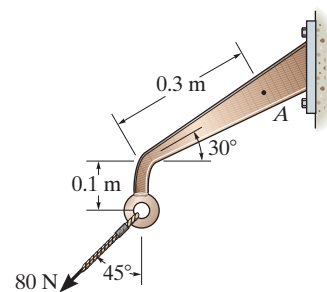


1-1. A force of 80 N is supported by the bracket as shown. Determine the resultant internal loadings acting on the section through point *A*.



SOLUTION

Equations of Equilibrium:

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

$$N_A = 77.3 \text{ N}$$

Ans.

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

$$V_A = 20.7 \text{ N}$$

Ans.

$$\zeta + \Sigma M_A = 0; \quad M_A + 80 \cos 45^\circ (0.3 \cos 30^\circ) - 80 \sin 45^\circ (0.1 + 0.3 \sin 30^\circ) = 0$$

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

Ans.

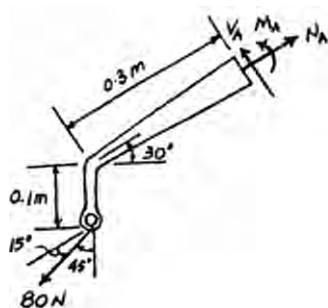
or

$$\zeta + \Sigma M_A = 0; \quad M_A + 80 \sin 15^\circ (0.3 + 0.1 \sin 30^\circ) - 80 \cos 15^\circ (0.1 \cos 30^\circ) = 0$$

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

Ans.

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



These solutions represent a preliminary version of the Instructors' Solutions Manual (ISM). It is possible and even likely that at this preliminary stage of preparing the ISM there are some omissions and errors in the draft solutions. These will be corrected and this manual will be republished.

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.

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

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

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

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

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

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

Equations of Equilibrium: For point D

$$\pm \Sigma F_x = 0; \quad N_D - 0.7031 = 0$$

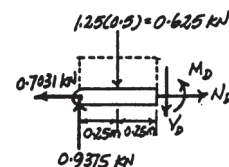
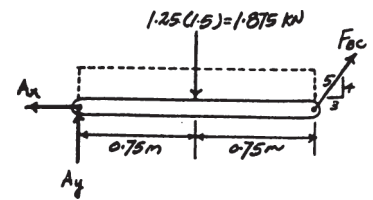
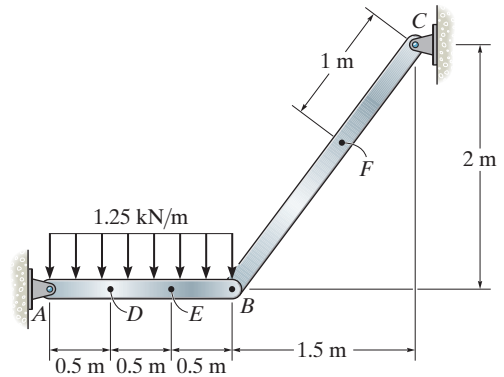
$$N_D = 0.703 \text{ kN}$$

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

$$V_D = 0.3125 \text{ kN}$$

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

$$M_D = 0.3125 \text{ kN} \cdot \text{m}$$



Ans.

Ans.

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.

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

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

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

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

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

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

Equations of Equilibrium: For point F

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

$$N_F = 1.17 \text{ kN}$$

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

$$\zeta + \Sigma M_F = 0; \quad M_F = 0$$

Equations of Equilibrium: For point E

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

$$N_E = 0.703 \text{ kN}$$

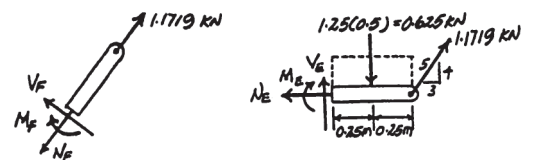
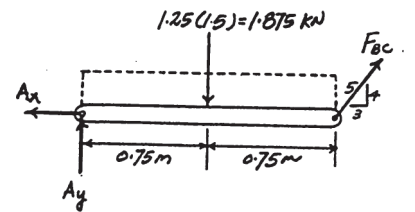
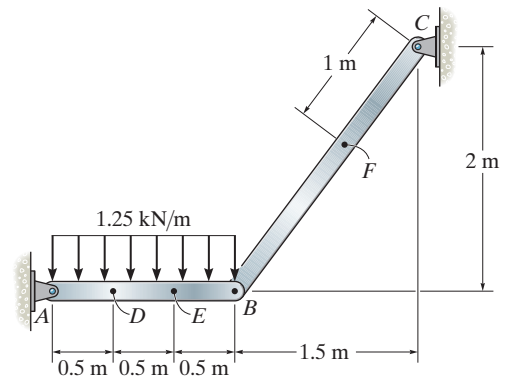
$$+\uparrow \Sigma F_y = 0; \quad V_E - 0.625 + \frac{4}{5}(1.1719) = 0$$

$$V_E = -0.3125 \text{ kN}$$

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

$$M_E = 0.3125 \text{ kN} \cdot \text{m}$$

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



Ans.

Ans.

Ans.

Ans.

Ans.

Ans.

Ans:

$$N_F = 1.17 \text{ kN},$$

$$V_F = 0,$$

$$M_F = 0,$$

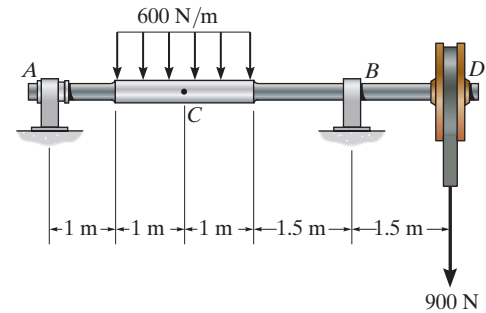
$$N_E = 0.703 \text{ kN},$$

$$V_E = -0.3125 \text{ kN},$$

$$M_E = 0.3125 \text{ kN} \cdot \text{m}$$

*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 B_y by writing the moment equation of equilibrium about *A* with reference to the free-body diagram of the entire shaft, Fig. *a*.

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

Internal Loadings: Using the result of B_y , section *CD* of the shaft will be considered. Referring to the free-body diagram of this part, Fig. *b*,

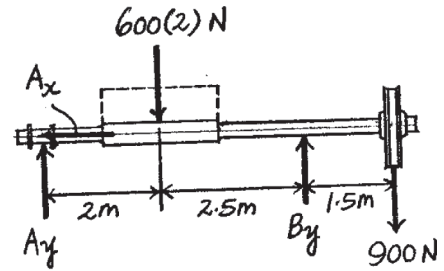
$$\pm \Sigma F_x = 0; \quad N_C = 0 \quad \text{Ans.}$$

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

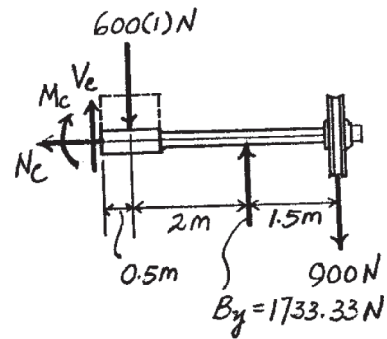
$$\zeta + \Sigma M_C = 0; \quad 1733.33(2.5) - 600(1)(0.5) - 900(4) - M_C = 0$$

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

The negative sign indicates that V_C acts in the opposite sense to that shown on the free-body diagram.



(a)



(b)

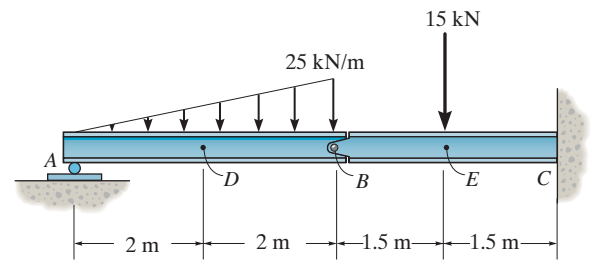
Ans:

$$N_C = 0,$$

$$V_C = -233 \text{ N},$$

$$M_C = 433 \text{ N} \cdot \text{m}$$

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*

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

$$\rightarrow \Sigma F_x = 0; \quad B_x = 0$$

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

Equations of Equilibrium: For point *D*

$$\rightarrow \Sigma F_x = 0; \quad N_D = 0$$

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

$$V_D = 4.17 \text{ kN}$$

Ans.

Ans.

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

$$M_D = 25.17 \text{ kN} \cdot \text{m}$$

Ans.

Equations of Equilibrium: For point *E*

$$\rightarrow \Sigma F_x = 0; \quad N_E = 0$$

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

$$V_E = -48.33 \text{ kN}$$

Ans.

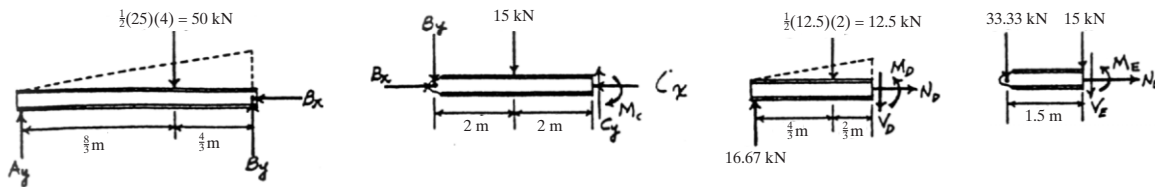
Ans.

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

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

Ans.

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



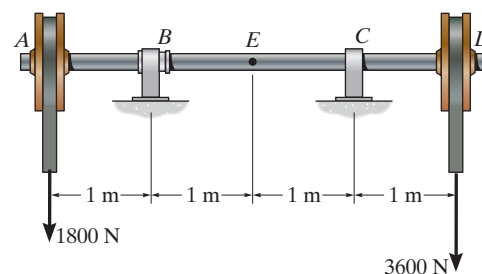
Ans:

$$N_D = 0, V_D = 4.17 \text{ kN},$$

$$M_D = 25.0 \text{ kN} \cdot \text{m}, N_E = 0, V_E = -48.3 \text{ kN},$$

$$M_E = -50.0 \text{ kN} \cdot \text{m}$$

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

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

Internal Loadings: Using the result for C_y , section DE of the shaft will be considered. Referring to the free-body diagram, Fig. b ,

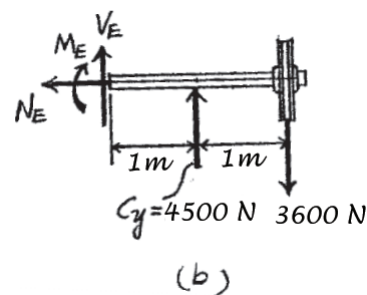
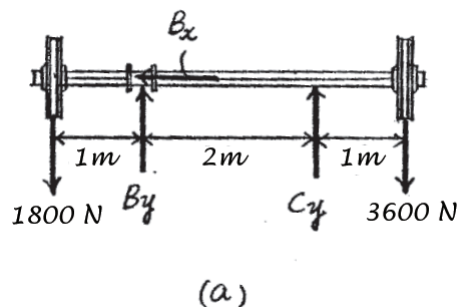
$$\rightarrow \Sigma F_x = 0; \quad N_E = 0 \quad \text{Ans.}$$

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

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

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

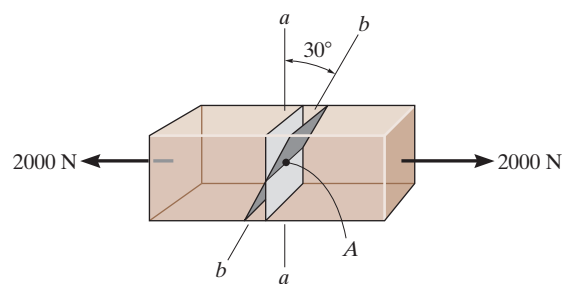
The negative signs indicates that V_E and M_E act in the opposite sense to that shown on the free-body diagram.



Ans:

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

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)

$$\rightarrow \Sigma F_x = 0; \quad N_a - 2000 = 0$$

$$N_a = 2000 \text{ N}$$

$$+\downarrow \Sigma F_y = 0; \quad V_a = 0$$

(b)

$$\searrow \Sigma F_x = 0; \quad N_b - 2000 \cos 30^\circ = 0$$

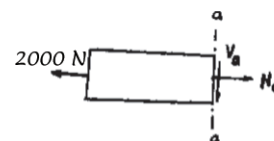
$$N_b = 1732 \text{ N}$$

$$+\nearrow \Sigma F_y = 0; \quad V_b - 2000 \sin 30^\circ = 0$$

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

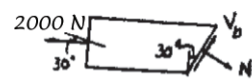
Ans.

Ans.



Ans.

Ans.



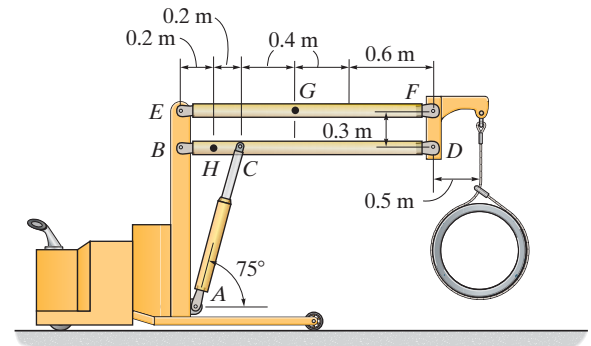
Ans:

$$N_a = 2000 \text{ N}, V_a = 0,$$

$$N_b = 1732 \text{ N}, V_b = 1000 \text{ N}$$

*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 .

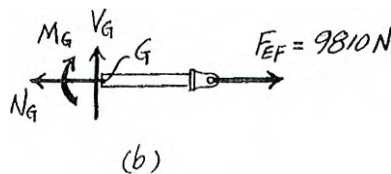
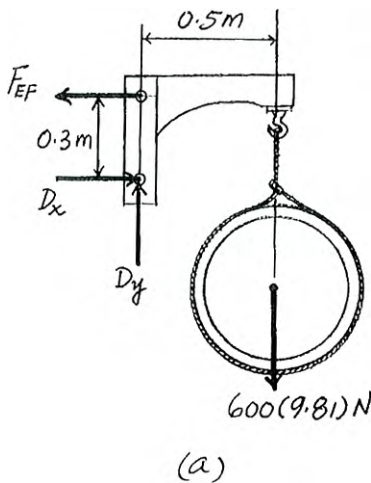
$$\zeta + \Sigma M_D = 0; \quad F_{EF}(0.3) - 600(9.81)(0.5) = 0 \quad F_{EF} = 9810 \text{ N}$$

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 ,

$$\rightarrow \Sigma F_x = 0; \quad 9810 - N_G = 0 \quad N_G = 9810 \text{ N} = 9.81 \text{ kN} \quad \text{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \quad V_G = 0 \quad \text{Ans.}$$

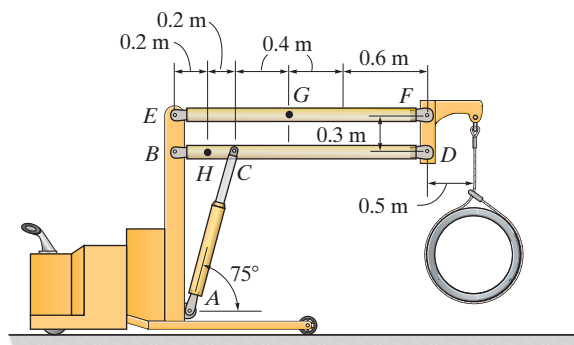
$$\zeta + \Sigma M_G = 0; \quad M_G = 0 \quad \text{Ans.}$$



Ans:

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

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 .

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

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

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

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

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

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

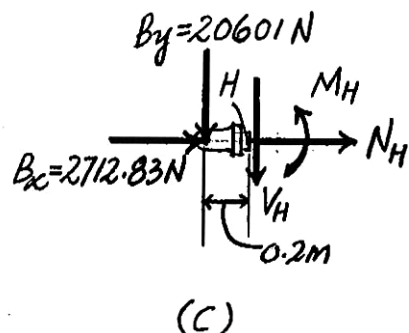
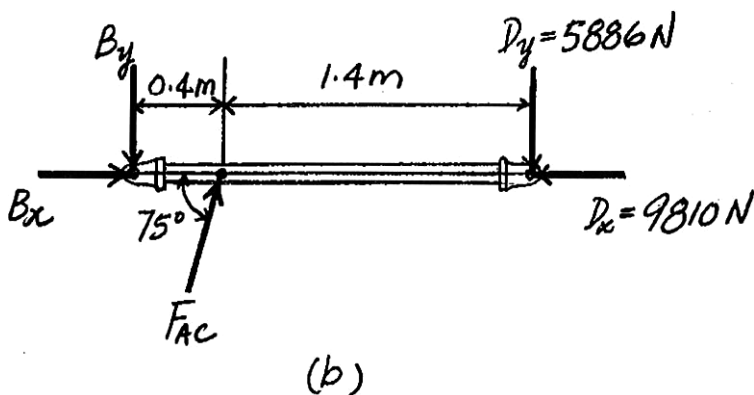
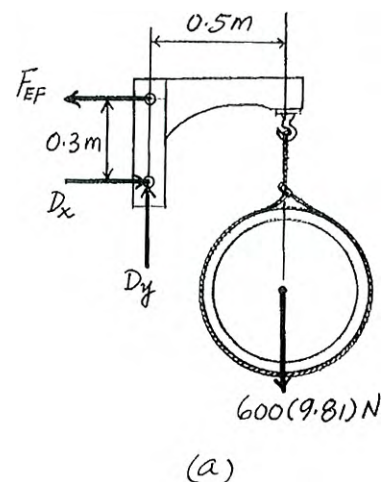
Internal Loadings: Using the results of B_x and B_y , section BH of member BCD will be considered. Referring to the free-body diagram of this part shown in Fig. c ,

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

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

$$\zeta + \Sigma M_D = 0; \quad M_H + 20601(0.2) = 0 \quad M_H = -4120.2 \text{ N} \cdot \text{m} \\ = -4.12 \text{ kN} \cdot \text{m} \quad \text{Ans.}$$

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.

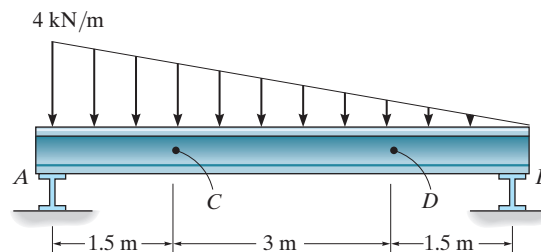


Ans:

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

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*,

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

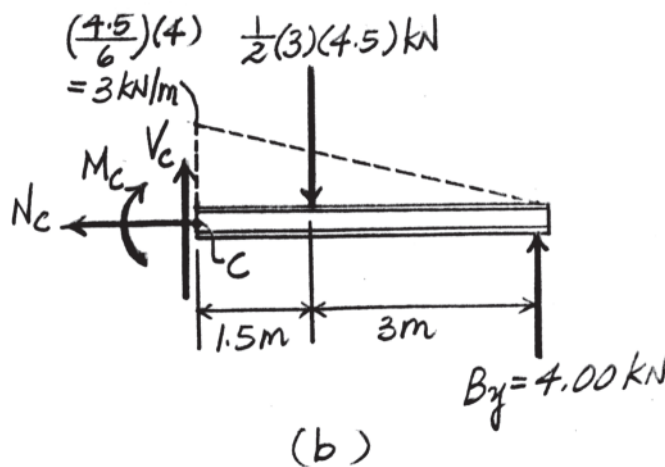
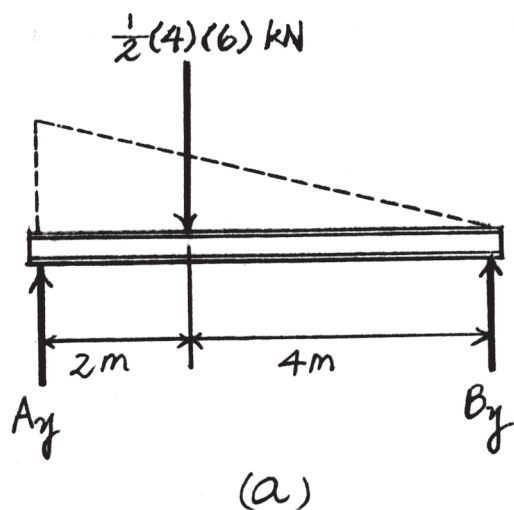
Internal Loadings: Referring to the FBD of the right segment of the beam sectioned through *C*, Fig. *b*,

$$\pm \Sigma F_x = 0; \quad N_C = 0 \quad \text{Ans.}$$

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

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

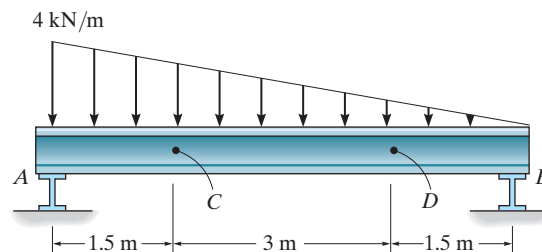
$$M_C = 7.875 \text{ kN} \cdot \text{m} \quad \text{Ans.}$$



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 ,

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

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

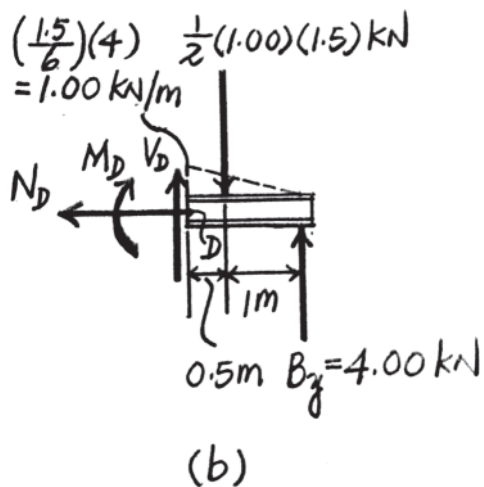
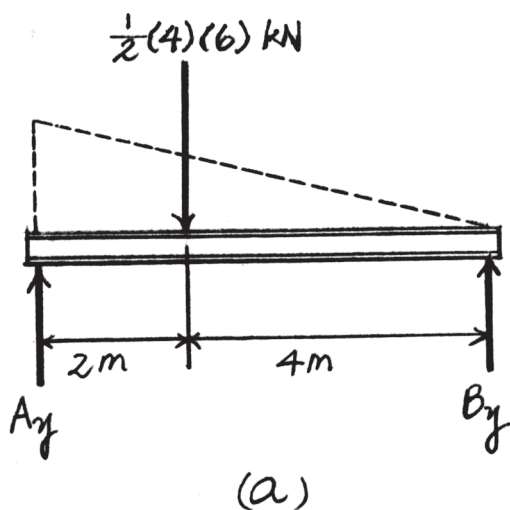
$$\rightarrow \Sigma F_x = 0; \quad N_D = 0 \quad \text{Ans.}$$

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

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

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

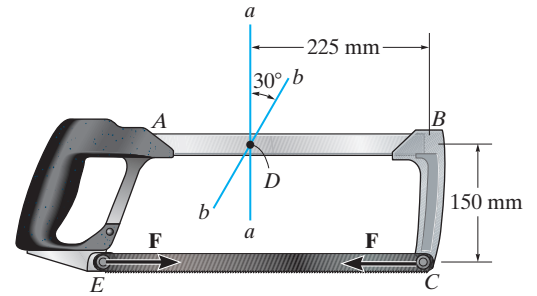
The negative sign indicates that V_D acts in the sense opposite to that shown on the FBD.



Ans:
 $N_D = 0$,
 $V_D = -3.25 \text{ kN}$,
 $M_D = 5.625 \text{ kN} \cdot \text{m}$

***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

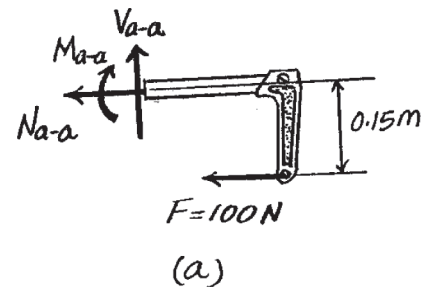
Internal Loadings: Referring to the free-body diagram of the section of the hacksaw shown in Fig. a ,

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

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

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

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.

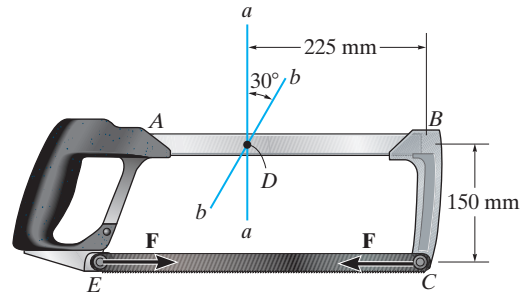


Ans:

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

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

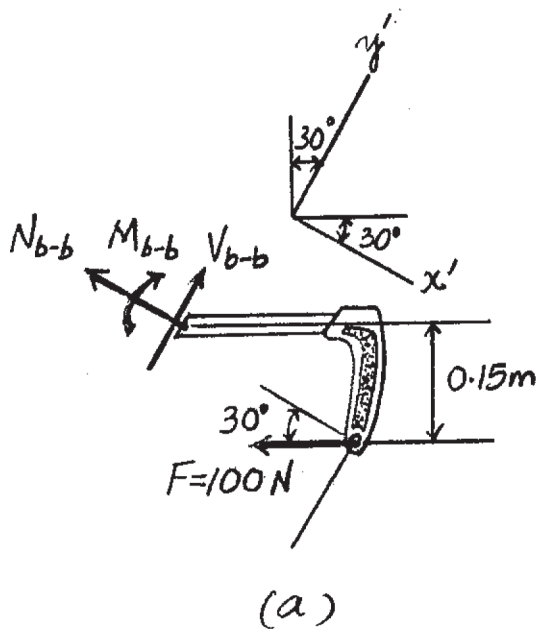
Internal Loadings: Referring to the free-body diagram of the section of the hacksaw shown in Fig. *a*,

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

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

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

The negative sign indicates that N_{b-b} and M_{b-b} act in the opposite sense to that shown on the free-body diagram.



Ans:

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

1-14. The boom DF of the jib crane and the column DE have a uniform weight 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

$$\begin{aligned}\leftarrow \Sigma F_x &= 0; & N_A &= 0 \\ +\uparrow \Sigma F_y &= 0; & V_A - 0.675 - 1.500 &= 0 \\ & & V_A &= 2.175 \text{ kN}\end{aligned}$$

$$\begin{aligned}\zeta + \Sigma M_A &= 0; & -M_A - 0.675(0.45) - 1.500(0.9) &= 0 \\ & & M_A &= -1.65 \text{ kN} \cdot \text{m}\end{aligned}$$

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

Equations of Equilibrium: For point B

$$\begin{aligned}\leftarrow \Sigma F_x &= 0; & N_B &= 0 \\ +\uparrow \Sigma F_y &= 0; & V_B - 2.475 - 1.5 &= 0 \\ & & V_B &= 3.975 \text{ kN}\end{aligned}$$

$$\begin{aligned}\zeta + \Sigma M_B &= 0; & -M_B - 2.475(1.65) - 1.500(3.3) &= 0 \\ & & M_B &= -9.03 \text{ kN} \cdot \text{m}\end{aligned}$$

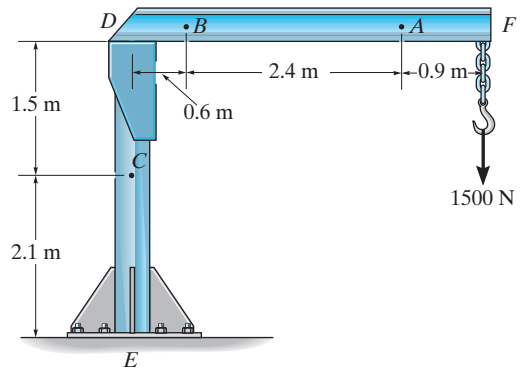
Negative sign indicates that M_B acts in the opposite direction to that shown on FBD.

Equations of Equilibrium: For point C

$$\begin{aligned}\leftarrow \Sigma F_x &= 0; & V_C &= 0 \\ +\uparrow \Sigma F_y &= 0; & -N_C - 1.125 - 2.925 - 1.500 &= 0 \\ & & N_C &= -5.55 \text{ kN}\end{aligned}$$

$$\begin{aligned}\zeta + \Sigma M_C &= 0; & -M_C - 2.925(1.95) - 1.500(3.9) &= 0 \\ & & M_C &= -11.6 \text{ kN} \cdot \text{m}\end{aligned}$$

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



Ans.

Ans.

Ans.

Ans.

Ans.

Ans.

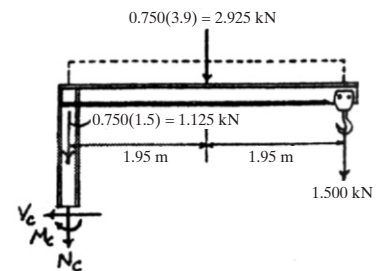
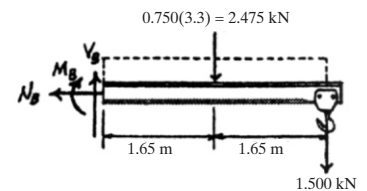
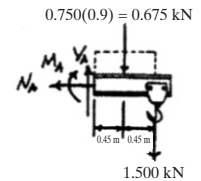
Ans.

Ans.

Ans.

Ans:

$$\begin{aligned}N_A &= 0, & V_A &= 2.175 \text{ kN}, & M_A &= -1.65 \text{ kN} \cdot \text{m}, \\ N_B &= 0, & V_B &= 3.975 \text{ kN}, & M_B &= -9.03 \text{ kN} \cdot \text{m}, \\ V_C &= 0, & N_C &= -5.55 \text{ kN}, & M_C &= -11.6 \text{ kN} \cdot \text{m}\end{aligned}$$



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:

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

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

$$+\uparrow \Sigma F_y = 0; \quad A_y - 1385.6 - 120 \cos 30^\circ = 0$$

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

$$\leftarrow \Sigma F_x = 0; \quad A_x - 120 \sin 30^\circ = 0; \quad A_x = 60 \text{ N}$$

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

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

Segment:

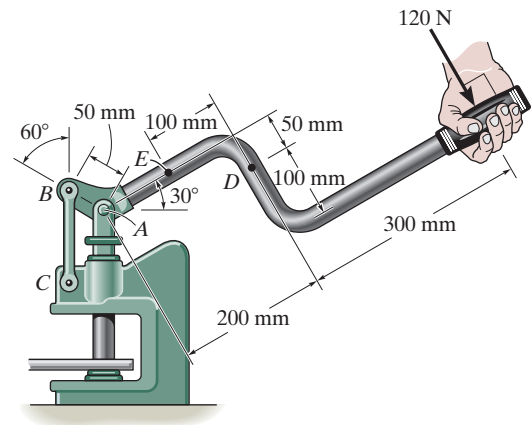
$$\nearrow \Sigma F_{x'} = 0; \quad N_D - 120 = 0$$

$$N_D = 120 \text{ N}$$

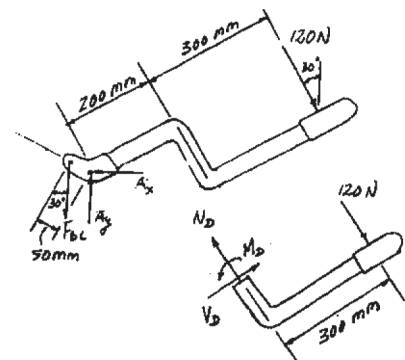
$$+\nearrow \Sigma F_{y'} = 0; \quad V_D = 0$$

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

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



Ans.



Ans.

Ans.

Ans.

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:

$$\zeta + \sum M_A = 0; \quad F_{BC} \cos 30^\circ (50) - 120(500) = 0$$

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

Segment:

$$\uparrow \sum F_{x'} = 0; \quad N_E = 0$$

$$\curvearrowleft + \sum F_{y'} = 0; \quad V_E - 120 = 0; \quad V_E = 120 \text{ N}$$

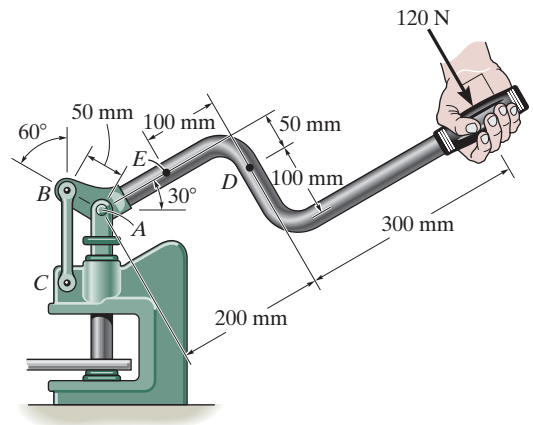
$$\zeta + \sum M_E = 0; \quad M_E - 120(0.4) = 0; \quad M_E = 48.0 \text{ N} \cdot \text{m}$$

Short link:

$$\leftarrow \sum F_x = 0; \quad V = 0$$

$$+\uparrow \sum F_y = 0; \quad 1.3856 - N = 0; \quad N = 1.39 \text{ kN}$$

$$\zeta + \sum M_H = 0; \quad M = 0$$



Ans.

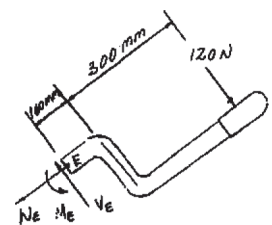
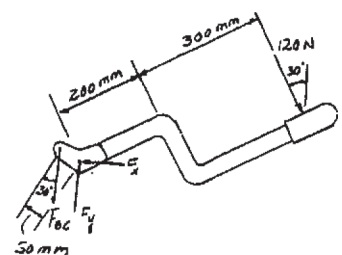
Ans.

Ans.

Ans.

Ans.

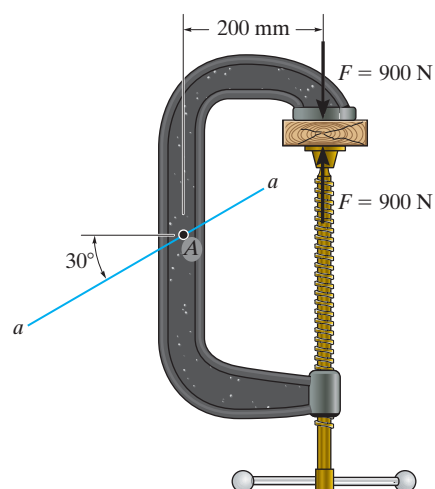
Ans.



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 $F = 900 \text{ N}$ on the wooden block. Determine the resultant internal loadings acting on section $a-a$ passing through point A .



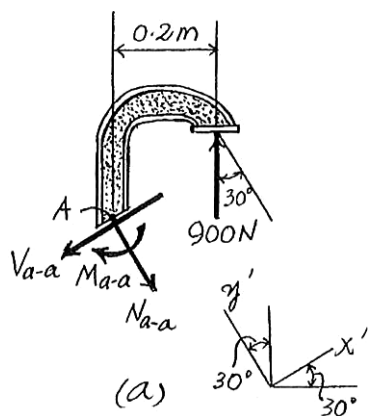
SOLUTION

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

$$\Sigma F_{y'} = 0; \quad 900 \cos 30^\circ - N_{a-a} = 0 \quad N_{a-a} = 779 \text{ N} \quad \text{Ans.}$$

$$\Sigma F_{x'} = 0; \quad V_{a-a} - 900 \sin 30^\circ = 0 \quad V_{a-a} = 450 \text{ N} \quad \text{Ans.}$$

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



Ans:

$$N_{a-a} = 779 \text{ N}, V_{a-a} = 450 \text{ N},$$

$$900(0.2) - M_{a-a} = 0, M_{a-a} = 180 \text{ N} \cdot \text{m}$$

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/m^2 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.

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

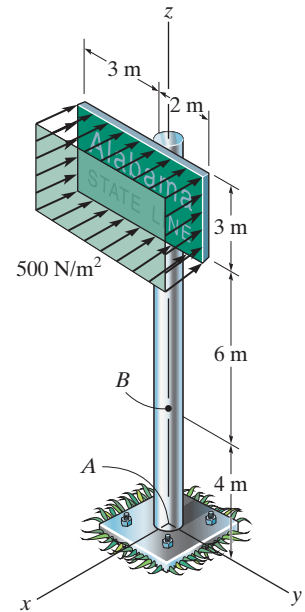
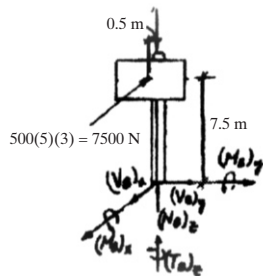
Ans.

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

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:

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

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.

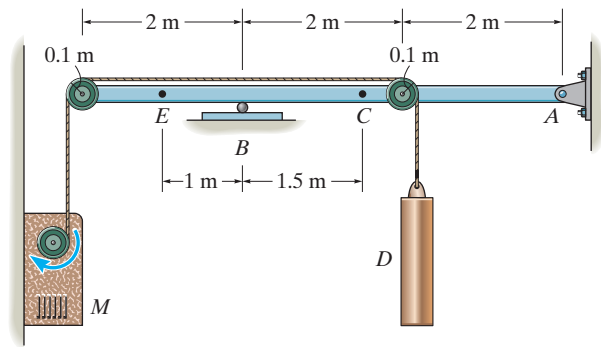
SOLUTION

$$\leftarrow \Sigma F_x = 0; \quad N_C + 2.943 = 0; \quad N_C = -2.94 \text{ kN}$$

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

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

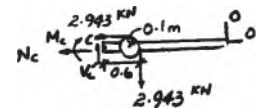
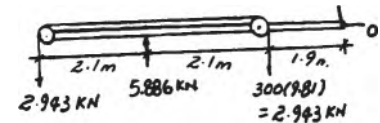
$$M_C = -1.47 \text{ kN} \cdot \text{m}$$



Ans.

Ans.

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

$$\pm \rightarrow \Sigma F_x = 0; \quad N_E + 2943 = 0$$

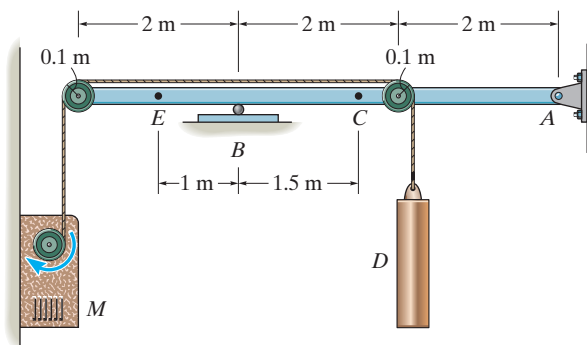
$$N_E = -2.94 \text{ kN}$$

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

$$V_E = -2.94 \text{ kN}$$

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

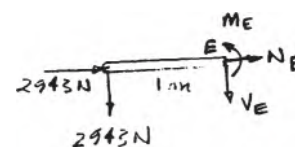
$$M_E = -2.94 \text{ kN} \cdot \text{m}$$



Ans.

Ans.

Ans.



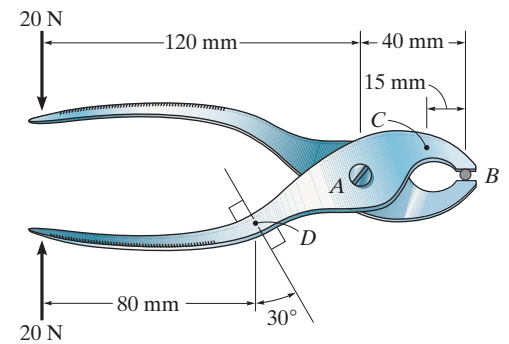
Ans:

$$N_E = -2.94 \text{ kN},$$

$$V_E = -2.94 \text{ kN},$$

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

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

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

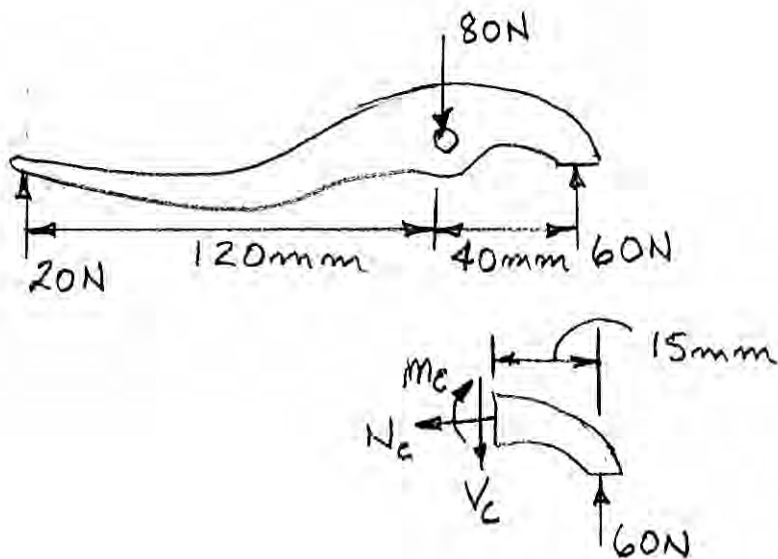
Ans.

$$\rightarrow \Sigma F_x = 0; \quad N_C = 0$$

Ans.

$$+\curvearrowright \Sigma M_C = 0; \quad -M_C + 60(0.015) = 0; \quad M_C = 0.9 \text{ N}\cdot\text{m}$$

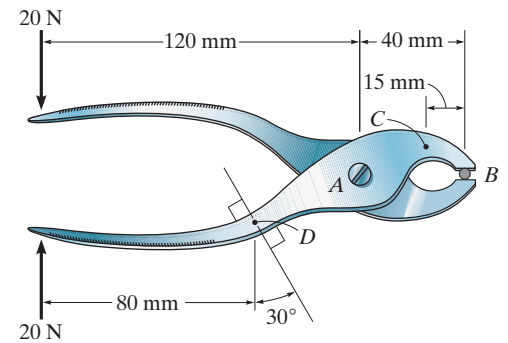
Ans.



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

$$+\uparrow \Sigma F_y = 0; \quad V_D - 20 \cos 30^\circ = 0; \quad V_D = 17.3 \text{ N}$$

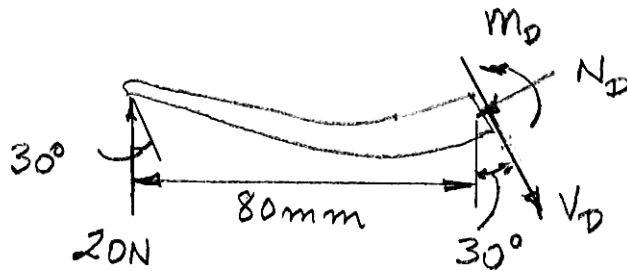
Ans.

$$+\swarrow \Sigma F_x = 0; \quad N_D - 20 \sin 30^\circ = 0; \quad N_D = 10 \text{ N}$$

Ans.

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

Ans.



Ans:

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

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:

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

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

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

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

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

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

Equations of Equilibrium: For point *C*

$$\Sigma F_x = 0; \quad (N_C)_x = 0$$

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

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

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

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

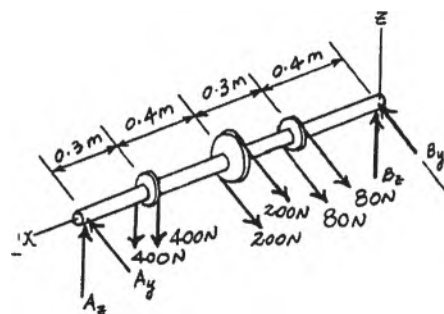
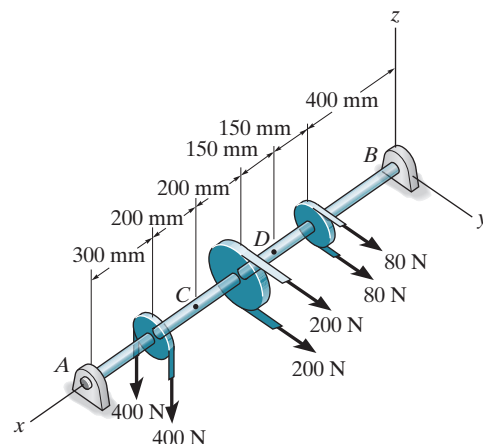
$$\Sigma M_x = 0; \quad (T_C)_x = 0$$

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

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

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

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



Ans.

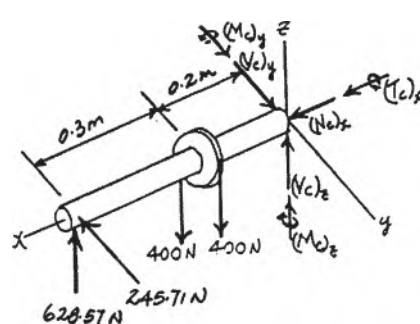
Ans.

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Ans.

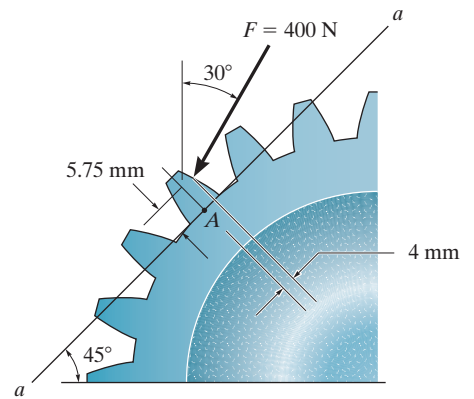


Ans:

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

*** 1.24.**

The force $F = 400 \text{ N}$ 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 $a-a$

$$+\nearrow \Sigma F_{x'} = 0; \quad V_A - 400 \cos 15^\circ = 0$$

$$V_A = 386.37 \text{ N}$$

Ans.

$$\searrow^+ \Sigma F_{y'} = 0; \quad N_A - 400 \sin 15^\circ = 0$$

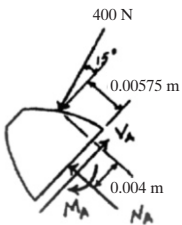
$$N_A = 103.53 \text{ N}$$

Ans.

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

$$M_A = 1.808 \text{ N} \cdot \text{m}$$

Ans.



Ans:

$$V_A = 386.37 \text{ N}, \quad N_A = 103.53 \text{ N},$$

$$M_A = 1.808 \text{ N} \cdot \text{m}$$

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:

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

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

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

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

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

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

Equations of Equilibrium: For point *D*

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

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

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

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

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

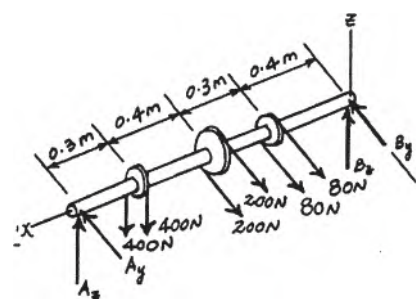
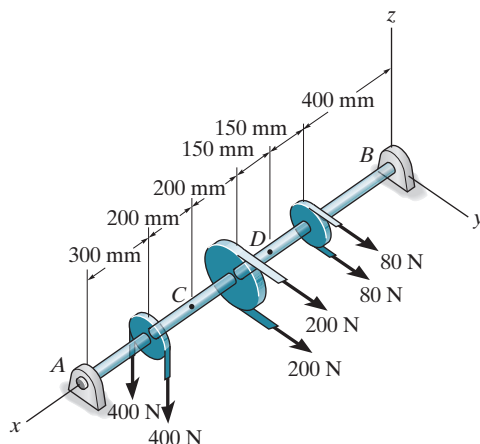
$$\Sigma M_x = 0; \quad (T_D)_x = 0$$

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

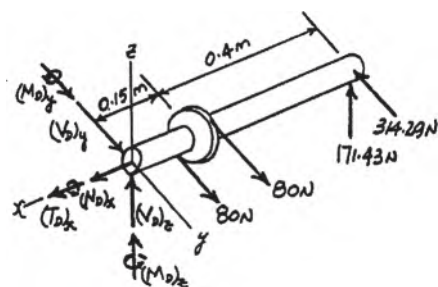
$$(M_D)_y = -94.3 \text{ N} \cdot \text{m}$$

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

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



Ans.



Ans.

Ans.

Ans.

Ans.

Ans.

Ans:

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