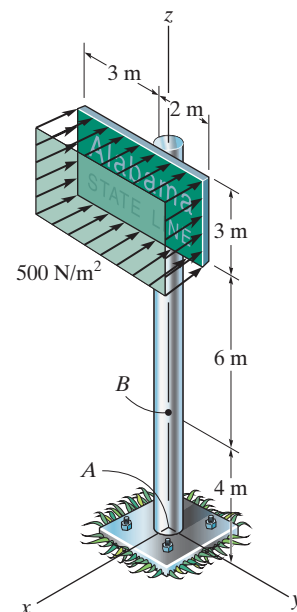$$\zeta + \Sigma M_A = 0; \qquad 900(0.2) - M_{a-a} = 0 \qquad M_{a-a} = 180 \text{ N} \cdot \text{m} \qquad \textbf{Ans.}$$

(a)

1–18. 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 500 N/m² acts perpendicular to the face of the sign.

SOLUTION

$\Sigma F_x = 0;$ $(V_B)_x - 7500 = 0;$ $(V_B)_x = 7500 \text{ N} = 7.5 \text{ kN}$ **Ans.**

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

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

$\Sigma M_x = 0;$ $(M_B)_x = 0$ **Ans.**
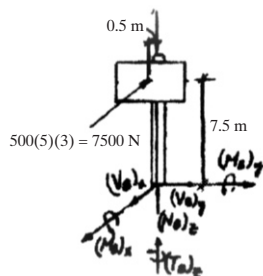
$\Sigma M_y = 0;$ $(M_B)_y - 7500(7.5) = 0;$ $(M_B)_y = 56250 \text{ N} \cdot \text{m} = 56.25 \text{ kN} \cdot \text{m}$ **Ans.**

$\Sigma M_z = 0;$ $(T_B)_z - 7500(0.5) = 0;$ $(T_B)_z = 3750 \text{ N} \cdot \text{m} = 3.75 \text{ kN} \cdot \text{m}$ **Ans.**

Ans:
$(V_B)_x = 7.5 \text{ kN}, (V_B)_y = 0, (N_B)_z = 0,$
$(M_B)_x = 0, (M_B)_y = 56.25 \text{ kN} \cdot \text{m},$
$(T_B)_z = 3.75 \text{ kN} \cdot \text{m}$

1–19.

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.
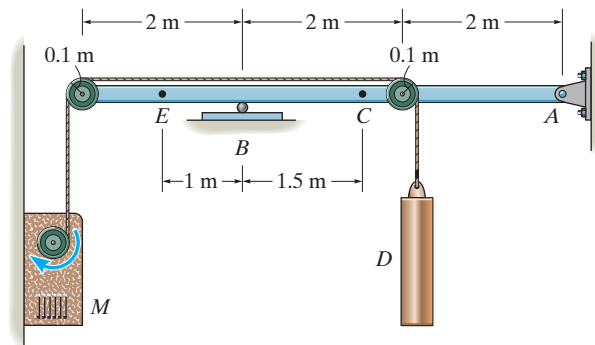

SOLUTION

$\xleftarrow{+} \Sigma F_x = 0;$ $N_C + 2.943 = 0;$ $N_C = -2.94$ kN   **Ans.**

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

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

$\qquad\qquad M_C = -1.47$ kN $\cdot$ m   **Ans.**
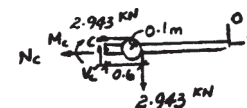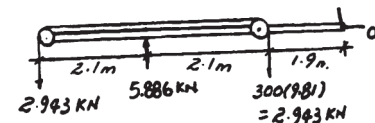
Ans:
$N_C = -2.94$ kN,
$V_C = 2.94$ kN,
$M_C = -1.47$ kN $\cdot$ m

*1–20.

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

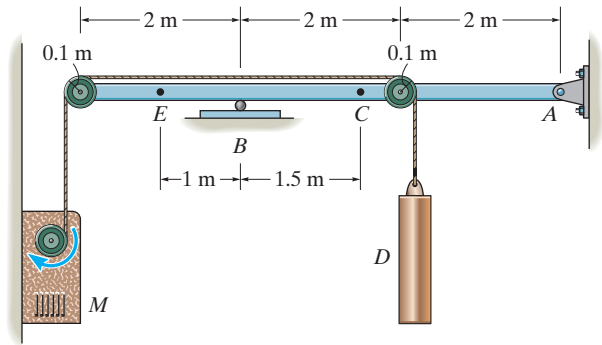$\xrightarrow{+} \Sigma F_x = 0; \qquad N_E + 2943 = 0$

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

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

$\qquad\qquad V_E = -2.94 \text{ kN}$ **Ans.**
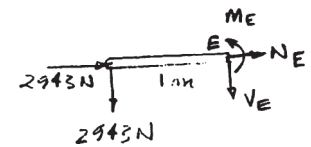
$\zeta + \Sigma M_E = 0; \qquad M_E + 2943(1) = 0$

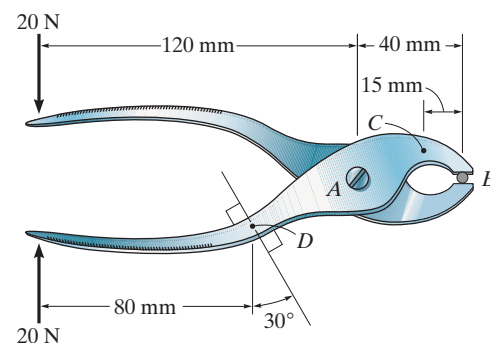$\qquad\qquad M_E = -2.94 \text{ kN} \cdot \text{m}$ **Ans.**

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

1–21. 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

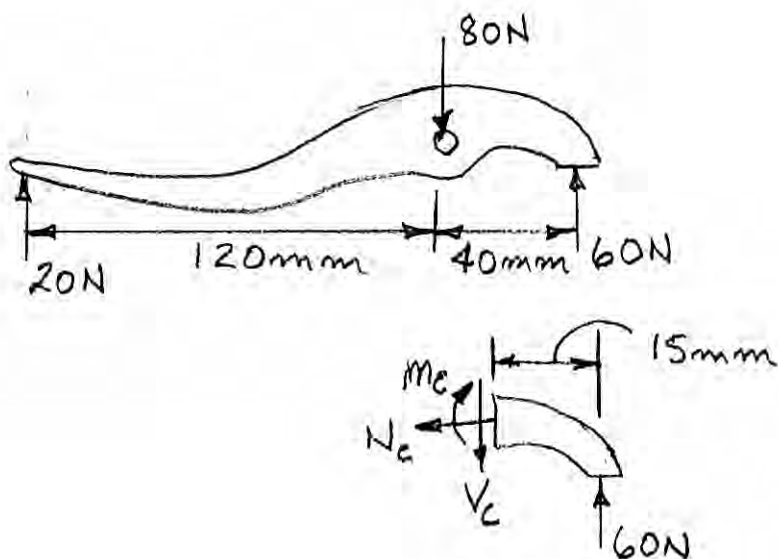$+\uparrow \Sigma F_y = 0;$ $-V_C + 60 = 0;$ $V_C = 60 \, \text{N}$ **Ans.**

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

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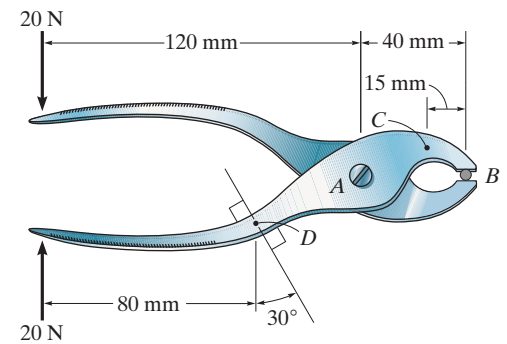

Ans:

$V_C = 60 \, \text{N}, \, N_C = 0, \, M_C = 0.9 \, \text{N} \cdot \text{m}$

1–22. Determine the resultant internal loading on the cross section through point D of the pliers.

SOLUTION

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

$+\nearrow \Sigma F_x = 0;$ $N_D - 20 \sin 30° = 0;$ $N_D = 10$ N   **Ans.**

$+\circlearrowright \Sigma M_D = 0;$ $M_D - 20(0.08) = 0;$ $M_D = 1.60$ N.m   **Ans.**
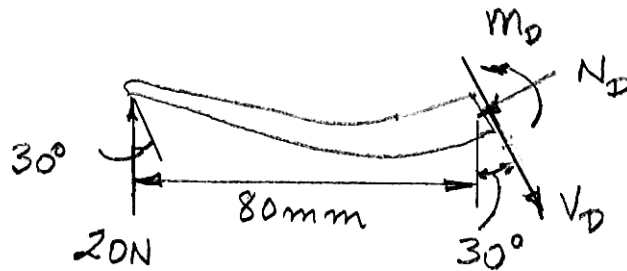
Ans:

$V_D = 17.3$ N, $N_D = 10$ N, $M_D = 1.60$ N · m

1–23.

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:

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

$$A_y = 245.71 \text{ N}$$

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

$$B_y = 314.29 \text{ N}$$

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

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

Equations of Equilibrium: For point C

$$\Sigma F_x = 0; \qquad (N_C)_x = 0 \qquad \textbf{Ans.}$$

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

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

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

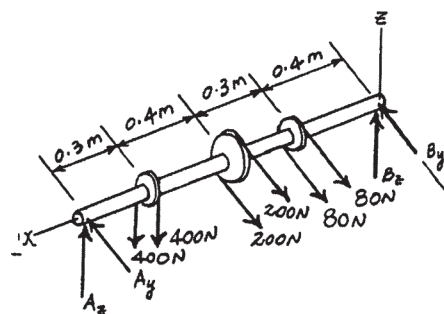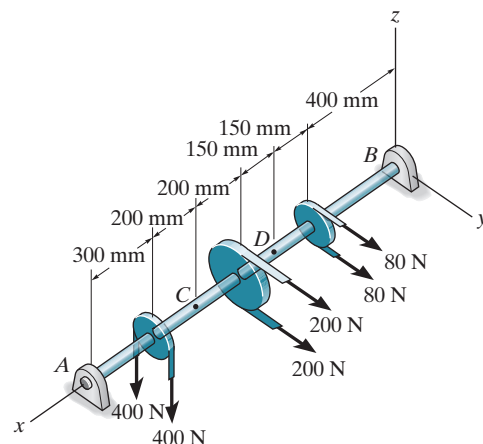$$(V_C)_z = -171 \text{ N} \qquad \textbf{Ans.}$$

$$\Sigma M_x = 0; \qquad (T_C)_x = 0 \qquad \textbf{Ans.}$$

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

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

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

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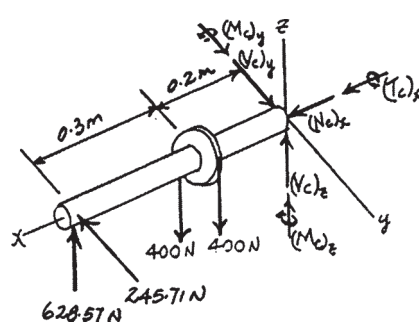
Ans:
$(N_C)_x = 0,$
$(V_C)_y = -246 \text{ N},$
$(V_C)_z = -171 \text{ N},$
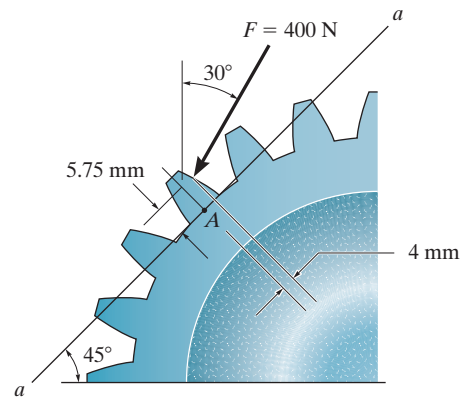$(T_C)_x = 0,$
$(M_C)_y = -154 \text{ N} \cdot \text{m},$
$(M_C)_z = -123 \text{ N} \cdot \text{m}$

*1.24.

The force $F = 400$ N acts on the gear tooth. Determine the resultant internal loadings on the root of the tooth, i.e., at the centroid point A of section a–a.

SOLUTION

Equations of Equilibrium: For section a–a

$\overset{+}{\nearrow}\Sigma F_{x'} = 0;$ $V_A - 400 \cos 15° = 0$

$\qquad\qquad\qquad V_A = 386.37$ N **Ans.**

$\overset{+}{\nwarrow}\Sigma F_{y'} = 0;$ $N_A - 400 \sin 15° = 0$

$\qquad\qquad\qquad N_A = 103.53$ N **Ans.**

$\zeta + \Sigma M_A = 0;$ $-M_A - 400 \sin 15°(0.004) + 400 \cos 15°(0.00575) = 0$

$\qquad\qquad\qquad M_A = 1.808$ N · m **Ans.**
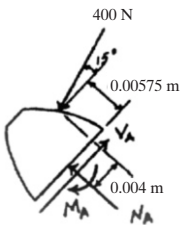
Ans:
$V_A = 386.37$ N, $N_A = 103.53$ N,
$M_A = 1.808$ N · m

1–25.

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:

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

$$A_y = 245.71 \text{ N}$$

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

$$B_y = 314.29 \text{ N}$$

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

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

Equations of Equilibrium: For point D

$$\Sigma F_x = 0; \quad (N_D)_x = 0 \quad \text{Ans.}$$

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

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

$$\Sigma F_z = 0; \quad 171.43 + (V_D)_z = 0$$
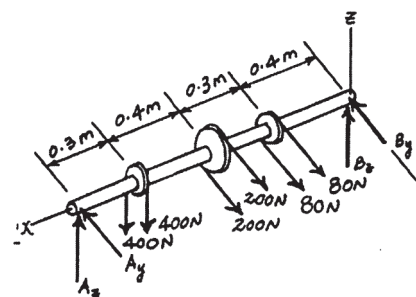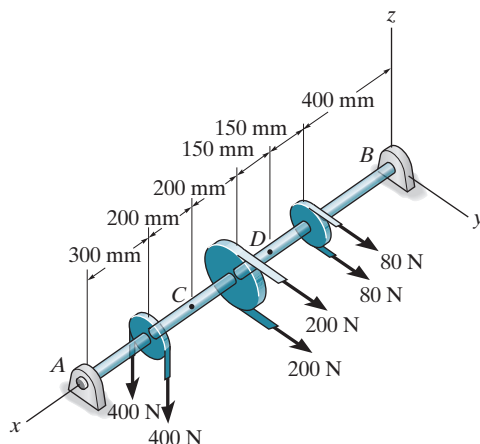
$$(V_D)_z = -171 \text{ N} \quad \text{Ans.}$$

$$\Sigma M_x = 0; \quad (T_D)_x = 0 \quad \text{Ans.}$$

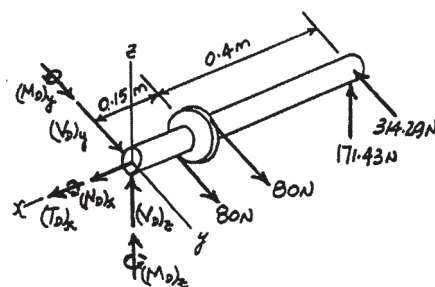$$\Sigma M_y = 0; \quad 171.43(0.55) + (M_D)_y = 0$$

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

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

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

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