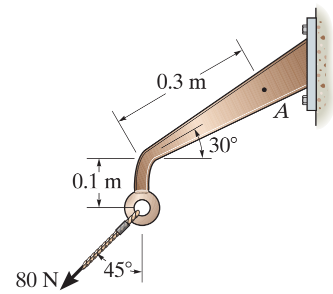
1–1. A force of 80 N is supported by the bracket as shown. Determine the resultant internal loadings acting on the section through point A.



SOLUTION

Equations of Equilibrium:

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

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

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

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

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

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

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

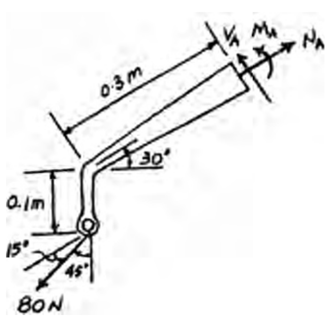
or

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

$-80 \cos 15°(0.1 \cos 30°) = 0$

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

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

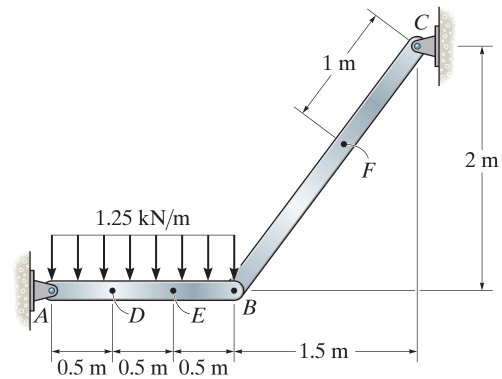


Ans:

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

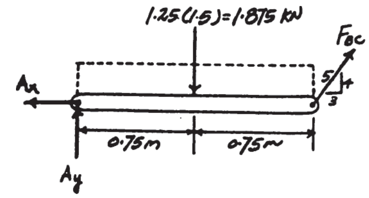
1–2.

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



SOLUTION

Support Reactions: Member BC is the two force member.



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

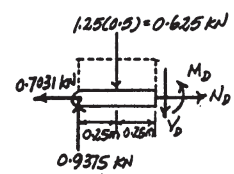
$$F_{BC} = 1.1719 \text{ kN}$$

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

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

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

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



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.**

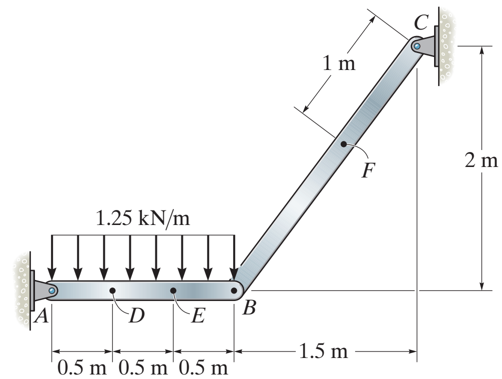
$$\circlearrowleft + \Sigma M_D = 0; \quad M_D + 0.625(0.25) - 0.9375(0.5) = 0$$

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

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

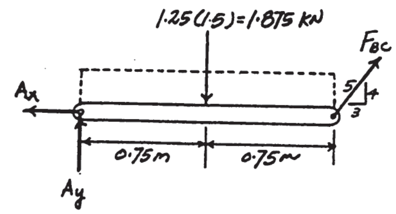
1–3.

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.



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

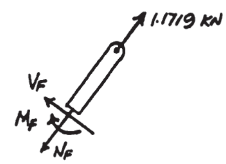
$F_{BC} = 1.1719 \text{ kN}$

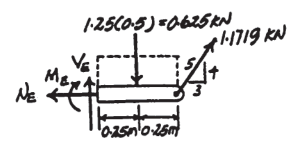
$+\uparrow \Sigma F_y = 0; \quad A_y + \frac{4}{5}(1.1719) - 1.875 = 0$

$A_y = 0.9375 \text{ kN}$

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

$A_x = 0.7031 \text{ kN}$





Equations of Equilibrium: For point F

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

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

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

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

Equations of Equilibrium: For point E

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

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

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

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

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

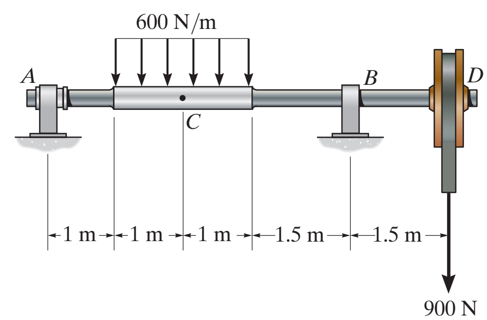
$M_E = 0.3125 \text{ kN} \cdot \text{m}$ **Ans.**

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

***1–4.**

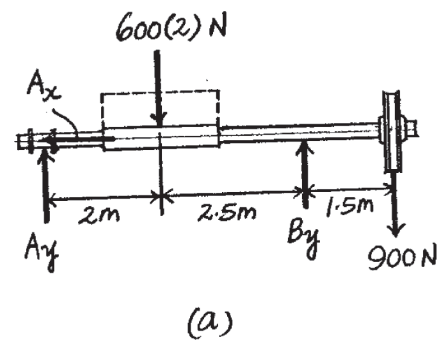
The shaft is supported by a smooth thrust bearing at A and a smooth journal bearing at B. Determine the resultant internal loadings acting on the cross section at C.



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*.

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



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*,

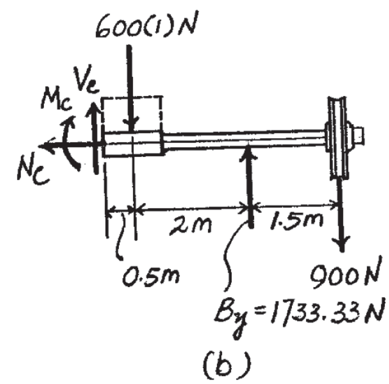
$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad N_C = 0$ **Ans.**

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

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

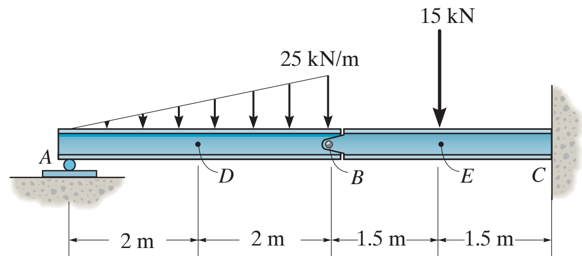
$M_C = 433\text{ N}\cdot\text{m}$ **Ans.**

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 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

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

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

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

Equations of Equilibrium: For point D

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

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

$V_D = 4.17\text{ kN}$ **Ans.**

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

$M_D = 25.17\text{ kN}\cdot\text{m}$ **Ans.**

Equations of Equilibrium: For point E

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

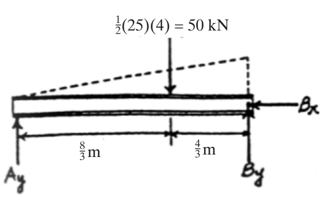
$+\uparrow \Sigma F_y = 0;\quad -33.33 - 15 - V_E = 0$

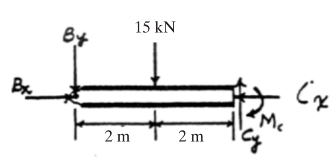
$V_E = -48.33\text{ kN}$ **Ans.**

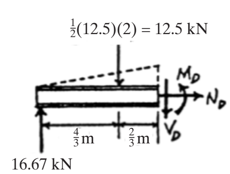
$\zeta + \Sigma M_E = 0;\quad M_E + 33.33(1.5) = 0$

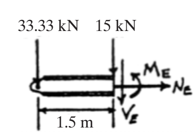
$M_E = -50.00\text{ kN}\cdot\text{m}$ **Ans.**

Negative signs indicate that M_E and V_E act in the opposite direction to that shown on FBD.



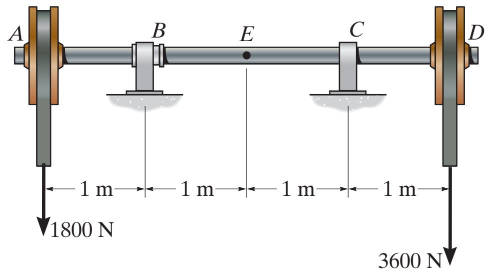






Ans:
$N_D = 0, V_D = 4.17\text{ kN},$
$M_D = 25.0\text{ kN}\cdot\text{m}, N_E = 0, V_E = -48.3\text{ kN},$
$M_E = -50.0\text{ kN}\cdot\text{m}$

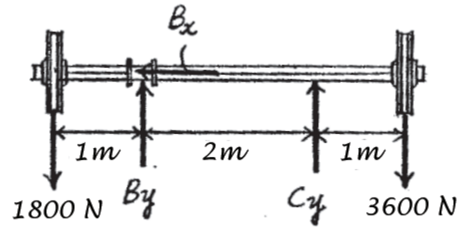
1–6. The shaft is supported by a smooth thrust bearing at B and a journal bearing at C. Determine the resultant internal loadings acting on the cross section at E.



SOLUTION

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

$\circlearrowleft +\Sigma M_B = 0; \quad C_y(2) + 1800(1) - 3600(3) = 0 \quad C_y = 4500\text{ N}$



(a)

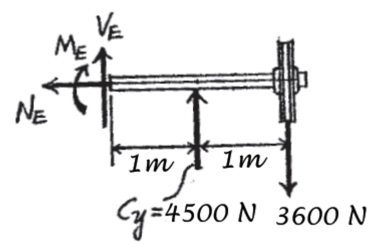
Internal Loadings: Using the result for $\mathbf{C}_y$, section DE of the shaft will be considered. Referring to the free-body diagram, Fig. *b*,

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

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

$\circlearrowleft +\Sigma M_E = 0; \; 4500(1) - 3600(2) - M_E = 0$

$M_E = -2700\text{ N}\cdot\text{m} = -2.70\text{ kN}\cdot\text{m}$ **Ans.**

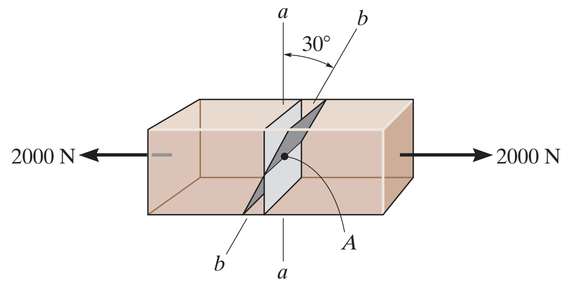


(b)

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:
$N_E = 0, \; V_E = -900\text{ N}, \; M_E = -2.7\text{ kN}\cdot\text{m}$

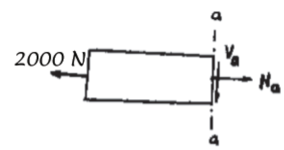
1–7. Determine the resultant internal normal and shear force in the member at (a) section *a–a* and (b) section *b–b*, each of which passes through point *A*. The 2000-N load is applied along the centroidal axis of the member.



(a)

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

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

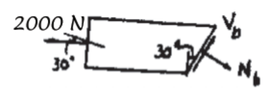


$+\downarrow \Sigma F_y = 0; \qquad V_a = 0$ **Ans.**

(b)

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

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



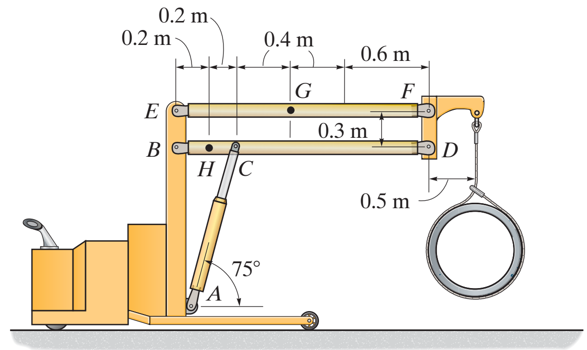
$^{+}\nearrow \Sigma F_y = 0; \qquad V_b - 2000 \sin 30° = 0$

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

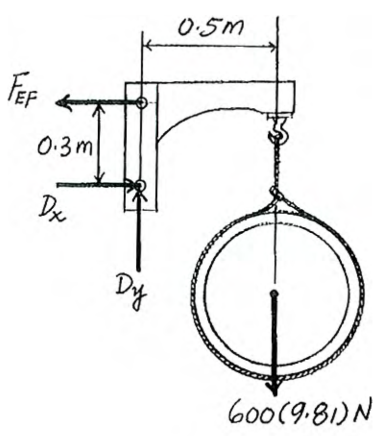
$$\circlearrowleft + \Sigma M_D = 0; \qquad F_{EF}(0.3) - 600(9.81)(0.5) = 0 \qquad F_{EF} = 9810\ \text{N}$$

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*,

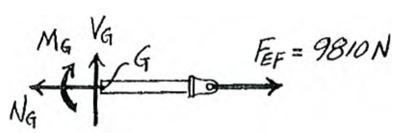
$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad 9810 - N_G = 0 \qquad N_G = 9810\ \text{N} = 9.81\ \text{kN} \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \qquad V_G = 0 \qquad \textbf{Ans.}$$

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



(a)

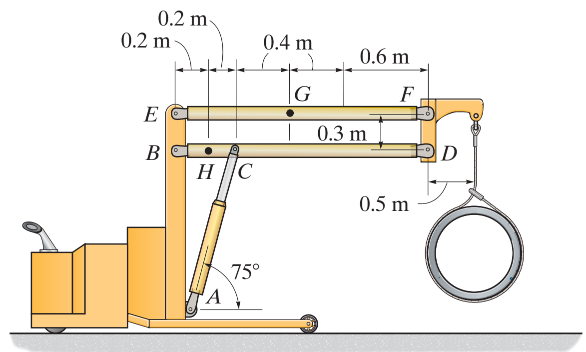


(b)

Ans:

$N_G = 9.81\ \text{kN},\ V_G = 0,\ M_G = 0$

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*.

$\circlearrowleft + \Sigma M_F = 0; \quad D_x(0.3) - 600(9.81)(0.5) = 0 \qquad D_x = 9810\text{ N}$

$+\uparrow \Sigma F_y = 0; \quad D_y - 600(9.81) = 0 \qquad D_y = 5886\text{ N}$

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

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

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

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

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*,

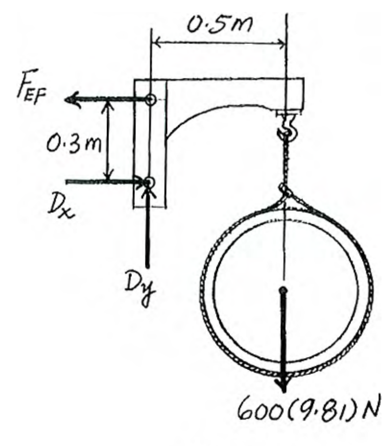
$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad N_H + 2712.83 = 0 \qquad N_H = -2712.83\text{ N} = -2.71\text{ kN}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \quad -V_H - 2060 = 0 \qquad V_H = -20601\text{ N} = -20.6\text{ kN}$ **Ans.**

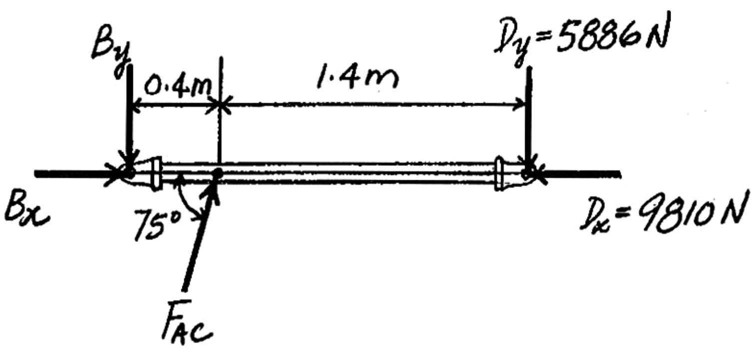
$\circlearrowleft + \Sigma M_D = 0; \quad M_H + 20601(0.2) = 0 \qquad M_H = -4120.2\text{ N}\cdot\text{m}$

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

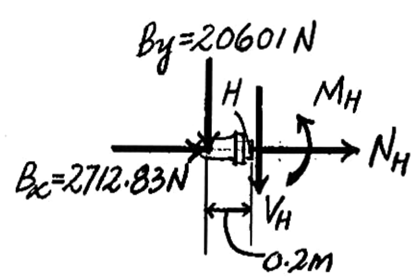
The negative signs indicates that N_H, V_H, and M_H act in the opposite sense to that shown on the free-body diagram.



(a)



(b)



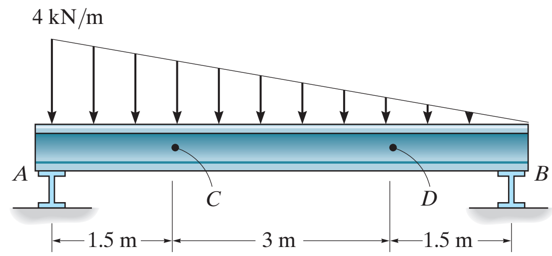
(c)

Ans:

$N_H = -2.71\text{ kN}$, $V_H = -20.6\text{ kN}$, $M_H = -4.12\text{ kN}\cdot\text{m}$

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.



SOLUTION

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

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

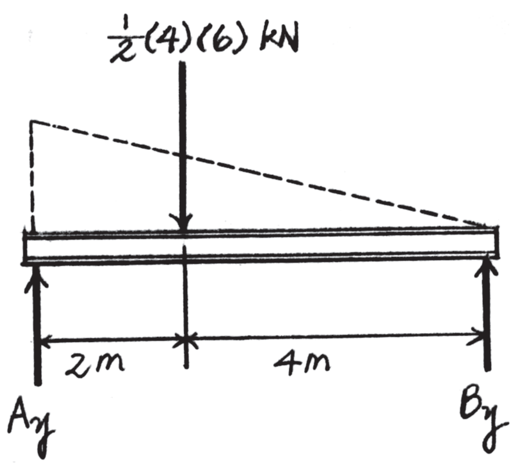
Internal Loadings: Referring to the FBD of the right segment of the beam sectioned through C, Fig. *b*,

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

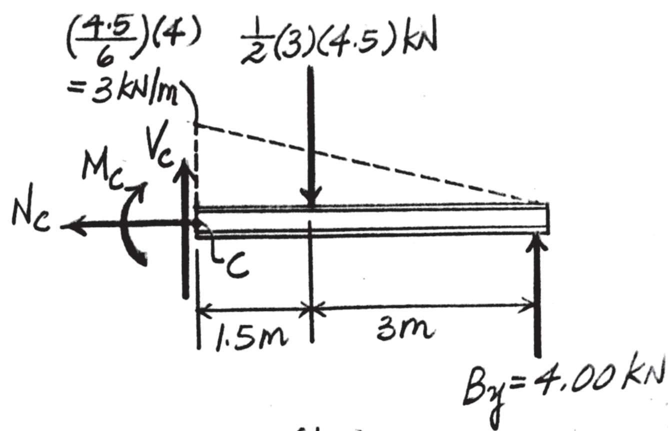
$+\uparrow \Sigma F_y = 0; \quad V_C + 4.00 - \frac{1}{2}(3)(4.5) = 0 \quad V_C = 2.75 \text{ kN}$ **Ans.**

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

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



(a)

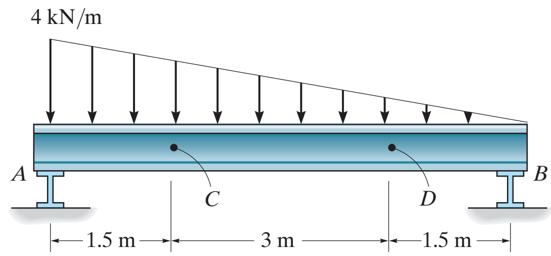


(b)

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

1–11.

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.



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*,

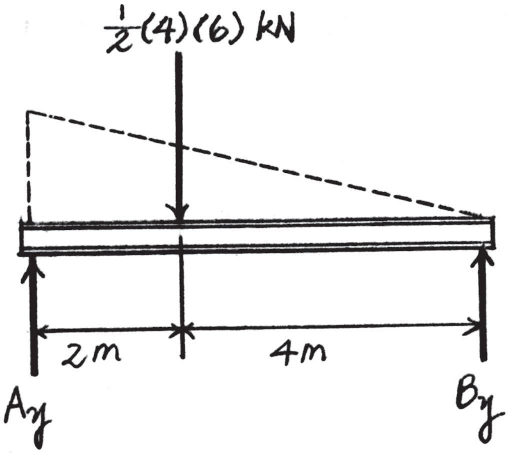
$$\xrightarrow{+} \Sigma F_x = 0; \qquad N_D = 0 \qquad \textbf{Ans.}$$

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

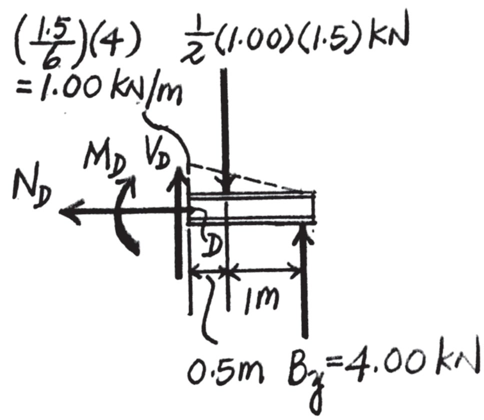
$$\circlearrowleft + \Sigma M_D = 0; \qquad 4.00(1.5) - \frac{}{2}(1.00)(1.5)(0.5) - M_D = 0$$

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

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



(a)

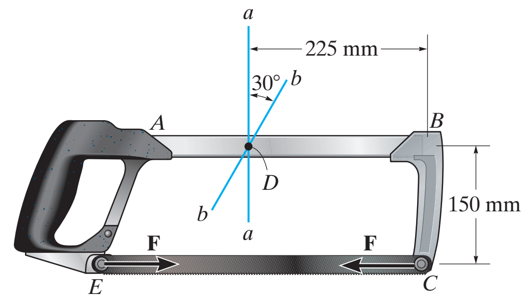


(b)

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

***1–12.**

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

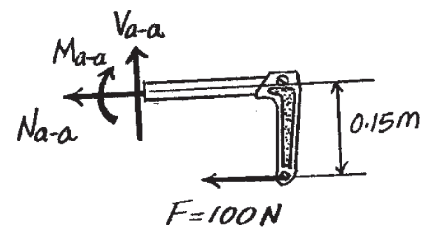
Internal Loadings: Referring to the free-body diagram of the section of the hacksaw shown in Fig. a,

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

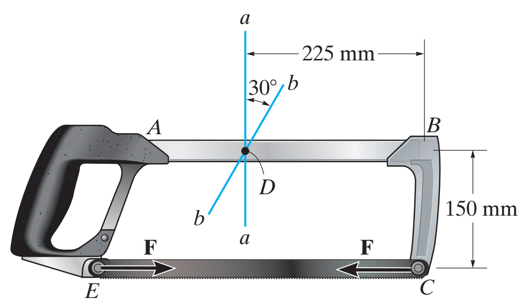


(a)

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

1–13.

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

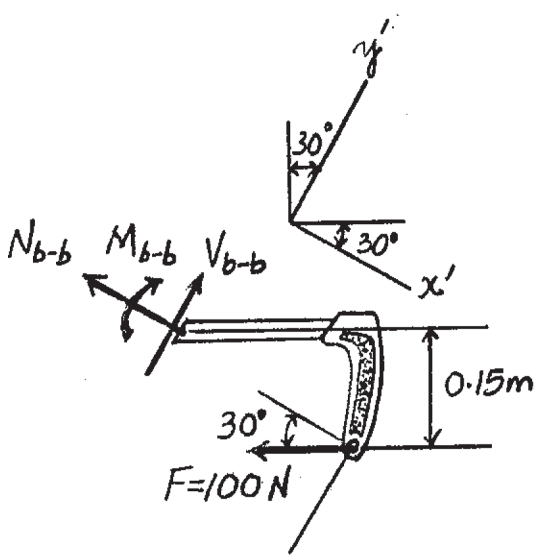
Internal Loadings: Referring to the free-body diagram of the section of the hacksaw shown in Fig. a,

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

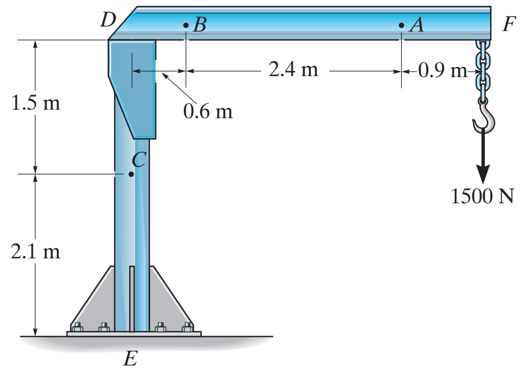
The negative sign indicates that $\mathbf{N}_{b-b}$ and $\mathbf{M}_{b-b}$ act in the opposite sense to that shown on the free-body diagram.



(a)

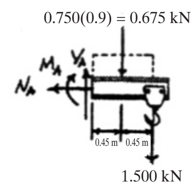
Ans:
$N_{b-b} = -86.6$ N, $V_{b-b} = 50$ N,
$M_{b-b} = -15$ N · m

1–14. 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



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

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

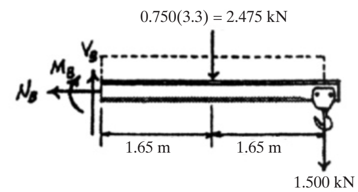
$V_A = 2.175 \text{ kN}$ **Ans.**

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

$M_A = -1.65 \text{ kN} \cdot \text{m}$ **Ans.**

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

Equations of Equilibrium: For point B



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

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

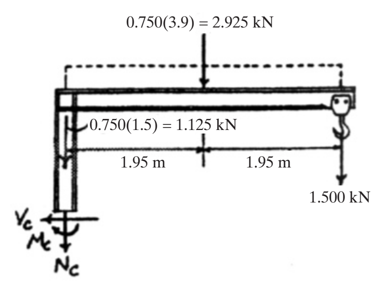
$V_B = 3.975 \text{ kN}$ **Ans.**

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

$M_B = -9.03 \text{ kN} \cdot \text{m}$ **Ans.**

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

Equations of Equilibrium: For point C



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

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

$N_C = -5.55 \text{ kN}$ **Ans.**

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

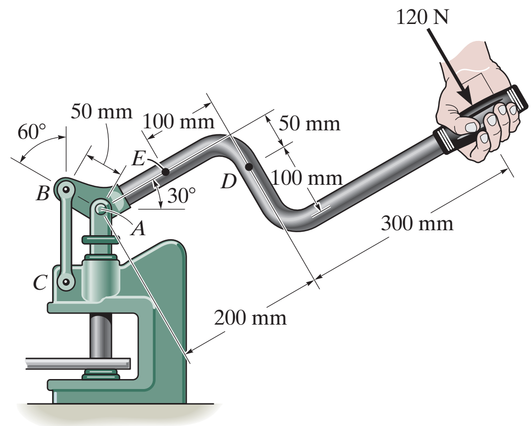
$M_C = -11.6 \text{ kN} \cdot \text{m}$ **Ans.**

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 · m,
$N_B = 0$, $V_B = 3.975$ kN, $M_B = -9.03$ kN · m,
$V_C = 0$, $N_C = -5.55$ kN, $M_C = -11.6$ kN · 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:

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

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

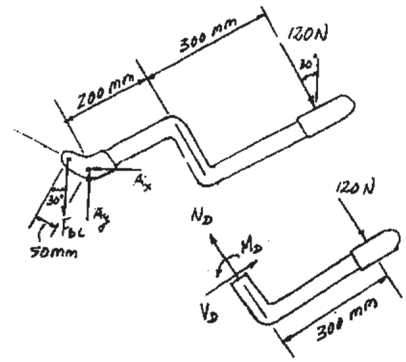
$+\uparrow \Sigma F_y = 0; \qquad A_y - 1385.6 - 120 \cos 30° = 0$

$A_y = 1489.56 \text{ N}$

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

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

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

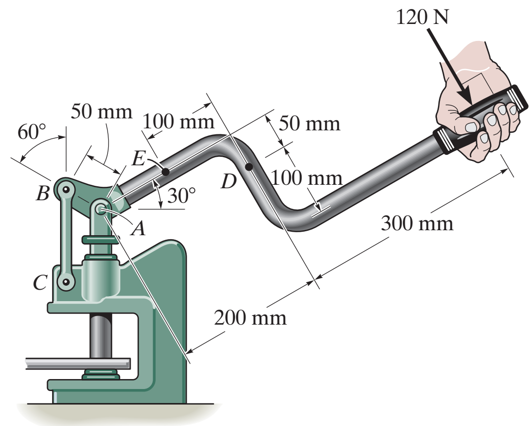
$\circlearrowleft + \Sigma M_D = 0; \qquad M_D - 120(0.3) = 0$

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

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

***1–16.**

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.



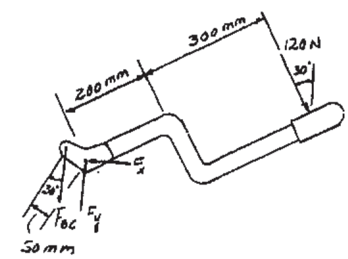
SOLUTION

Member:

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

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

Segment:

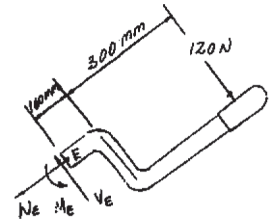


$+\swarrow \Sigma F_{x'} = 0; \qquad N_E = 0$ **Ans.**

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



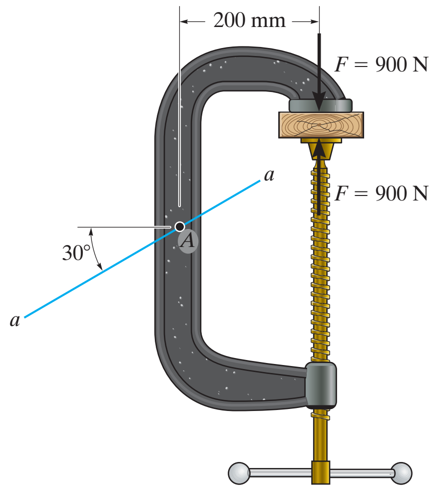
$\overset{+}{\leftarrow} \Sigma F_x = 0; \qquad V = 0$ **Ans.**

$+\uparrow \Sigma F_y = 0; \qquad 1.3856 - N = 0; \qquad N = 1.39 \text{ kN}$ **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: $V = 0, N = 1.39 \text{ kN}, M = 0$

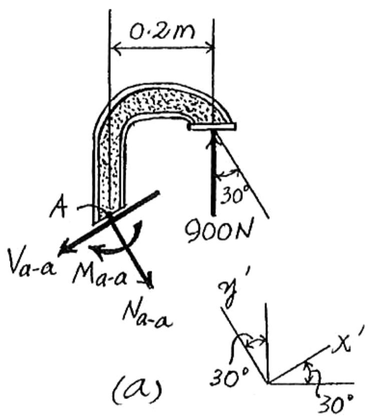
1–17. The forged steel clamp exerts a force of $F = 900$ N on the wooden block. Determine the resultant internal loadings acting on section *a–a* passing through point *A*.



SOLUTION

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

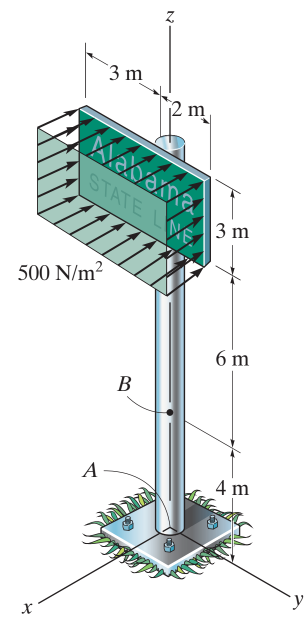
$\Sigma F_{y'} = 0;$	$900 \cos 30° - N_{a-a} = 0$	$N_{a-a} = 779 \text{ N}$	**Ans.**
$\Sigma F_{x'} = 0;$	$V_{a-a} - 900 \sin 30° = 0$	$V_{a-a} = 450 \text{ N}$	**Ans.**
$\circlearrowleft + \Sigma M_A = 0;$	$900(0.2) - M_{a-a} = 0$	$M_{a-a} = 180 \text{ N} \cdot \text{m}$	**Ans.**



Ans:
$N_{a-a} = 779 \text{ N}, V_{a-a} = 450 \text{ N},$
$900(0.2) - M_{a-a} = 0, M_{a-a} = 180 \text{ N} \cdot \text{m}$

pe

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

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

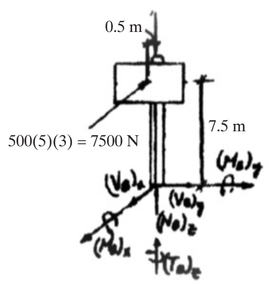
$\Sigma F_y = 0;\quad (V_B)_y = 0$ **Ans.**

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

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

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

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

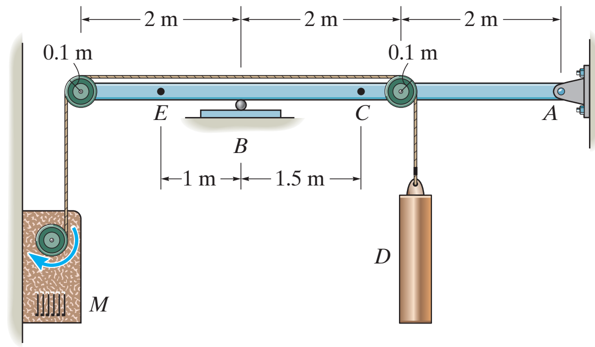


Ans:

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

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.



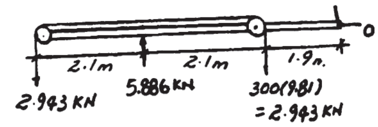
SOLUTION

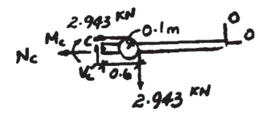
$\overset{+}{\leftarrow} \Sigma F_x = 0; \qquad N_C + 2.943 = 0; \qquad N_C = -2.94\text{ kN}$ **Ans.**

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



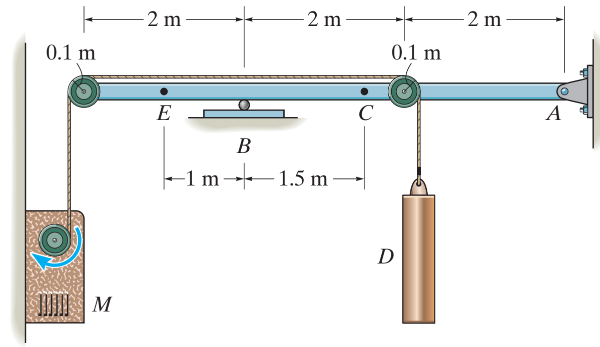


Ans:

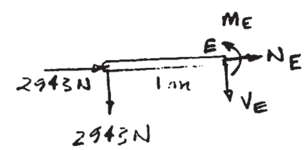
$N_C = -2.94\text{ kN},$
$V_C = 2.94\text{ kN},$
$M_C = -1.47\text{ kN}\cdot\text{m}$

***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



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

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

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

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

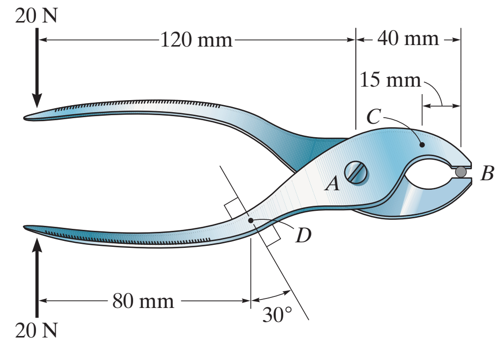
$\circlearrowleft + \Sigma M_E = 0;$ $\quad M_E + 2943(1) = 0$

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

Ans:

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

1–21. 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.

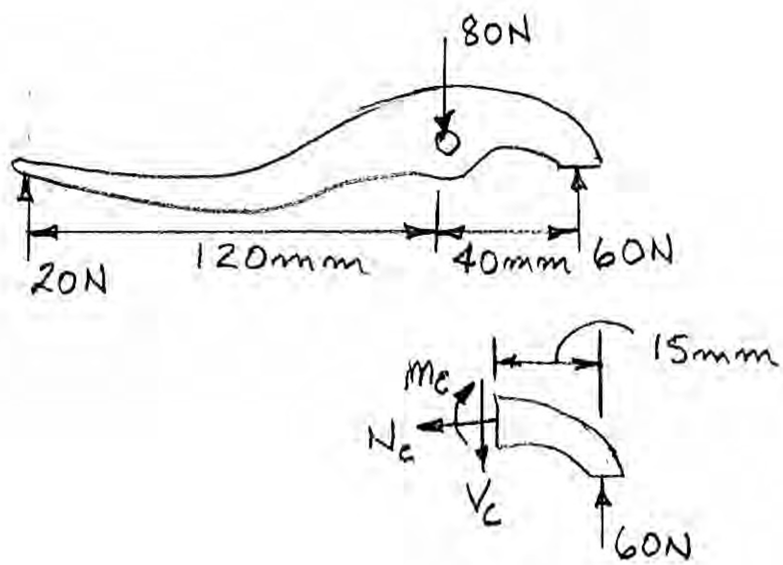


SOLUTION

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

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

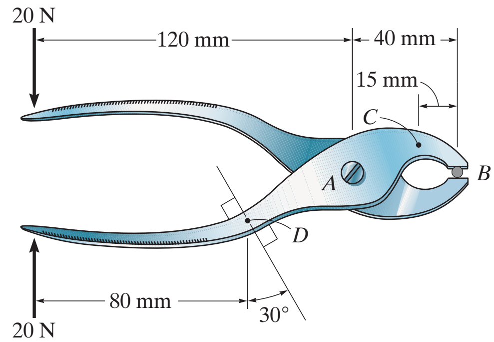
$+\circlearrowleft \Sigma M_C = 0; \quad -M_C + 60(0.015) = 0; \quad M_C = 0.9\text{ N.m}$ **Ans.**



Ans:

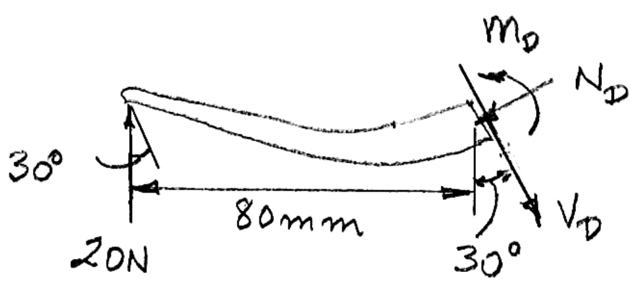
$V_C = 60\text{ N}, N_C = 0, M_C = 0.9\text{ N}\cdot\text{m}$

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



SOLUTION

$\searrow + \Sigma F_y = 0;$	$V_D - 20\cos 30° = 0;$	$V_D = 17.3\text{ N}$	**Ans.**
$+\swarrow \Sigma F_x = 0;$	$N_D - 20\sin 30° = 0;$	$N_D = 10\text{ N}$	**Ans.**
$+\circlearrowleft \Sigma M_D = 0;$	$M_D - 20(0.08) = 0;$	$M_D = 1.60\text{ N.m}$	**Ans.**

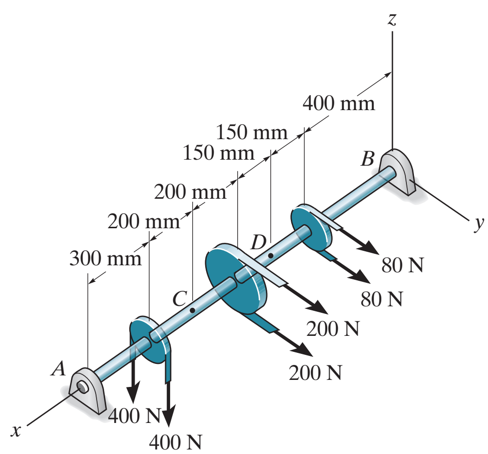


Ans:

$V_D = 17.3\text{ N}, N_D = 10\text{ N}, M_D = 1.60\text{ N}\cdot\text{m}$

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:

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

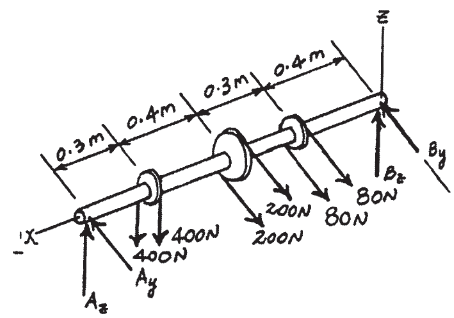
$A_y = 245.71\text{ N}$

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

$B_y = 314.29\text{ N}$

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

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



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.**

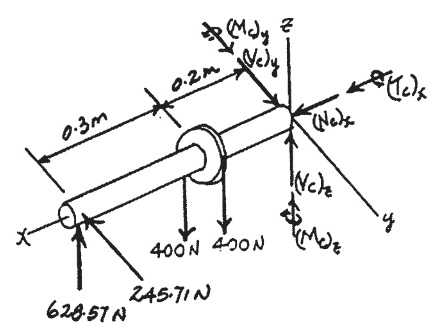
$\Sigma M_x = 0; \qquad (T_C)_x = 0$ **Ans.**

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

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

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

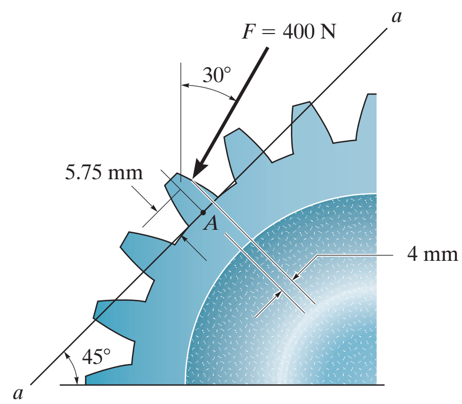
$(M_C)_z = -123\text{ N}\cdot\text{m}$ **Ans.**



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

***1.24.**

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

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

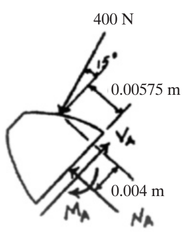
$V_A = 386.37$ N **Ans.**

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

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

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

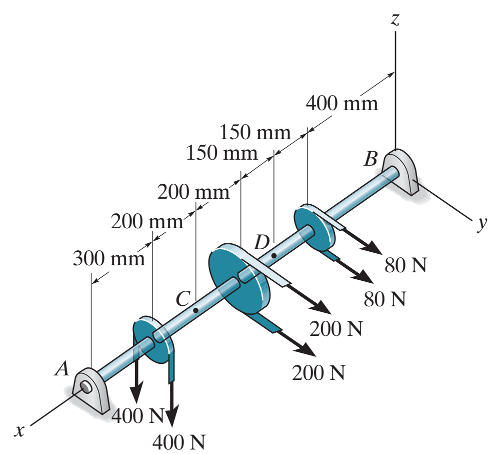
$M_A = 1.808 \text{ N} \cdot \text{m}$ **Ans.**



Ans:
$V_A = 386.37$ N, $N_A = 103.53$ N,
$M_A = 1.808 \text{ N} \cdot \text{m}$

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:

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

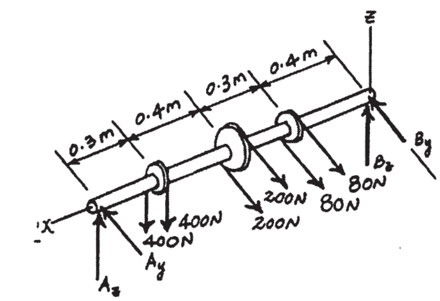
$A_y = 245.71 \text{ N}$

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

$B_y = 314.29 \text{ N}$

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

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



Equations of Equilibrium: For point D

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

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

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

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

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

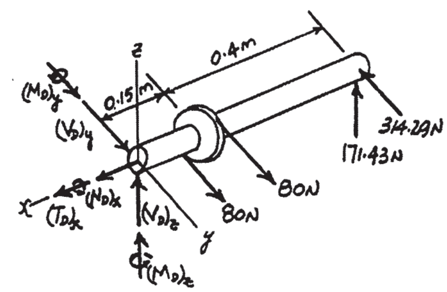
$\Sigma M_x = 0; \quad (T_D)_x = 0$ **Ans.**

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

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

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

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



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