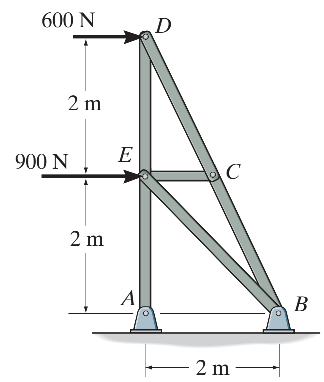
**•6–1.** Determine the force in each member of the truss, and state if the members are in tension or compression.




**Method of Joints:** We will begin by analyzing the equilibrium of joint $D$, and then proceed to analyze joints $C$ and $D$.

**Joint $D$:** From geometry, $\theta = \tan^{-1}\left(\frac{1}{2}\right) = 26.57°$. Thus, from the free - body diagram in Fig. $a$,

$\overset{+}{\rightarrow}\Sigma F_x = 0;$ $\quad 600 - F_{DC}\sin 26.57° = 0$

$F_{DC} = 1341.64 \text{ N} = 1.34 \text{ kN (C)}$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad 1341.64\cos 26.57° - F_{DE} = 0$

$F_{DE} = 1200 \text{ N} = 1.20 \text{ kN (T)}$ **Ans.**

**Joint $C$:** From the free - body diagram in Fig. $b$,

$+\nearrow \Sigma F_{x'} = 0;$ $\quad -F_{CE}\cos 26.57° = 0$

$F_{CE} = 0$ **Ans.**

$+\nwarrow \Sigma F_{y'} = 0;$ $\quad F_{CB} - 1341.64 = 0$

$F_{CB} = 1341.64 \text{ N} = 1.34 \text{ kN (C)}$ **Ans.**

**Joint $E$:** From the free - body diagram in Fig. $c$,

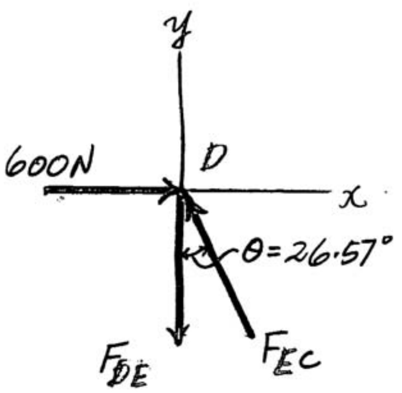
$\overset{+}{\rightarrow}\Sigma F_x = 0;$ $\quad 900 - F_{EB}\sin 45° = 0$

$F_{EB} = 1272.79 \text{ N} = 1.27 \text{ kN (C)}$ **Ans.**

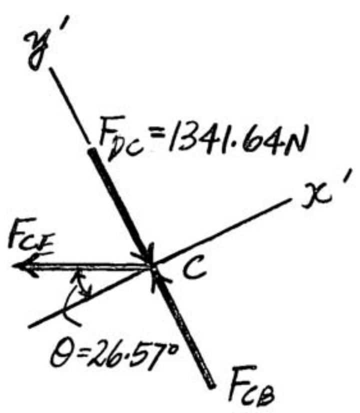
$+\uparrow \Sigma F_y = 0;$ $\quad 1200 + 1272.79\cos 45° - F_{EA} = 0$

$F_{EA} = 2100 \text{ N} = 2.10 \text{ kN (T)}$ **Ans.**

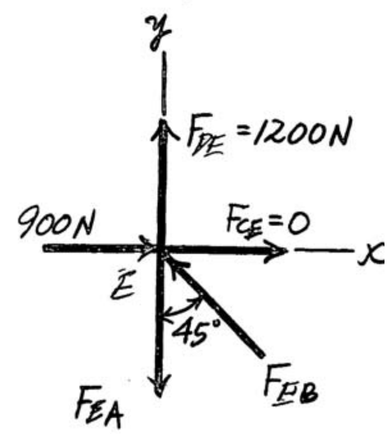
*Note:* The equilibrium analysis of joint $A$ can be used to determine the components of support reaction at $A$.



(a)

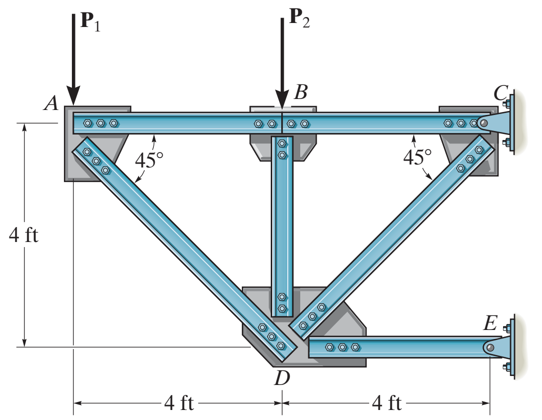


(b)



(c)

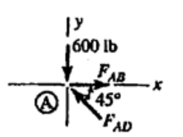
**6–2.** The truss, used to support a balcony, is subjected to the loading shown. Approximate each joint as a pin and determine the force in each member. State whether the members are in tension or compression. Set $P_1 = 600$ lb, $P_2 = 400$ lb.




**Joint $A$:**

$+\uparrow \Sigma F_y = 0;\qquad F_{AD}\sin 45° - 600 = 0$

$F_{AD} = 848.528 = 849 \text{ lb (C)}$ **Ans**



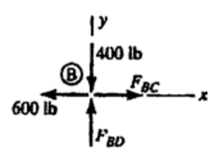

$\xrightarrow{+}\Sigma F_x = 0;\qquad F_{AB} - 848.528\cos 45° = 0$

$F_{AB} = 600 \text{ lb (T)}$ **Ans**

**Joint $B$:**

$+\uparrow \Sigma F_y = 0;\qquad F_{BD} - 400 = 0$

$F_{BD} = 400 \text{ lb (C)}$ **Ans**




$\xrightarrow{+}\Sigma F_x = 0;\qquad F_{BC} - 600 = 0$

$F_{BC} = 600 \text{ lb (T)}$ **Ans**

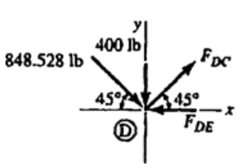
**Joint $D$:**

$+\uparrow \Sigma F_y = 0;\qquad F_{DC}\sin 45° - 400 - 848.528\sin 45° = 0$

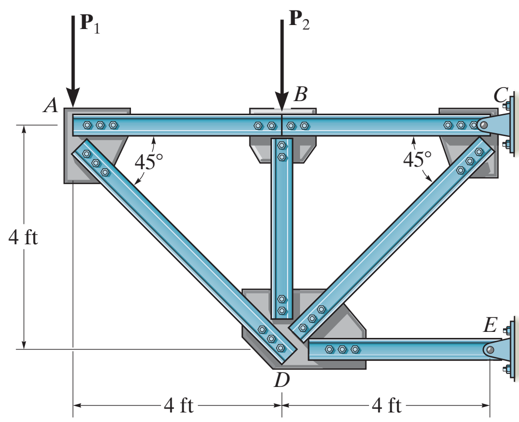
$F_{DC} = 1414.214 \text{ lb} = 1.41 \text{ kip (T)}$ **Ans**

$\xrightarrow{+}\Sigma F_x = 0;\qquad 848.528\cos 45° + 1414.214\cos 45° - F_{DE} = 0$

$F_{DE} = 1600 \text{ lb} = 1.60 \text{ kip (C)}$ **Ans**



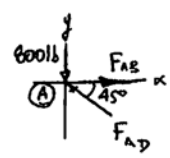
**6–3.** The truss, used to support a balcony, is subjected to the loading shown. Approximate each joint as a pin and determine the force in each member. State whether the members are in tension or compression. Set $P_1 = 800$ lb, $P_2 = 0$.




**Joint *A* :**

$+\uparrow\Sigma F_y = 0;$ $\quad F_{AD}\sin 45° - 800 = 0$

$F_{AD} = 1131.4 \text{ lb} = 1.13 \text{ kip (C)}$ **Ans**



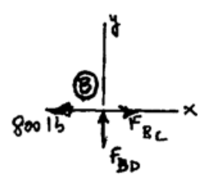

$\xrightarrow{+}\Sigma F_x = 0;$ $\quad F_{AB} - 1131.4\cos 45° = 0$

$F_{AB} = 800 \text{ lb (T)}$ **Ans**

**Joint *B* :**

$+\uparrow\Sigma F_y = 0;$ $\quad F_{BD} - 0 = 0$

$F_{BD} = 0$ **Ans**



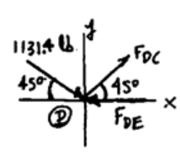

$\xrightarrow{+}\Sigma F_x = 0;$ $\quad F_{BC} - 800 = 0$

$F_{BC} = 800 \text{ lb (T)}$ **Ans**

**Joint *D* :**

$+\uparrow\Sigma F_y = 0;$ $\quad F_{DC}\sin 45° - 0 - 1131.4\sin 45° = 0$

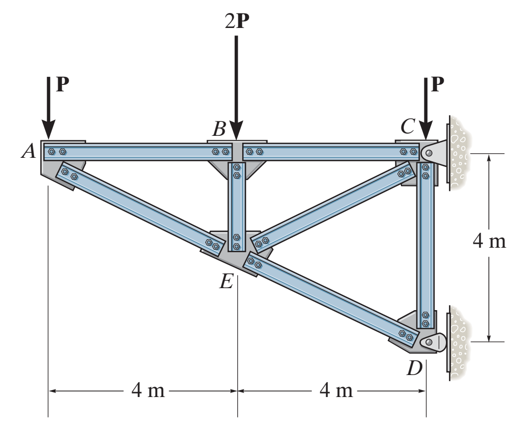
$F_{DC} = 1131.4 \text{ lb} = 1.13 \text{ kip (T)}$ **Ans**




$\xrightarrow{+}\Sigma F_x = 0;$ $\quad 1131.4\cos 45° + 1131.4\cos 45° - F_{DE} = 0$

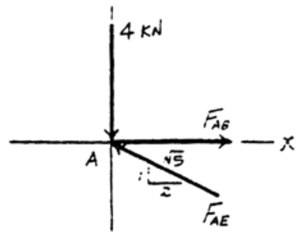
$F_{DE} = 1600 \text{ lb} = 1.60 \text{ kip (C)}$ **Ans**

***6–4.** Determine the force in each member of the truss and state if the members are in tension or compression. Assume each joint as a pin. Set $P = 4$ kN.




***Method of Joints :*** In this case, the support reactions are not required for determining the member forces.

**Joint *A***



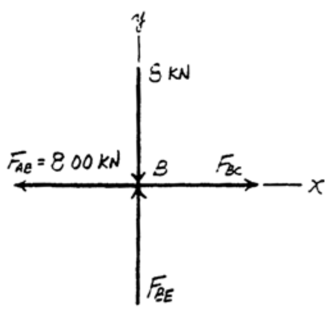

$$+\uparrow \Sigma F_y = 0; \quad F_{AE}\left(\frac{1}{\sqrt{5}}\right) - 4 = 0$$

$$F_{AE} = 8.944 \text{ kN (C)} = 8.94 \text{ kN (C)} \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AB} - 8.944\left(\frac{2}{\sqrt{5}}\right) = 0$$

$$F_{AB} = 8.00 \text{ kN (T)} \qquad \textbf{Ans}$$

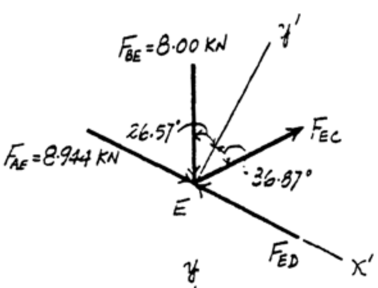
**Joint *B***




$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{BC} - 8.00 = 0 \qquad F_{BC} = 8.00 \text{ kN (T)} \qquad \textbf{Ans}$$

$$+\uparrow \Sigma F_y = 0; \quad F_{BE} - 8 = 0 \qquad F_{BE} = 8.00 \text{ kN (C)} \qquad \textbf{Ans}$$

**Joint *E***



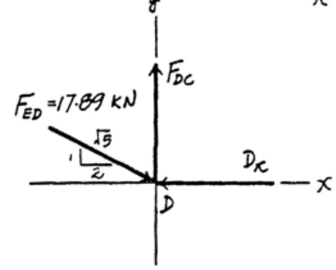

$$+\nearrow \Sigma F_{y'} = 0; \quad F_{EC}\cos 36.87° - 8.00\cos 26.57° = 0$$

$$F_{EC} = 8.944 \text{ kN (T)} = 8.94 \text{ kN (T)} \qquad \textbf{Ans}$$

$$\nwarrow + \Sigma F_{x'} = 0; \quad 8.944 + 8.00\sin 26.57° + 8.944\sin 36.87° - F_{ED} = 0$$

$$F_{ED} = 17.89 \text{ kN (C)} = 17.9 \text{ kN (C)} \qquad \textbf{Ans}$$

**Joint *D***

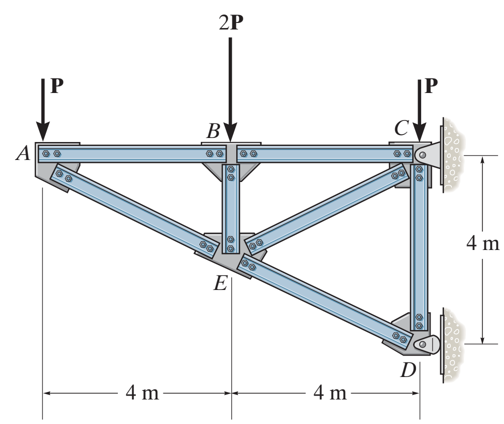



$$+\uparrow \Sigma F_y = 0; \quad F_{DC} - 17.89\left(\frac{1}{\sqrt{5}}\right) = 0 \qquad F_{DC} = 8.00 \text{ kN (T)} \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad D_x - 17.89\left(\frac{2}{\sqrt{5}}\right) = 0 \qquad D_x = 16.0 \text{ kN}$$

**Note :** The support reactions $C_x$ and $C_y$ can be determined by analysing Joint *C* using the results obtained above.

**•6–5.** Assume that each member of the truss is made of steel having a mass per length of 4 kg/m. Set $P = 0$, determine the force in each member, and indicate if the members are in tension or compression. Neglect the weight of the gusset plates and assume each joint is a pin. Solve the problem by assuming the weight of each member can be represented as a vertical force, half of which is applied at the end of each member.



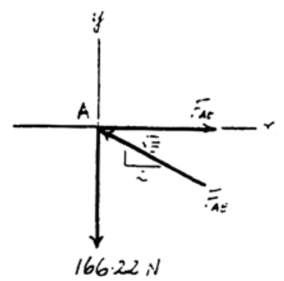

***Joint Forces :***

$$F_A = 4(9.81)\left(2+\frac{\sqrt{20}}{2}\right) = 166.22 \text{ N}$$

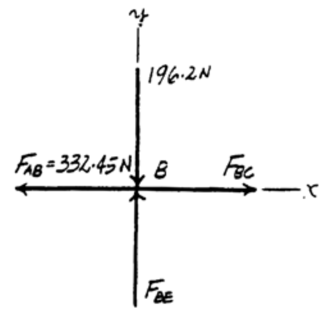
$$F_B = 4(9.81)(2+2+1) = 196.2 \text{ N}$$

$$F_E = 4(9.81)\left[1+3\left(\frac{\sqrt{20}}{2}\right)\right] = 302.47 \text{ N}$$

$$F_D = 4(9.81)\left(2+\frac{\sqrt{20}}{2}\right) = 166.22 \text{ N}$$




***Method of Joints :*** In this case, the support reactions are not required for determining the member forces.




**Joint *A***

$$+\uparrow \Sigma F_y = 0; \quad F_{AE}\left(\frac{1}{\sqrt{5}}\right) - 166.22 = 0$$

$$F_{AE} = 371.69 \text{ N (C)} = 372 \text{ N (C)} \quad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AB} - 371.69\left(\frac{2}{\sqrt{5}}\right) = 0$$

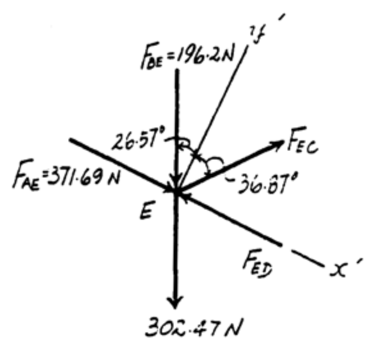
$$F_{AB} = 332.45 \text{ N (T)} = 332 \text{ N (T)} \quad \textbf{Ans}$$

**Joint *B***

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{BC} - 332.45 = 0 \quad F_{BC} = 332 \text{ N (T)} \quad \textbf{Ans}$$

$$+\uparrow \Sigma F_y = 0; \quad F_{BE} - 196.2 = 0$$

$$F_{BE} = 196.2 \text{ N (C)} = 196 \text{ N (C)} \quad \textbf{Ans}$$



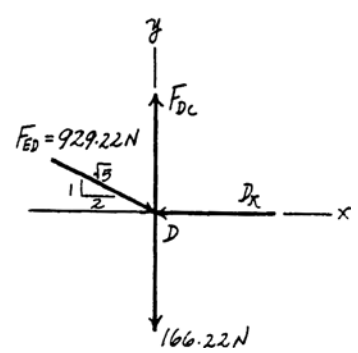

**Joint *E***

$$\nearrow + \Sigma F_{y'} = 0; \quad F_{EC}\cos 36.87° - (196.2+302.47)\cos 26.57° = 0$$

$$F_{EC} = 557.53 \text{ N (T)} = 558 \text{ N (T)} \quad \textbf{Ans}$$

$$\searrow + \Sigma F_{x'} = 0; \quad 371.69 + (196.2+302.47)\sin 26.57° + 557.53\sin 36.87° - F_{ED} = 0$$

$$F_{ED} = 929.22 \text{ N (C)} = 929 \text{ N (C)} \quad \textbf{Ans}$$

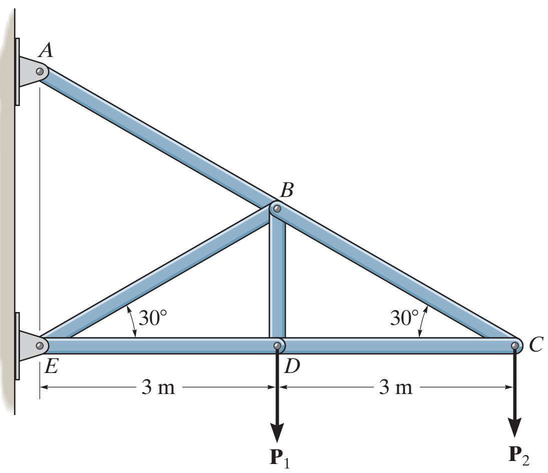



**Joint *D*:**

$$+\uparrow \Sigma F_y = 0; \quad -166.22 - 929.22\frac{1}{\sqrt{5}} + F_{DC} = 0$$

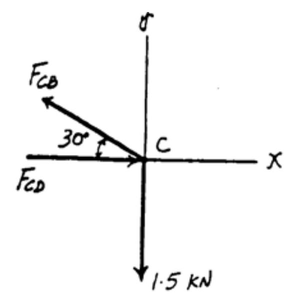
$$F_{DC} = 582\text{N (T)} \quad \textbf{Ans.}$$

**6–6.** Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 2$ kN and $P_2 = 1.5$ kN.




***Method of Joints :*** In this case, the support reactions are not required for determining the member forces.

**Joint *C***



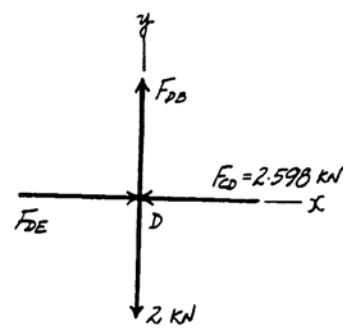

$+\uparrow \Sigma F_y = 0; \quad F_{CB} \sin 30° - 1.5 = 0$

$F_{CB} = 3.00$ kN (T) **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad F_{CD} - 3.00 \cos 30° = 0$

$F_{CD} = 2.598$ kN (C) $= 2.60$ kN (C) **Ans**

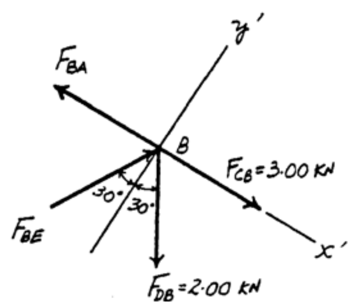
**Joint *D***




$\xrightarrow{+} \Sigma F_x = 0; \quad F_{DE} - 2.598 = 0 \qquad F_{DE} = 2.60$ kN (C) **Ans**

$+\uparrow \Sigma F_y = 0; \quad F_{DB} - 2 = 0 \qquad F_{DB} = 2.00$ kN (T) **Ans**

**Joint *B***




$+\nearrow \Sigma F_{y'} = 0; \quad F_{BE} \cos 30° - 2.00 \cos 30° = 0$

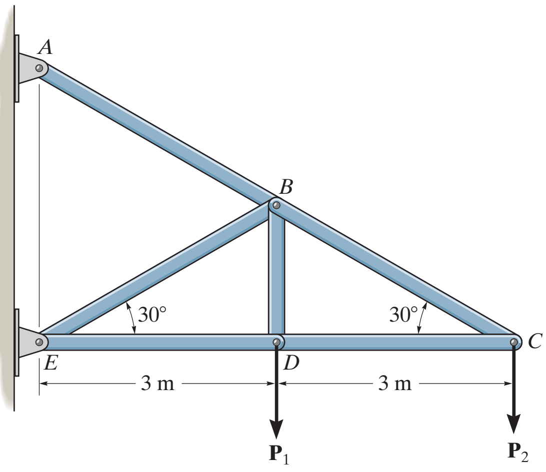
$F_{BE} = 2.00$ kN (C) **Ans**

$\nwarrow + \Sigma F_{x'} = 0; \quad (2.00 + 2.00) \sin 30° + 3.00 - F_{BA} = 0$

$F_{BA} = 5.00$ kN (T) **Ans**

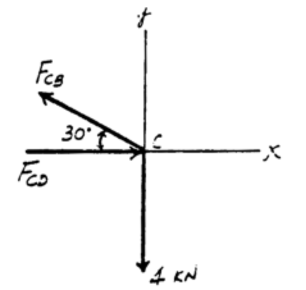
**Note :** The support reactions at support *A* and *E* can be determined by analyzing Joints *A* and *E* respectively using the results obtained above.

**6–7.** Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = P_2 = 4$ kN.




***Method of Joints :*** In this case, the support reactions are not required for determining the member forces.

**Joint *C***



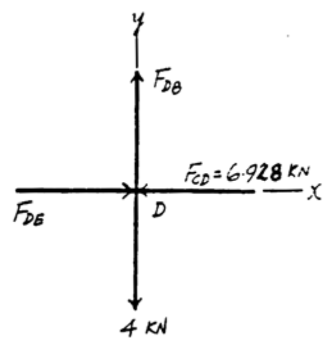

$+\uparrow \Sigma F_y = 0;\quad F_{CB} \sin 30° - 4 = 0$

$F_{CB} = 8.00$ kN (T) **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad F_{CD} - 8.00 \cos 30° = 0$

$F_{CD} = 6.928$ kN (C) $= 6.93$ kN (C) **Ans**

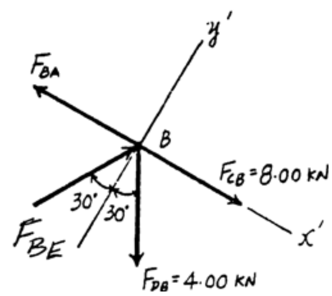
**Joint *D***




$\xrightarrow{+} \Sigma F_x = 0;\quad F_{DE} - 6.928 = 0 \quad F_{DE} = 6.93$ kN (C) **Ans**

$+\uparrow \Sigma F_y = 0;\quad F_{DB} - 4 = 0 \quad F_{DB} = 4.00$ kN (T) **Ans**

**Joint *B***




$\nearrow + \Sigma F_{y'} = 0;\quad F_{BE} \cos 30° - 4.00 \cos 30° = 0$

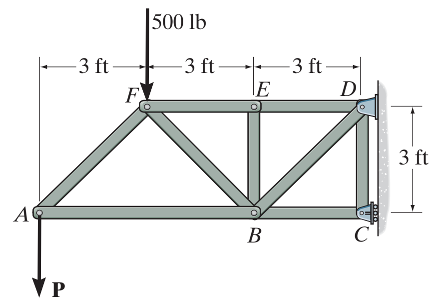
$F_{BE} = 4.00$ kN (C) **Ans**

$\searrow + \Sigma F_{x'} = 0;\quad (4.00 + 4.00) \sin 30° + 8.00 - F_{BA} = 0$

$F_{BA} = 12.0$ kN (T) **Ans**

**Note :** The support reactions at support *A* and *E* can be determined by analyzing Joints *A* and *E* respectively using the results obtained above.

***6–8.** Determine the force in each member of the truss, and state if the members are in tension or compression. Set $P = 800$ lb.




**Method of Joints:** We will analyze the equilibrium of the joints in the following sequence: $A \rightarrow F \rightarrow E \rightarrow B \rightarrow C$.

**Joint *A*:** From the free - body diagram in Fig. *a*,

$+\uparrow \Sigma F_y = 0; \qquad F_{AF} \sin 45° - 800 = 0$

$F_{AF} = 1131.37 \text{ lb} = 1131 \text{ lb (T)}$ **Ans.**

$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad 1131.37 \cos 45° - F_{AB} = 0$

$F_{AB} = 800 \text{ lb (C)}$ **Ans.**

**Joint *F*:** From the free - body diagram in Fig. *b*,

$+\uparrow \Sigma F_y = 0; \qquad F_{FB} \cos 45° - 1131.37 \cos 45° - 500 = 0$

$F_{FB} = 1838.48 \text{ lb} = 1838 \text{ lb (C)}$ **Ans.**

$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad F_{FE} - 1838.48 \sin 45° - 1131.37 \sin 45° = 0$

$F_{FE} = 2100 \text{ lb (T)}$ **Ans.**

**Joint *E*:** From the free - body diagram in Fig. *c*,

$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad F_{ED} - 2100 = 0$

$F_{ED} = 2100 \text{ lb (T)}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \qquad F_{EB} = 0$ **Ans.**

**Joint *B*:** From the free - body diagram in Fig. *d*,

$+\uparrow \Sigma F_y = 0; \qquad F_{BD} \sin 45° - 1838.48 \sin 45° = 0$

$F_{BD} = 1838.48 \text{ lb} = 1838 \text{ lb (T)}$ **Ans.**

$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad 800 + 1838.48 \cos 45° + 1838.48 \cos 45° - F_{BC} = 0$

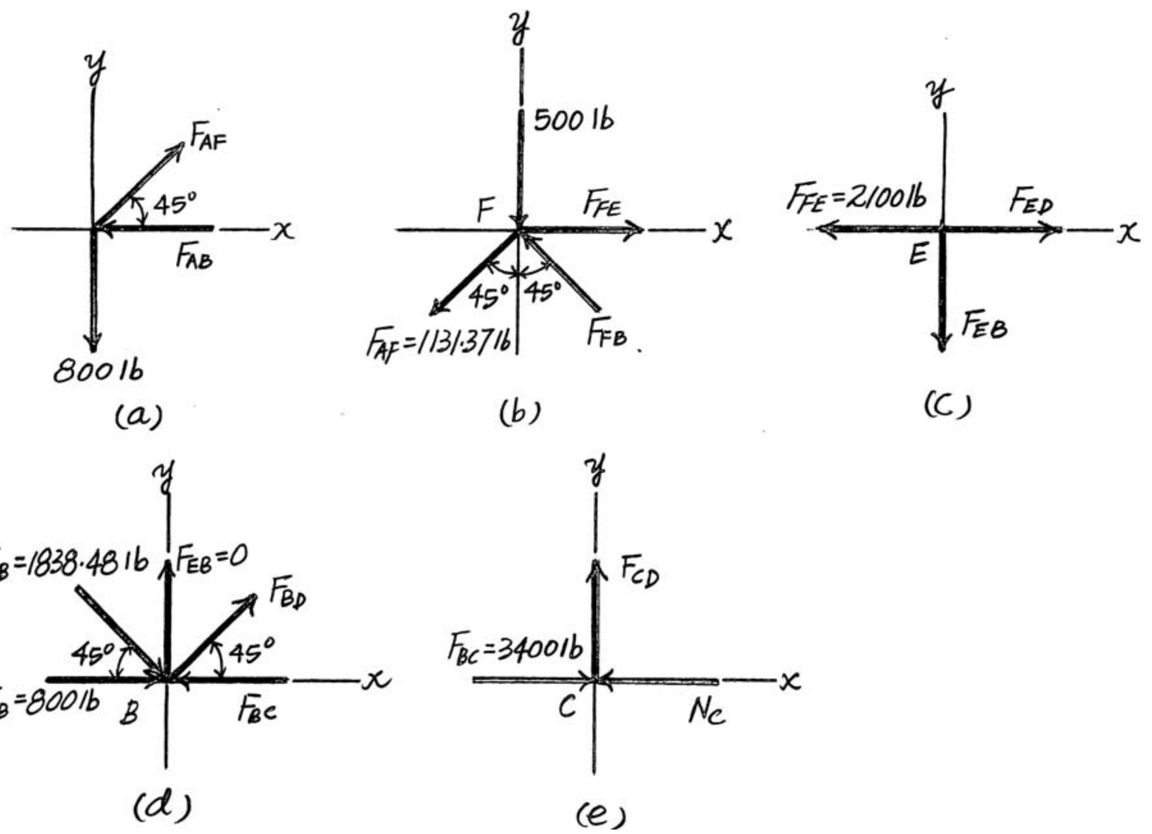
$F_{BC} = 3400 \text{ lb (C)}$ **Ans.**

**Joint *C*:** From the free - body diagram in Fig. *e*,

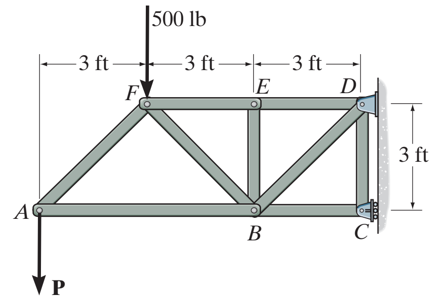
$+\uparrow \Sigma F_y = 0; \qquad F_{CD} = 0$ **Ans.**

$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad 3400 - N_C = 0$

$N_C = 3400 \text{ lb}$



**•6–9.** Remove the 500-lb force and then determine the greatest force $P$ that can be applied to the truss so that none of the members are subjected to a force exceeding either 800 lb in tension or 600 lb in compression.




**Method of Joints:** We will analyze the equilibrium of the joints in the following sequence: $A \rightarrow F \rightarrow E \rightarrow B \rightarrow C$.

**Joint** $A$**:** From the free - body diagram in Fig. $a$,

$+\uparrow \Sigma F_y = 0; \qquad F_{AF} \sin 45° - P = 0$

$F_{AF} = 1.4142P$ (T)

$\xrightarrow{+} \Sigma F_x = 0; \qquad 1.4142P \cos 45° - F_{AB} = 0$

$F_{AB} = P$ (C)

**Joint** $F$**:** From the free - body diagram in Fig. $b$,

$+\uparrow \Sigma F_y = 0; \qquad F_{FB} \cos 45° - 1.4142P \cos 45° = 0$

$F_{FB} = 1.4142P$ (C)

$\xrightarrow{+} \Sigma F_x = 0; \qquad F_{FE} - 1.4142P \sin 45° - 1.4142P \sin 45° = 0$

$F_{FE} = 2P$ (T)

**Joint** $E$**:** From the free - body diagram in Fig. $c$,

$\xrightarrow{+} \Sigma F_x = 0; \qquad F_{ED} - 2P = 0$

$F_{ED} = 2P$ (T)

$+\uparrow \Sigma F_y = 0; \qquad F_{EB} = 0$

**Joint** $B$**:** From the free - body diagram in Fig. $d$,

$+\uparrow \Sigma F_y = 0; \qquad F_{BD} \sin 45° - 1.4142P \sin 45° = 0$

$F_{BD} = 1.4142P$ (T)

$\xrightarrow{+} \Sigma F_x = 0; \qquad P + 1.4142P \cos 45° + 1.4142P \cos 45° - F_{BC} = 0$

$F_{BC} = 3P$ (C)

**Joint** $C$**:** From the free - body diagram in Fig. $e$,

$\xrightarrow{+} \Sigma F_x = 0; \qquad 3P - N_C = 0$

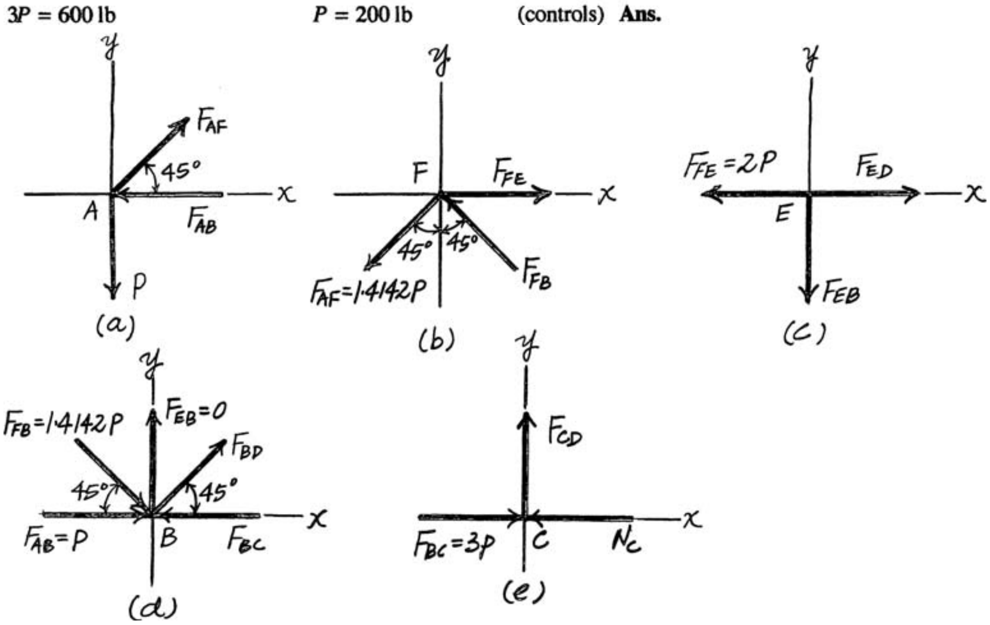
$N_C = 3P$

$+\uparrow \Sigma F_y = 0; \qquad F_{CD} = 0$

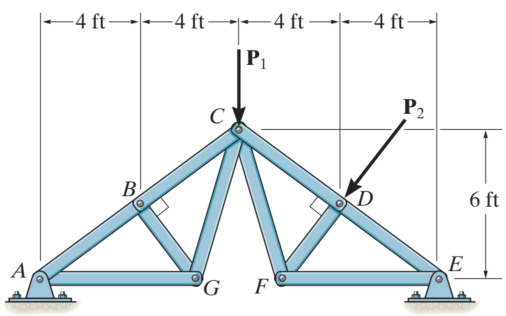
From the above results, the greatest compressive and tensile forces developed in the member are $3P$ and $2P$, respectively.

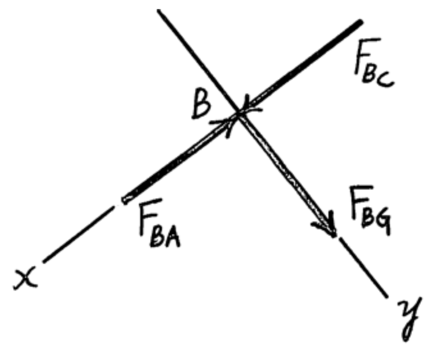
$2P = 800$ lb $\qquad P = 400$ lb

$3P = 600$ lb $\qquad P = 200$ lb $\qquad$ (controls) **Ans.**



**6–10.** Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 800$ lb, $P_2 = 0$.



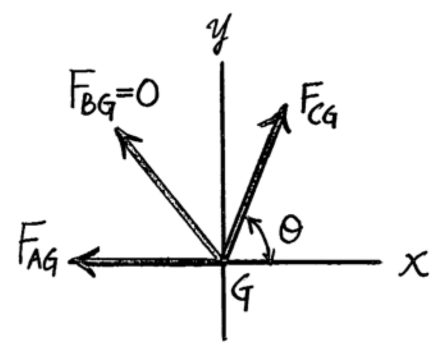




Joint $B$:

$\searrow + \Sigma F_y = 0;\quad F_{BG} = 0$

$\nearrow + \Sigma F_x = 0;\quad F_{BA} = F_{BC}$

Joint $G$:




$+\uparrow \Sigma F_y = 0;\quad F_{CG} \sin\theta = 0$

$F_{CG} = 0$

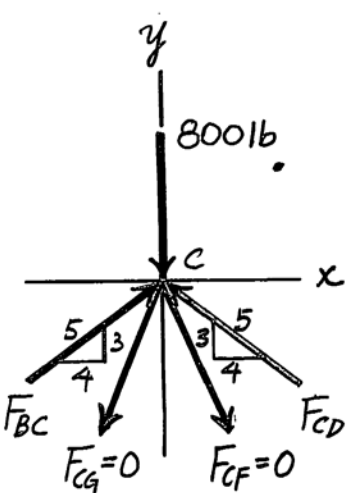
$\xrightarrow{+} \Sigma F_x = 0;\quad F_{AG} = 0$

Joint $C$:

$\xrightarrow{+} \Sigma F_x = 0;\quad \frac{4}{5}F_{BC} - \frac{4}{5}F_{CD} = 0$

$+\uparrow \Sigma F_y = 0;\quad \frac{3}{5}(F_{BC}) + \frac{3}{5}(F_{CD}) - 800 = 0$

$F_{BC} = F_{CD} = 667$ lb (C)




Due to symmetry:

$F_{DF} = F_{BG} = 0$ **Ans**

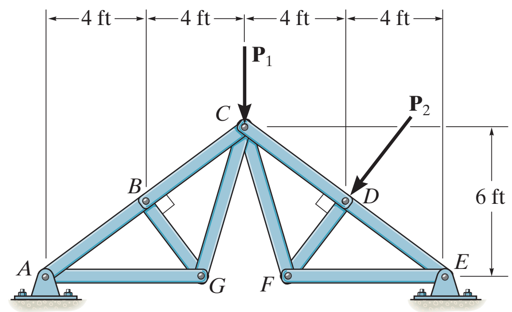
$F_{CF} = F_{CG} = 0$ **Ans**

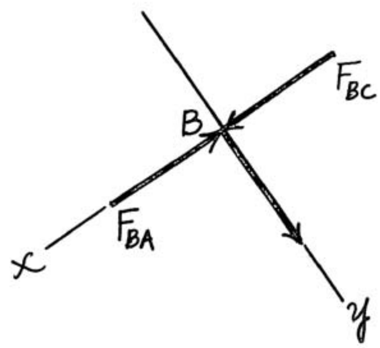
$F_{EF} = F_{AG} = 0$ **Ans**

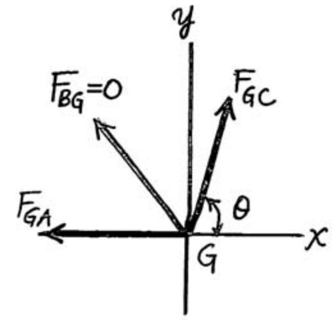
$F_{AB} = F_{DE} = 667$ lb (C) **Ans**

$F_{BC} = F_{CD} = 667$ lb (C) **Ans**

**6–11.** Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 600$ lb, $P_2 = 400$ lb.




**Joint B:**

$+\searrow \Sigma F_y = 0; \quad F_{BG} = 0 \quad$ **Ans**

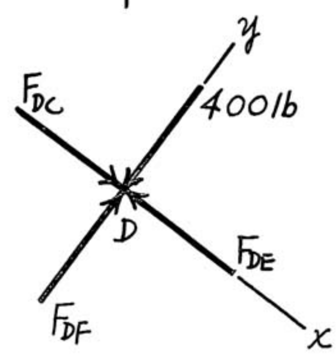
$+\nearrow \Sigma F_x = 0; \quad F_{BC} = F_{BA}$

**Joint G:**

$+\uparrow \Sigma F_y = 0; \quad F_{GC} \sin\theta = 0$

$F_{GC} = 0 \quad$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad F_{GA} = 0 \quad$ **Ans**



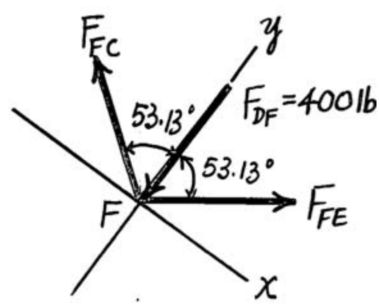

**Joint D:**

$+\searrow \Sigma F_x = 0; \quad F_{DE} - F_{DC} = 0$

$F_{DE} = F_{DC}$

$+\nearrow \Sigma F_y = 0; \quad F_{DF} - 400 = 0$

$F_{DF} = 400$ lb (C) **Ans**




**Joint F:**

$+\searrow \Sigma F_x = 0; \quad F_{FE} \sin 53.13° - F_{FC} \sin 53.13° = 0$

$F_{FE} = F_{FC}$

$+\nearrow \Sigma F_y = 0; \quad 2F \cos 53.13° - 400 = 0$

$F_{FC} = F_{FE} = 333.33 = 333$ lb (T) **Ans**

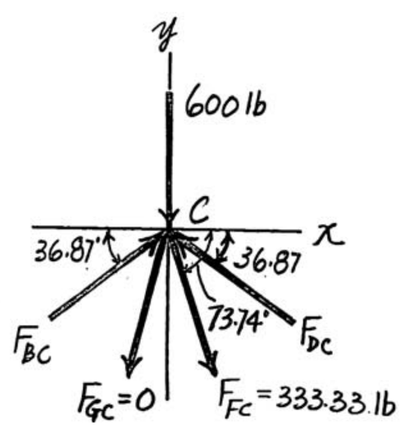
**Joint C:**

$\xrightarrow{+} \Sigma F_x = 0; \quad F_{BC} \cos 36.87° - F_{DC} \cos 36.87° + 333.33 \cos 73.74° = 0$

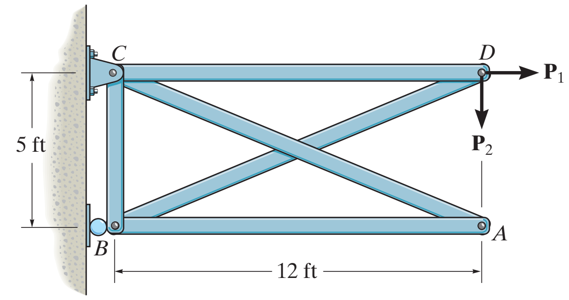
$+\uparrow \Sigma F_y = 0; \quad F_{BC} \sin 36.87° + F_{DC} \sin 36.87° - 600 - 333.33 \sin 73.74° = 0$

$F_{BC} = F_{BA} = 708$ lb (C) **Ans**

$F_{DC} = F_{DE} = 825$ lb (C) **Ans**



***6–12.** Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 240$ lb, $P_2 = 100$ lb.



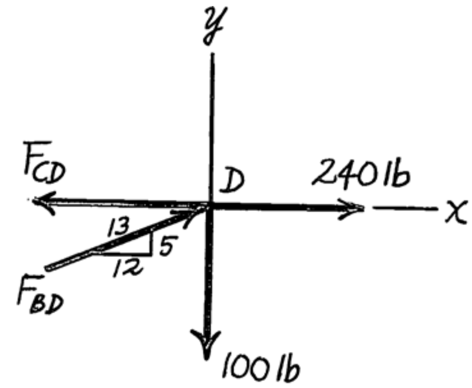

**Joint D:**

$+\uparrow \Sigma F_y = 0;\quad F_{BD}\left(\frac{5}{13}\right) - 100 = 0$

$F_{BD} = 260$ lb (C) **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad 240 - F_{CD} + 260\left(\frac{12}{13}\right) = 0$

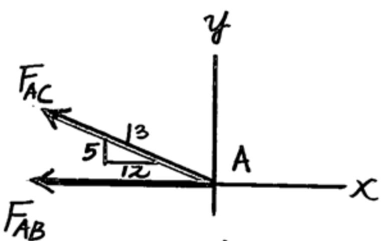
$F_{CD} = 480$ lb (T) **Ans**




**Joint A:**

$+\uparrow \Sigma F_y = 0;\quad F_{AC} = 0$ **Ans**

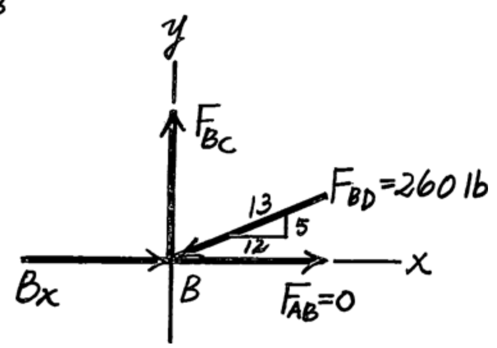
$\xrightarrow{+} \Sigma F_x = 0;\quad F_{AB} = 0$ **Ans**



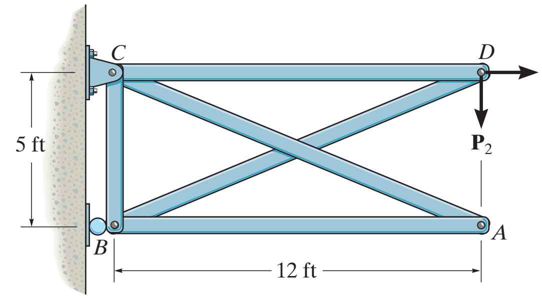

**Joint B:**

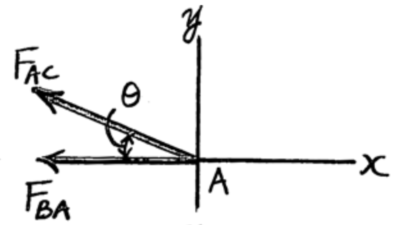
$+\uparrow \Sigma F_y = 0;\quad F_{BC} - 260\left(\frac{5}{13}\right) = 0$

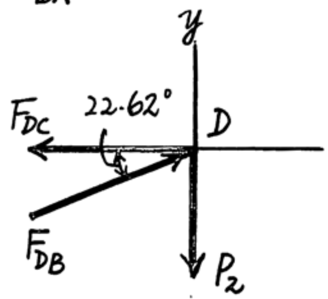
$F_{BC} = 100$ lb (T) **Ans**

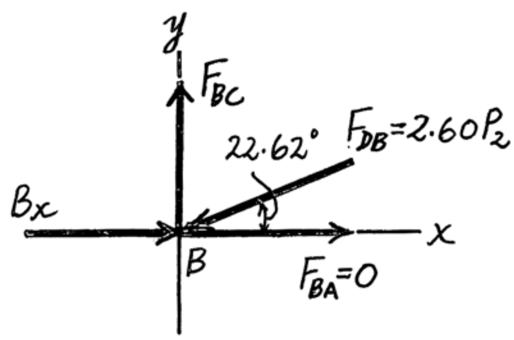


•**6–13.** Determine the largest load $P_2$ that can be applied to the truss so that the force in any member does not exceed 500 lb (T) or 350 lb (C). Take $P_1 = 0$.




**Joint A :**

$+\uparrow \Sigma F_y = 0; \quad F_{AC} \sin\theta = 0$

$F_{AC} = 0$

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

**Joint D :**

$+\uparrow \Sigma F_y = 0; \quad -P_2 + F_{DB} \sin 22.62° = 0$

$F_{DB} = 2.60\, P_2 \text{ (C)}$

$\xrightarrow{+} \Sigma F_x = 0; \quad 2.60\, P_2 \cos 22.62° - F_{DC} = 0$

$F_{DC} = 2.40\, P_2 \text{ (T)}$

**Joint B :**

$+\uparrow \Sigma F_y = 0; \quad F_{BC} - 2.60\, P_2 \sin 22.62° = 0$

$F_{BC} = P_2 \text{ (T)}$

Maximum tension member is *DC* :

$500 = 2.40\, P_2$

$P_2 = 208 \text{ lb}$

Maximum compression member is *DB* :

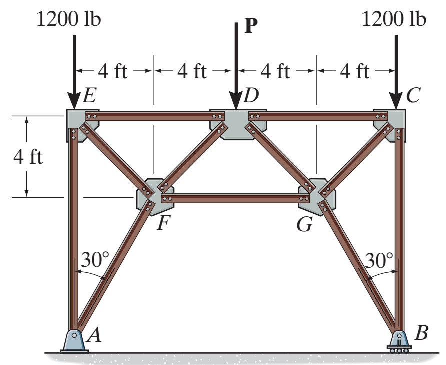
$350 = 2.60\, P_2$

$P_2 = 135 \text{ lb}$

Thus member *DB* reaches the critical value first.

$P_2 = 135 \text{ lb}$ **Ans**

**6–14.** Determine the force in each member of the truss, and state if the members are in tension or compression. Set $P = 2500$ lb.




**Support Reactions:** Applying the moment equation of equilibrium about point $A$ to the free-body diagram of the truss, Fig. $a$,

$$\circlearrowleft + \Sigma M_A = 0; \qquad N_B(8+8) - 1200(8+8) - 2500(8) = 0$$
$$N_B = 2450 \text{ lb}$$

**Method of Joints:** We will begin by analyzing the equilibrium of joint $B$, and then that of joints $C$ and $G$.

**Joint $B$:** From the free-body diagram in Fig. $b$,

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad F_{BG} = 0 \qquad \textbf{Ans.}$$
$$+\uparrow \Sigma F_y = 0; \qquad 2450 - F_{BC} = 0$$
$$F_{BC} = 2450 \text{ lb (C)} \qquad \textbf{Ans.}$$

**Joint $C$:** From the free-body diagram in Fig. $c$,

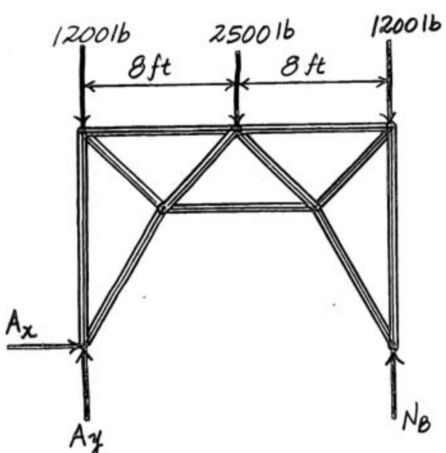
$$+\uparrow \Sigma F_y = 0; \qquad 2450 - 1200 - F_{CG}\sin 45° = 0$$
$$F_{CG} = 1767.77 \text{ lb} = 1768 \text{ lb (T)} \qquad \textbf{Ans.}$$
$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad F_{CD} - 1767.77\cos 45° = 0$$
$$F_{CD} = 1250 \text{ lb (C)} \qquad \textbf{Ans.}$$

**Joint $G$:** From the free-body diagram in Fig. $d$,

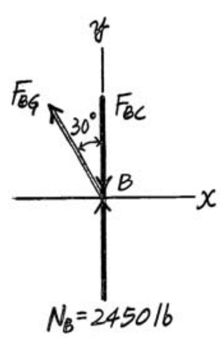
$$+\uparrow \Sigma F_y = 0; \qquad 1767.77\cos 45° - F_{GD}\cos 45° = 0$$
$$F_{GD} = 1767.77 \text{ lb} = 1768 \text{ lb (C)} \qquad \textbf{Ans.}$$
$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad 1767.77\sin 45° + 1767.77\sin 45° - F_{GF} = 0$$
$$F_{GF} = 2500 \text{ lb (T)} \qquad \textbf{Ans.}$$

Due to the symmetry of the system and the loading,

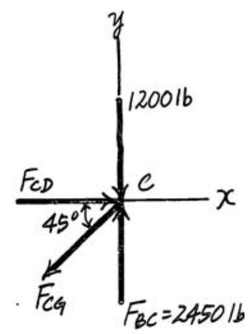
$$F_{AE} = F_{BC} = 2450 \text{ lb (C)} \qquad \textbf{Ans.}$$
$$F_{AF} = F_{BG} = 0 \qquad \textbf{Ans.}$$
$$F_{ED} = F_{CD} = 1250 \text{ lb (C)} \qquad \textbf{Ans.}$$
$$F_{EF} = F_{CG} = 1767.77 \text{ lb} = 1768 \text{ lb (T)} \qquad \textbf{Ans.}$$
$$F_{FD} = F_{GD} = 1767.77 \text{ lb} = 1768 \text{ lb (C)} \qquad \textbf{Ans.}$$



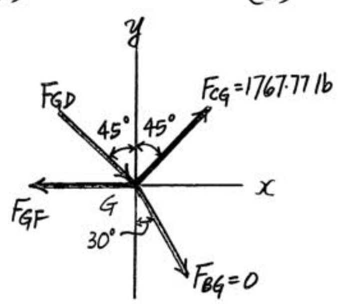

(a)




(b)

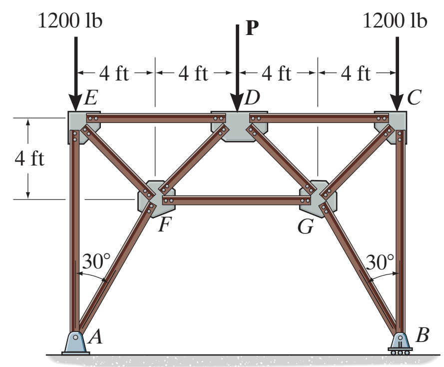



(c)




(d)

**6–15.** Remove the 1200-lb forces and determine the greatest force $P$ that can be applied to the truss so that none of the members are subjected to a force exceeding either 2000 lb in tension or 1500 lb in compression.




**Support Reactions:** Applying the moment equation of equilibrium about point $A$ to the free-body diagram of the truss, Fig. $a$,

$\circlearrowleft + \Sigma M_A = 0; \qquad N_B(8+8) - P(8) = 0$

$N_B = 0.5P$

**Method of Joints:** We will begin by analyzing the equilibrium of joint $B$, and then that of joints $C$ and $G$.

**Joint $B$:** From the free-body diagram in Fig. $b$,

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

$+\uparrow \Sigma F_y = 0; \qquad 0.5P - F_{BC} = 0$

$F_{BC} = 0.5P\ (C)$

**Joint $C$:** From the free-body diagram in Fig. $c$,

$+\uparrow \Sigma F_y = 0; \qquad 0.5P - F_{CG}\sin 45° = 0$

$F_{CG} = 0.7071P\ (T)$

$\xrightarrow{+} \Sigma F_x = 0; \qquad F_{CD} - 0.7071P\cos 45° = 0$

$F_{CD} = 0.5P\ (C)$

**Joint $G$:** From the free-body diagram in Fig. $d$,

$+\uparrow \Sigma F_y = 0; \qquad 0.7071P\cos 45° - F_{GD}\cos 45° = 0$

$F_{GD} = 0.7071P\,(C)$

$\xrightarrow{+} \Sigma F_x = 0; \qquad 0.7071P\sin 45° + 0.7071P\sin 45° - F_{GF} = 0$

$F_{GF} = P\ (T)$

Due to the symmetry of the system and the loading,

$F_{AE} = F_{BC} = 0.5P\ (C)$

$F_{AF} = F_{BG} = 0$

$F_{ED} = F_{CD} = 0.5P\,(C)$

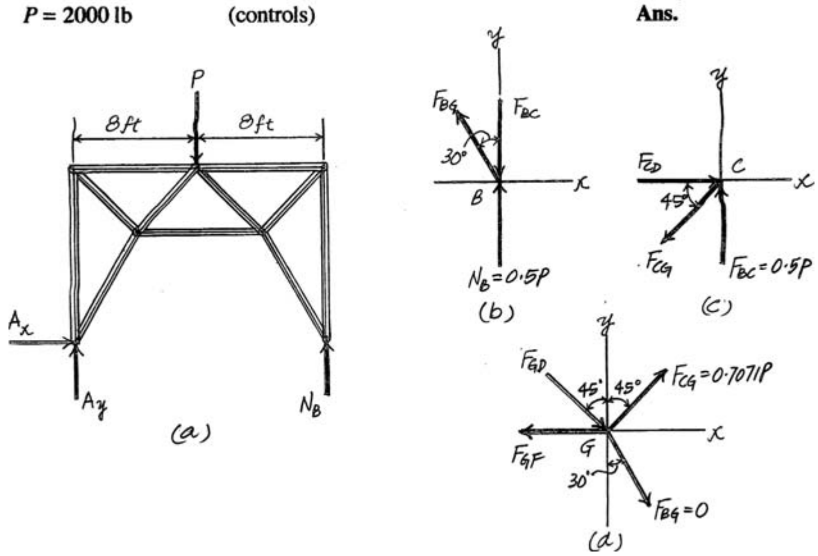
$F_{EF} = F_{CG} = 0.7071P\,(T)$

$F_{FD} = F_{GD} = 0.7071P\ (C)$

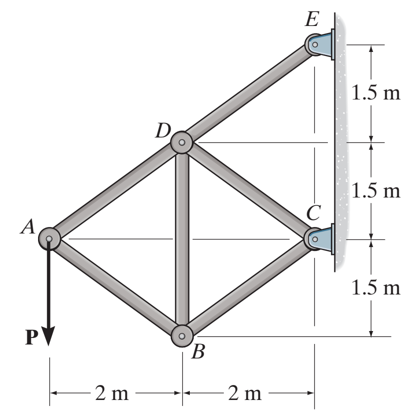
From the above results, the greatest tensile and compressive forces developed in the member of the truss are $P$ and $0.7071P$, respectively. Thus,

$0.7071P = 1500 \qquad P = 2121.33\,\text{lb}$

$P = 2000\ \text{lb} \qquad \text{(controls)}$ **Ans.**



***6–16.** Determine the force in each member of the truss, and state if the members are in tension or compression. Set $P = 5$ kN.




**Method of Joints:** We will begin by analyzing the equilibrium of joint $A$, and then proceed to analyzing that of joints $B$ and $D$.

**Joint** $A$**:** From the free - body diagram in Fig. $a$,

$\Sigma F_{y'} = 0;\quad F_{AD}\sin 73.74° - 5\sin 53.13° = 0$

$F_{AD} = 4.167\text{ kN} = 4.17\text{ kN (T)}$ **Ans.**

$\Sigma F_{x'} = 0;\quad 4.167\cos 73.74° + 5\cos 53.13° - F_{AB} = 0$

$F_{AB} = 4.167\text{ kN} = 4.17\text{ kN (C)}$ **Ans.**

**Joint** $B$**:** From the free - body diagram in Fig. $b$,

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad 4.167\left(\frac{4}{5}\right) - F_{BC}\left(\frac{4}{5}\right) = 0$

$F_{BC} = 4.167\text{ kN} = 4.17\text{ kN (C)}$ **Ans.**

$+\uparrow\Sigma F_y = 0;\quad F_{BD} - 4.167\left(\frac{3}{5}\right) - 4.167\left(\frac{3}{5}\right) = 0$

$F_{BD} = 5\text{ kN (T)}$ **Ans.**

**Joint** $D$**:** From the free - body diagram in Fig. $c$,

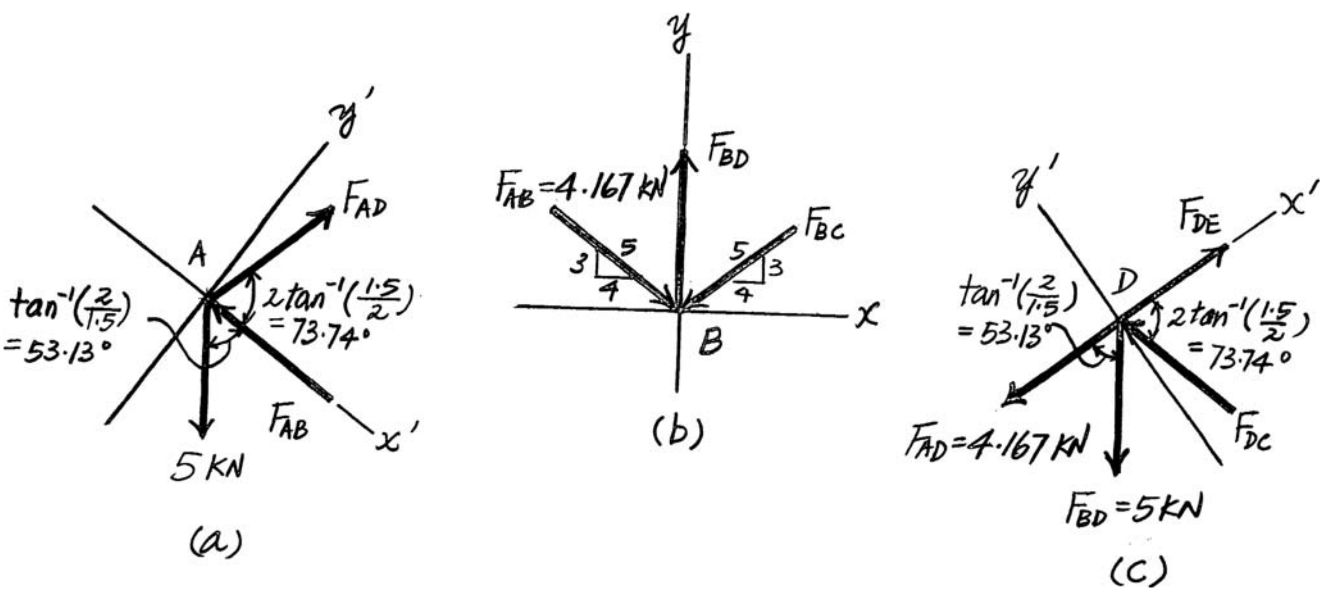
$+\nwarrow\Sigma F_{y'} = 0;\quad F_{DC}\sin 73.74° - 5\sin 53.13° = 0$

$F_{DC} = 4.167\text{ kN} = 4.17\text{ kN (C)}$ **Ans.**

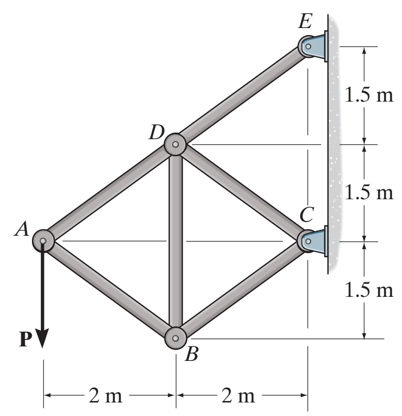
$+\nearrow\Sigma F_{x'} = 0;\quad F_{DE} - 4.167 - 5\cos 53.13° - 4.167\cos 73.74° = 0$

$F_{DE} = 8.333\text{ kN} = 8.33\text{ kN (T)}$ **Ans.**

*Note:* The equilibrium analysis of joints $E$ and $C$ can be used to determine the components of the support reaction at supports $E$ and $C$, respectively.



•**6–17.** Determine the greatest force $P$ that can be applied to the truss so that none of the members are subjected to a force exceeding either 2.5 kN in tension or 2 kN in compression.




**Method of Joints:** We will begin by analyzing the equilibrium of joint $A$, and then proceed to analyzing that of joints $B$ and $D$.

**Joint $A$:** From the free - body diagram in Fig. $a$,

$+\nearrow \Sigma F_{y'} = 0;\quad F_{AD}\sin 73.74° - P\sin 53.13° = 0$

$F_{AD} = 0.8333P$ (T)

$+\searrow \Sigma F_{x'} = 0;\quad 0.8333P\cos 73.74° + P\cos 53.13° - F_{AB} = 0$

$F_{AB} = 0.8333P$ (C)

**Joint $B$:** From the free - body diagram in Fig. $b$,

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad 0.8333P\left(\frac{4}{5}\right) - F_{BC}\left(\frac{4}{5}\right) = 0$

$F_{BC} = 0.8333P$ (C)

$+\uparrow \Sigma F_y = 0;\quad F_{BD} - 0.8333P\left(\frac{3}{5}\right) - 0.8333P\left(\frac{3}{5}\right) = 0$

$F_{BD} = P$ (T)

**Joint $D$:** From the free - body diagram in Fig. $c$,

$+\nwarrow \Sigma F_{y'} = 0;\quad F_{DC}\sin 73.74° - P\sin 53.13° = 0$

$F_{DC} = 0.8333P$(C)

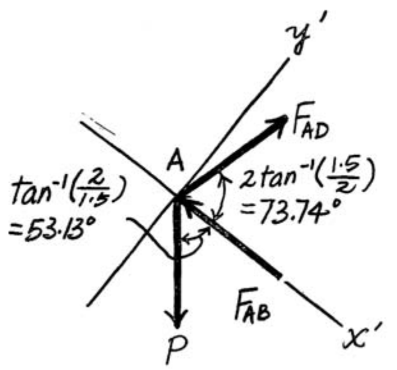
$+\nearrow \Sigma F_{x'} = 0;\quad F_{DE} - 0.8333P - P\cos 53.13° - 0.8333P\cos 73.74° = 0$

$F_{DE} = 1.6667P$ (T)

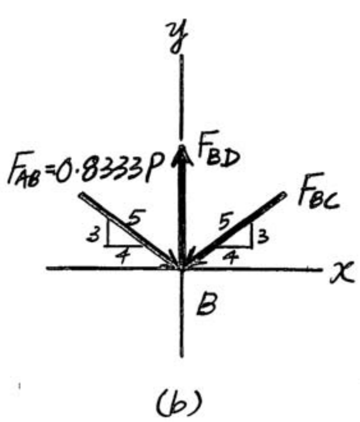
From the above results, the greatest compressive and tensile forces developed in the member are $0.8333P$ and $1.6667P$, respectively. Thus,

$0.8333P = 2 \qquad P = 2.40\text{ kN}$

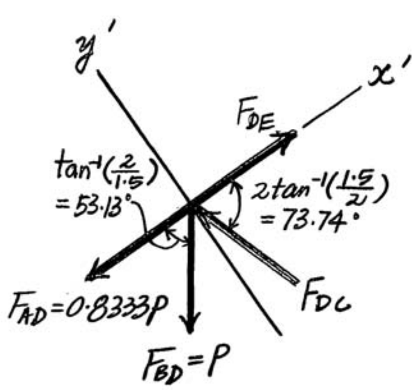
$1.6667P = 2.5 \qquad P = 1.50\text{ kN (controls)}$ **Ans.**




(a)

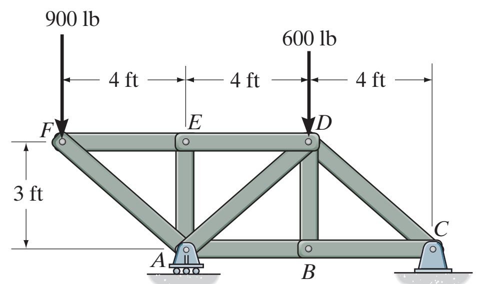



(b)




(c)

**6–18.** Determine the force in each member of the truss, and state if the members are in tension or compression.




**Support Reactions:** Applying the moment equation of equilibrium about point $C$ to the free-body diagram of the truss, Fig. $a$,

$\curvearrowleft +\Sigma M_C = 0;\qquad 600(4) + 900(4+4+4) - N_A = 0$

$N_A = 1650 \text{ lb}$

**Method of Joints:** We will analyze the equilibrium of the joints in the following sequence: $F \to E \to A \to B \to D$.

**Joint $F$:** From the free-body diagram in Fig. $b$,

$+\uparrow \Sigma F_y = 0;\qquad F_{FA}\left(\frac{3}{5}\right) - 900 = 0$

$F_{FA} = 1500 \text{ lb (C)}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0;\qquad F_{FE} - 1500\left(\frac{4}{5}\right) = 0$

$F_{FE} = 1200 \text{ lb (T)}$ **Ans.**

**Joint $E$:** From the free-body diagram in Fig. $c$,

$\xrightarrow{+} \Sigma F_x = 0;\qquad F_{ED} - 1200 = 0$

$F_{ED} = 1200 \text{ lb (T)}$ **Ans.**

$+\uparrow \Sigma F_y = 0;\qquad F_{EA} = 0$ **Ans.**

**Joint $A$:** From the free-body diagram in Fig. $d$,

$+\uparrow \Sigma F_y = 0;\qquad 1650 - 1500\left(\frac{3}{5}\right) - F_{AD}\left(\frac{3}{5}\right) = 0$

$F_{AD} = 1250 \text{ lb (C)}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0;\qquad 1500\left(\frac{4}{5}\right) - 1250\left(\frac{4}{5}\right) - F_{AB} = 0$

$F_{AB} = 200 \text{ lb (C)}$ **Ans.**

**Joint $B$:** From the free-body diagram in Fig. $e$,

$\xrightarrow{+} \Sigma F_x = 0;\qquad 200 - F_{BC} = 0$

$F_{BC} = 200 \text{ lb (C)}$ **Ans.**

$+\uparrow \Sigma F_y = 0;\qquad F_{BD} = 0$ **Ans.**

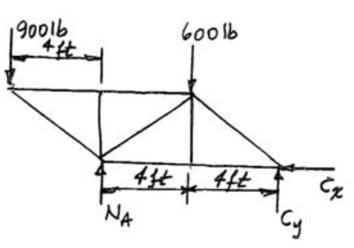
**Joint $D$:** From the free-body diagram in Fig. $f$,

$\xrightarrow{+} \Sigma F_x = 0;\qquad F_{DC}\left(\frac{4}{5}\right) + 1250\left(\frac{4}{5}\right) - 1200 = 0$

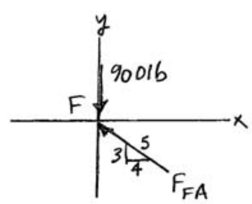
$F_{DC} = 250 \text{ lb (T)}$ **Ans.**

$+\uparrow \Sigma F_y = 0;\qquad 1250\left(\frac{3}{5}\right) - 250\left(\frac{3}{5}\right) - 600 = 0$ (check)

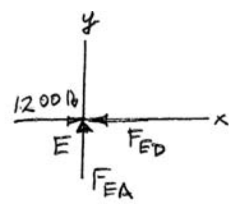
*Note:* The equilibrium analysis of joint $C$ must be used to determine the components of the support reaction at $C$.



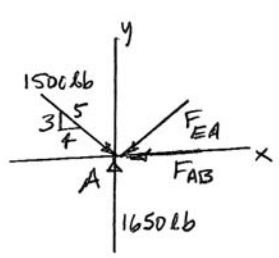
(a)



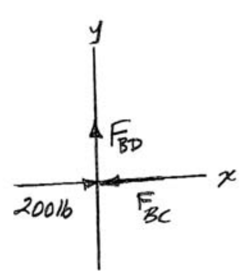
(b)



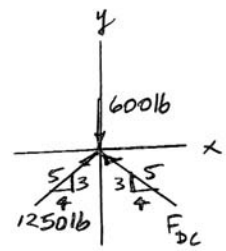
(c)



(d)

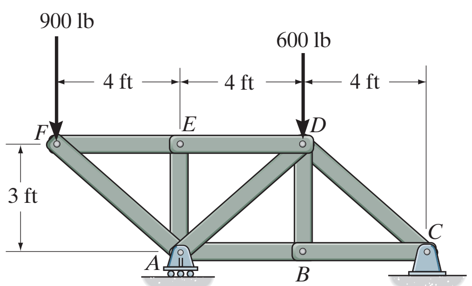


(e)



(f)

**6–19.** The truss is fabricated using members having a weight of 10 lb/ft. Remove the external forces from the truss, and determine the force in each member due to the weight of the members. State whether the members are in tension or compression. Assume that the total force acting on a joint is the sum of half of the weight of every member connected to the joint.




**Joint Loadings:**

$$F_C = F_F = 10\left(\frac{4+5}{2}\right) = 45 \text{ lb}$$

$$F_E = F_B = 10\left(\frac{4+4+3}{2}\right) = 55 \text{ lb}$$

$$F_A = F_D = 10\left(\frac{5+5+4+3}{2}\right) = 85 \text{ lb}$$

**Support Reactions:** Applying the moment equation of equilibrium about point $C$ to the free-body diagram of the truss, Fig. $a$,

$\circlearrowleft + \Sigma M_C = 0;$ $\quad 45(4+4+4)+55(4+4)+85(4+4)+85(4)+55(4)-N_A(4+4)=0$

$N_A = 277.5 \text{ lb}$

**Method of Joints:** We will analyze the equilibrium of the joints in the following sequence: $F \rightarrow E \rightarrow A \rightarrow B \rightarrow D$.

**Joint $F$:** From the free-body diagram in Fig. $b$,

$+\uparrow \Sigma F_y = 0;$ $\quad F_{FA}\left(\frac{3}{5}\right) - 45 = 0$

$F_{FA} = 75 \text{ lb (C)}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad F_{FE} - 75\left(\frac{4}{5}\right) = 0$

$F_{FE} = 60 \text{ lb (T)}$ **Ans.**

**Joint $E$:** From the free-body diagram in Fig. $c$,

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad F_{ED} - 60 = 0$

$F_{ED} = 60 \text{ lb (T)}$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad F_{EA} - 55 = 0$

$F_{EA} = 55 \text{ lb (C)}$ **Ans.**

**Joint $A$:** From the free-body diagram in Fig. $d$,

$+\uparrow \Sigma F_y = 0;$ $\quad 277.5 - 55 - 85 - 75\left(\frac{3}{5}\right) - F_{AD}\left(\frac{3}{5}\right) = 0$

$F_{AD} = 154.17 \text{ lb} = 154 \text{ lb (C)}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad F_{AB} + 75\left(\frac{4}{5}\right) - 154.17\left(\frac{4}{5}\right) = 0$

$F_{AB} = 63.33 \text{ lb} = 63.3 \text{ lb (T)}$ **Ans.**

**Joint $B$:** From the free-body diagram in Fig. $e$,

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad F_{BC} - 63.33 = 0$

$F_{BC} = 63.33 \text{ lb} = 63.3 \text{ lb (T)}$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad F_{BD} - 55 = 0$

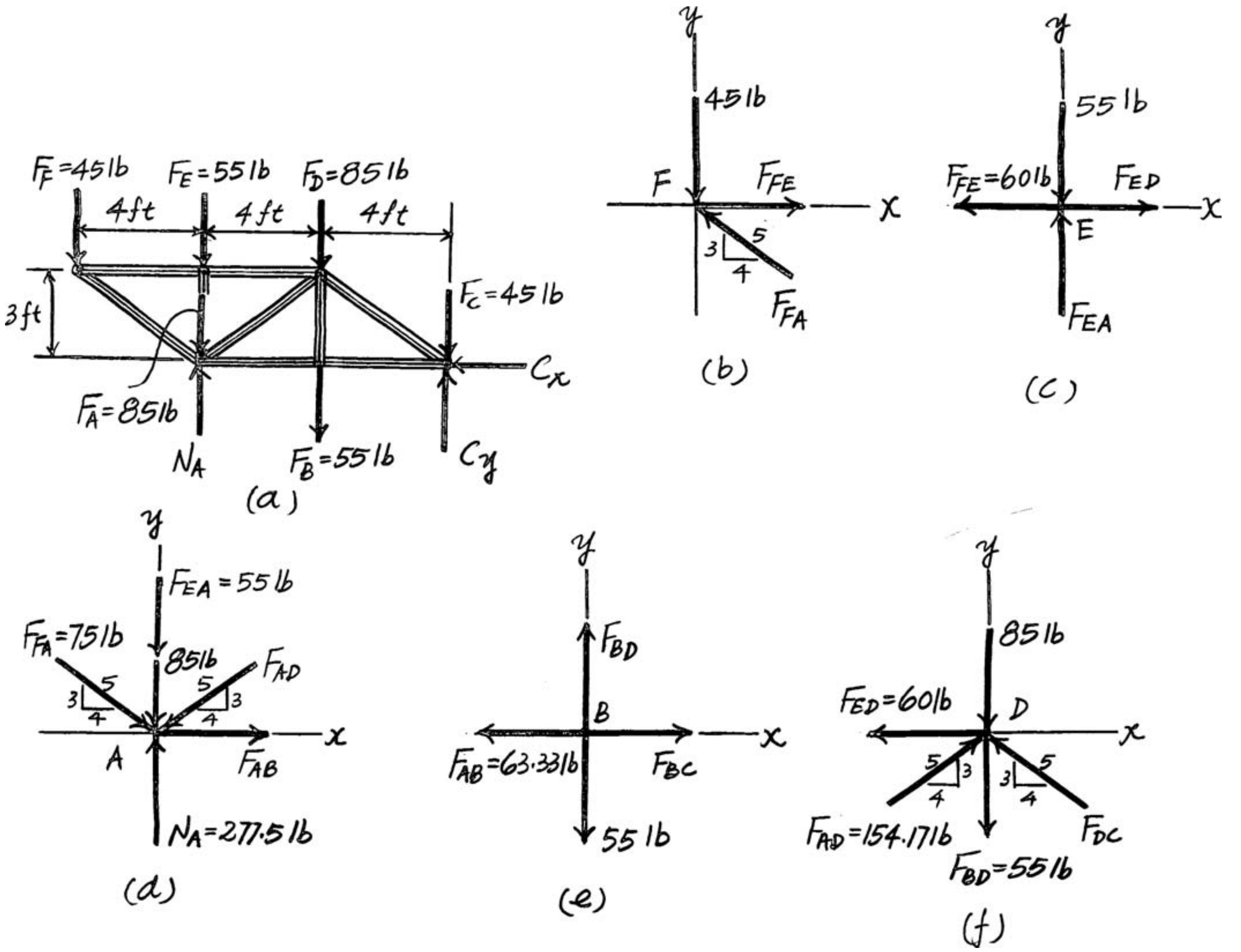
$F_{BD} = 55 \text{ lb (T)}$ **Ans.**

**Joint $D$:** From the free-body diagram in Fig. $f$,

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad 154.17\left(\frac{4}{5}\right) - 60 - F_{DC}\left(\frac{4}{5}\right) = 0$

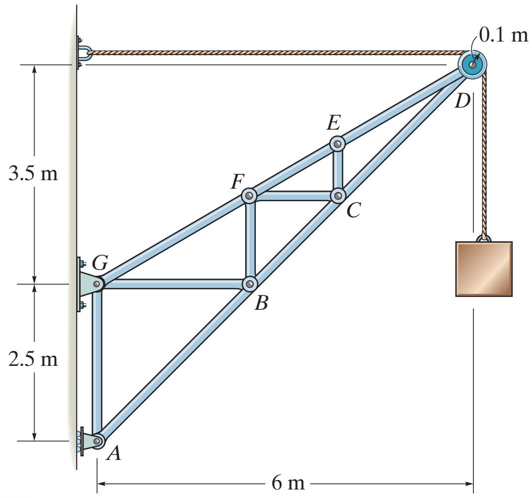
$F_{DC} = 79.17 \text{ lb} = 79.2 \text{ lb (C)}$ **Ans.**

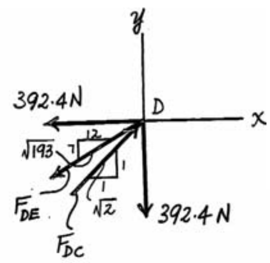
$+\uparrow \Sigma F_y = 0;$ $\quad 154.17\left(\frac{3}{5}\right) + 79.17\left(\frac{3}{5}\right) - 85 - 55 = 0$ (check)



$F_F = 45$ lb
$F_E = 55$ lb
$F_D = 85$ lb
4 ft
4 ft
4 ft
3 ft
$F_C = 45$ lb
$C_x$
$F_A = 85$ lb
$N_A$
$F_B = 55$ lb
$C_y$
(a)
y
45 lb
F
$F_{FE}$
x
3
5
4
$F_{FA}$
(b)
y
55 lb
$F_{FE} = 60$ lb
$F_{ED}$
x
E
$F_{EA}$
(c)
y
$F_{EA} = 55$ lb
$F_{FA} = 75$ lb
85 lb
$F_{AD}$
x
A
$F_{AB}$
$N_A = 277.5$ lb
(d)
y
$F_{BD}$
B
x
$F_{AB} = 63.33$ lb
$F_{BC}$
55 lb
(e)
y
85 lb
$F_{ED} = 60$ lb
D
x
$F_{AD} = 154.17$ lb
$F_{DC}$
$F_{BD} = 55$ lb
(f)

***6–20.** Determine the force in each member of the truss and state if the members are in tension or compression. The load has a mass of 40 kg.




Joint $D$ :

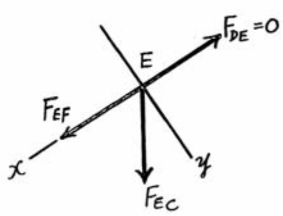
$\xrightarrow{+} \Sigma F_x = 0;\quad F_{DC}\left(\frac{1}{\sqrt{2}}\right) - 392.4 - F_{DE}\left(\frac{12}{\sqrt{193}}\right) = 0$

$+\uparrow \Sigma F_y = 0;\quad F_{DC}\left(\frac{1}{\sqrt{2}}\right) - F_{DE}\left(\frac{7}{\sqrt{193}}\right) - 392.4 = 0$

Solving,

$F_{DE} = 0$ Ans

$F_{DC} = 555\text{ N (C)}$ Ans




Joint $E$ :

$+\searrow \Sigma F_y = 0;\quad F_{EC} = 0$ Ans

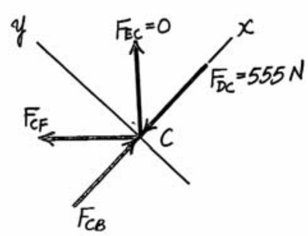
$+\nearrow \Sigma F_x = 0;\quad F_{EF} = 0$ Ans

Joint $C$ :

$+\nwarrow \Sigma F_y = 0;\quad F_{CF} = 0$ Ans

$+\nearrow \Sigma F_x = 0;\quad -555 + F_{CB} = 0$

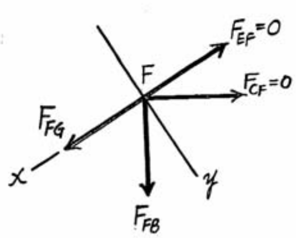
$F_{CB} = 555\text{ N (C)}$ Ans




Joint $F$ :

$+\searrow \Sigma F_y = 0;\quad F_{FB} = 0$ Ans

$+\nearrow \Sigma F_x = 0;\quad F_{FG} = 0$ Ans




Joint $B$ :

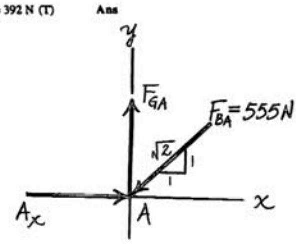
$+\nwarrow \Sigma F_y = 0;\quad F_{BG} = 0$ Ans

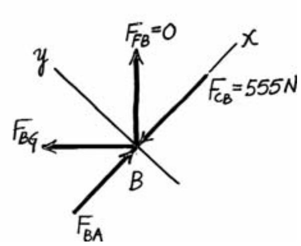
$+\nearrow \Sigma F_x = 0;\quad F_{BA} = 555\text{ N (C)}$ Ans

Joint $A$ :

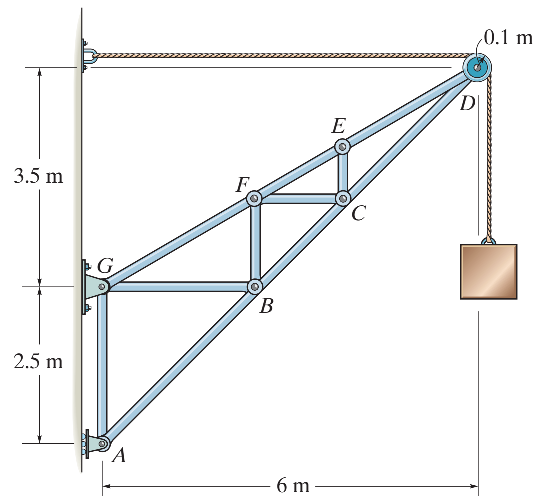
$+\uparrow \Sigma F_y = 0;\quad F_{GA} - 555\left(\frac{1}{\sqrt{2}}\right) = 0$

$F_{GA} = 392\text{ N (T)}$ Ans



**•6–21.** Determine the largest mass $m$ of the suspended block so that the force in any member does not exceed 30 kN (T) or 25 kN (C).




Inspection of joints $E$, $C$, $F$, and $B$ indicates that $EC$, $CF$, $FB$, and $BG$ are all zero-force members.

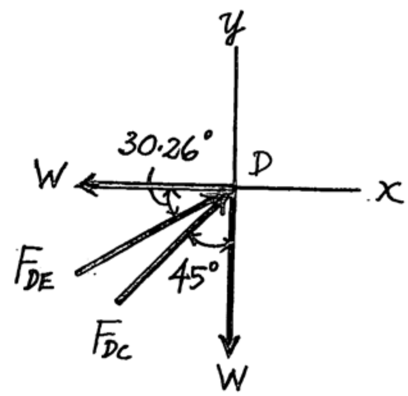
Joint $D$:

$\xrightarrow{+} \Sigma F_x = 0; \quad F_{DC} \sin 45° + F_{DE} \cos 30.25° - W = 0$

$+\uparrow \Sigma F_y = 0; \quad F_{DC} \cos 45° + F_{DE} \sin 30.25° - W = 0$

$F_{DC} = 1.414\,W \text{ (C)}$

$F_{DE} = 0$




Joint $A$:

$+\uparrow \Sigma F_y = 0; \quad F_{AG} - 1.414\,W \sin 45° = 0$

$F_{AG} = W \text{ (T)}$

For compression of members $DC$, $BC$, and $AB$,

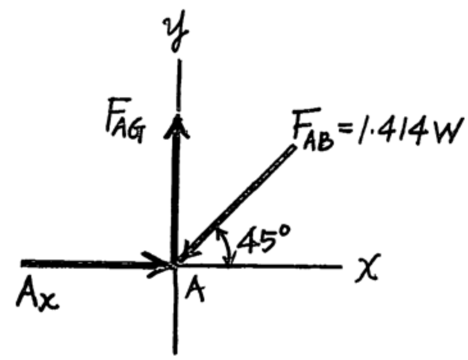
$25 \text{ kN} = 1.414\,W$

$W = 17.678 \text{ kN}$

For tension of member $AG$,

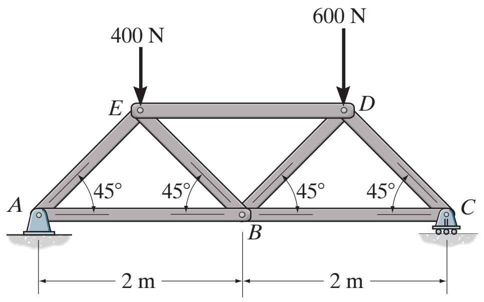
$W = 30 \text{ kN}$

Thus the critical value is compression.




$$m = \frac{17.678\,(10^3)\text{ N}}{9.81} = 1.80 \text{ Mg} \quad \text{Ans}$$

**6–22.** Determine the force in each member of the truss, and state if the members are in tension or compression.




**Support Reaction:** Applying the moment equation of equilibrium about point $A$ on the free-body diagram of the truss, Fig. $a$,

$+\Sigma M_A = 0;\quad N_C(4) - 400(1) - 600(3) = 0$

$N_C = 550\text{ N}$

**Method of Joints:** We will analyze the equilibrium of the joints in the following sequence: $C \rightarrow D \rightarrow E \rightarrow B$.

**Joint $C$:** From the free-body diagram in Fig. $b$,

$+\uparrow \Sigma F_y = 0;\quad 550 - F_{CD}\sin 45° = 0$

$F_{CD} = 777.82\text{ N} = 778\text{ N (C)}$ **Ans.**

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad 777.82\cos 45° - F_{CB} = 0$

$F_{CB} = 550\text{ N (T)}$ **Ans.**

**Joint $D$:** From the free-body diagram in Fig. $c$,

$+\uparrow \Sigma F_y = 0;\quad F_{DB}\sin 45° + 777.82\sin 45° - 600 = 0$

$F_{DB} = 70.71\text{ N} = 70.7\text{ N (C)}$ **Ans.**

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad F_{DE} + 70.71\cos 45° - 777.82\cos 45° = 0$

$F_{DE} = 500\text{ N (C)}$ **Ans.**

**Joint $E$:** From the free-body diagram in Fig. $d$,

$\Sigma F_{x'} = 0;\quad F_{EA} - 400\sin 45° - 500\sin 45° = 0$

$F_{EA} = 636.40\text{ N} = 636\text{ N (C)}$ **Ans.**

$\Sigma F_{y'} = 0;\quad 500\cos 45° - 400\cos 45° - F_{EB} = 0$

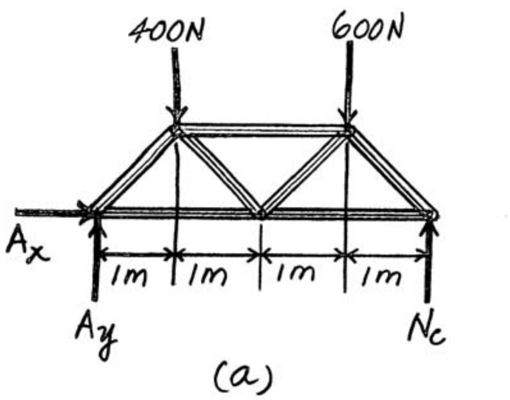
$F_{EB} = 70.71\text{N} = 70.7\text{ N (T)}$ **Ans.**

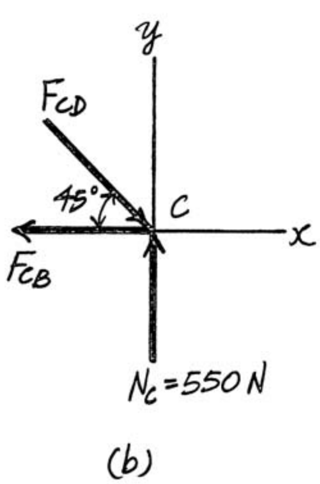
**Joint $B$:** From the free-body diagram in Fig. $e$,

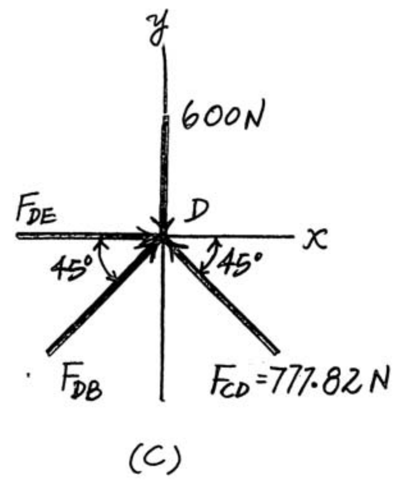
$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad 550 - 70.71\cos 45° - 70.71\cos 45° - F_{BA} = 0$

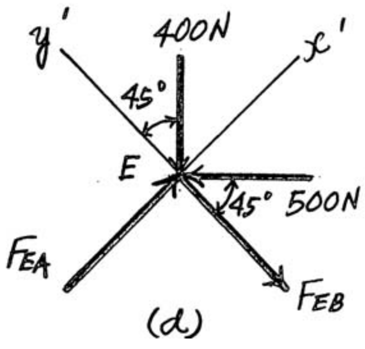
$F_{BA} = 450\text{ N (T)}$ **Ans.**

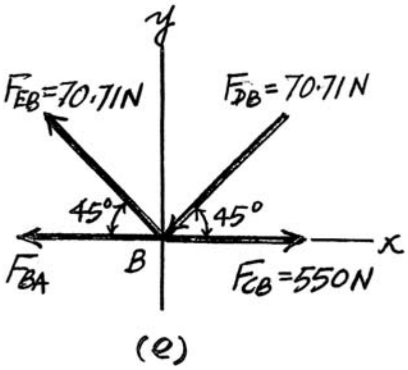
$+\uparrow \Sigma F_y = 0;\quad 70.71\sin 45° - 70.71\sin 45° = 0$ (check)



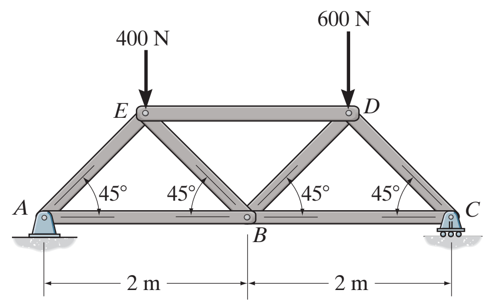



**6–23.** The truss is fabricated using uniform members having a mass of 5 kg/m. Remove the external forces from the truss, and determine the force in each member due to the weight of the truss. State whether the members are in tension or compression. Assume that the total force acting on a joint is the sum of half of the weight of every member connected to the joint.




**Joint Loading:**

$$F_C = F_A = 5(9.81)\left[\frac{2+\sqrt{2}}{2}\right] = 83.73\text{ N}$$

$$F_B = 5(9.81)\left[\frac{2+2+\sqrt{2}+\sqrt{2}}{2}\right] = 167.47\text{ N}$$

$$F_E = F_D = 5(9.81)\left[\frac{2+\sqrt{2}+\sqrt{2}}{2}\right] = 118.2\text{ N}$$

**Support Reactions:** Applying the moment equation of equilibrium about point $A$ to the free-body diagram of the truss, Fig. $a$,

$\circlearrowleft +\Sigma M_A = 0;$ $\quad N_C(4) - 83.73(4) - 118.42(3) - 167.47(2) - 118.42(1) = 0$

$N_C = 285.88\text{ N}$

**Method of Joints:** We will begin by analyzing the equilibrium of joint $C$, and then that of joint $D$.

**Joint $C$:** From the free-body diagram in Fig. $b$,

$+\uparrow \Sigma F_y = 0;$ $\quad 285.88 - 83.73 - F_{CD}\sin 45° = 0$

$F_{CD} = 285.88\text{ N} = 286\text{ N (C)}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad 285.88\cos 45° - F_{CB} = 0$

$F_{CB} = 202.15\text{ N} = 202\text{ N (T)}$ **Ans.**

**Joint $D$:** From the free-body diagram in Fig. $c$,

$+\uparrow \Sigma F_y = 0;$ $\quad 285.88\sin 45° - 118.42 - F_{DB}\sin 45° = 0$

$F_{DB} = 118.42\text{ N} = 118\text{ N (T)}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad F_{DE} - 285.88\cos 45° - 118.42\cos 45° = 0$

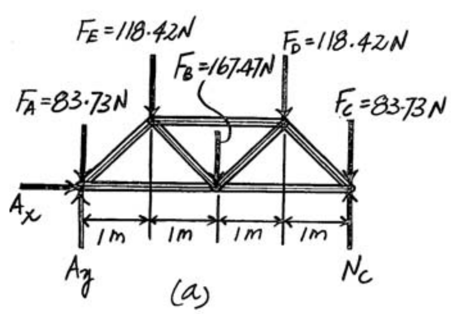
$F_{DE} = 285.88\text{ N} = 286\text{ N (C)}$ **Ans.**

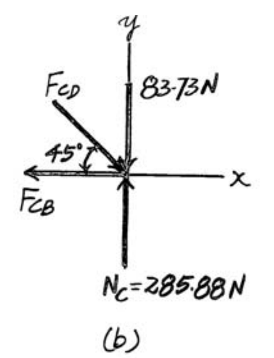
Due to the symmetry of the system and the loading,

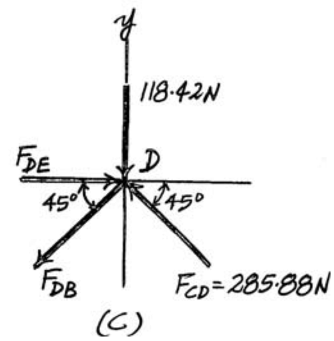
$F_{BE} = F_{DB} = 118.42\text{ N} = 118\text{ N (T)}$ **Ans.**

$F_{BA} = F_{CB} = 202.15\text{ N} = 202\text{ N (T)}$ **Ans.**

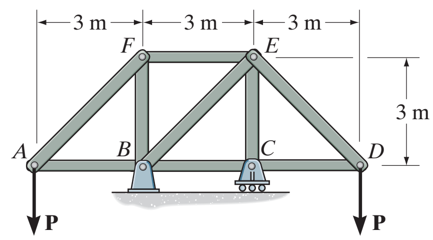
$F_{EA} = F_{CD} = 285.88\text{ N} = 286\text{ N (C)}$ **Ans.**



***6–24.** Determine the force in each member of the truss, and state if the members are in tension or compression. Set $P = 4$ kN.




**Method of Joints:** We will analyze the equilibrium of the joints in the following sequence: $A \rightarrow D \rightarrow F \rightarrow E \rightarrow C$.

**Joint** $A$: From the free - body diagram in Fig. $a$,

$+\uparrow \Sigma F_y = 0;$ $\quad F_{AF} \sin 45° - 4 = 0$

$F_{AF} = 5.657 \text{ kN} = 5.66 \text{ kN (T)}$ **Ans.**

$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad 5.657 \cos 45° - F_{AB} = 0$

$F_{AB} = 4 \text{ kN (C)}$ **Ans.**

**Joint** $D$: From the free - body diagram in Fig. $b$,

$+\uparrow \Sigma F_y = 0;$ $\quad F_{DE} \sin 45° - 4 = 0$

$F_{DE} = 5.657 \text{ kN} = 5.66 \text{ kN (T)}$ **Ans.**

$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad F_{DC} - 5.657 \cos 45° = 0$

$F_{DC} = 4 \text{ kN (C)}$ **Ans.**

**Joint** $F$: From the free - body diagram in Fig. $c$,

$+\uparrow \Sigma F_y = 0;$ $\quad F_{FB} - 5.657 \cos 45° = 0$

$F_{FB} = 4 \text{ kN (C)}$ **Ans.**

$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad F_{FE} - 5.657 \sin 45° = 0$

$F_{FE} = 4 \text{ kN (T)}$ **Ans.**

**Joint** $E$: From the free - body diagram in Fig. $d$,

$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad 5.657 \sin 45° - 4 - F_{EB} \sin 45° = 0$

$F_{EB} = 0$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad F_{BC} - 5.657 \cos 45° = 0$

$F_{BC} = 4 \text{ kN (C)}$ **Ans.**

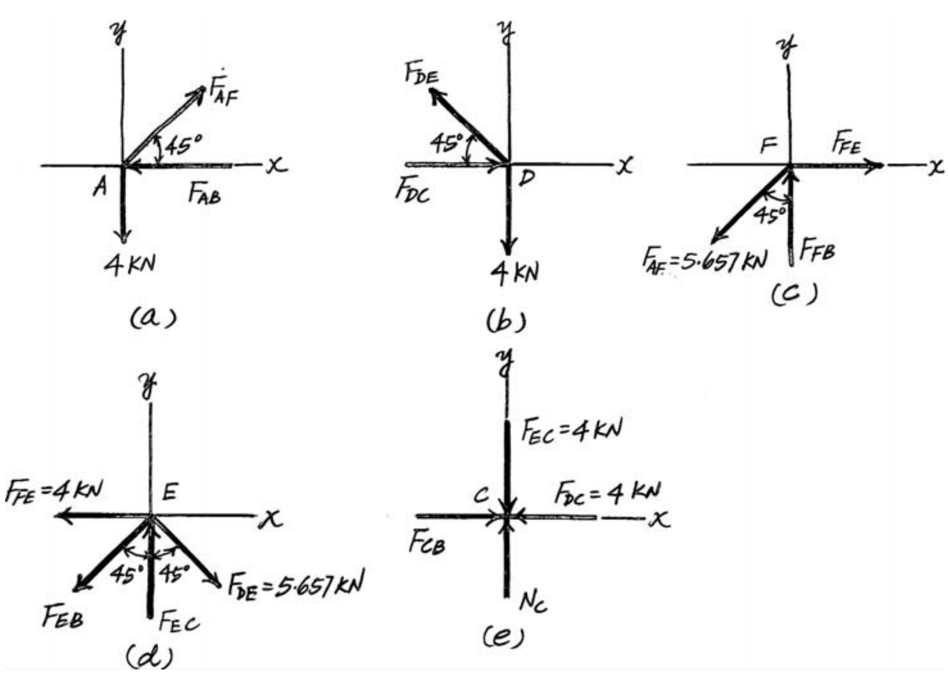
**Joint** $C$: From the free - body diagram in Fig. $e$,

$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad F_{CB} - 4 = 0$

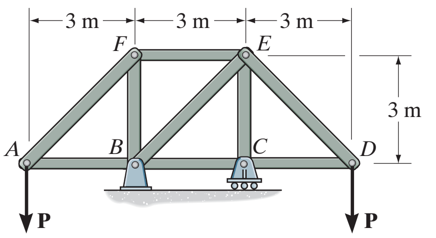
$F_{CB} = 4 \text{ kN (C)}$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad N_C - 4 = 0$

$N_C = 4 \text{ kN}$



**•6–25.** Determine the greatest force $P$ that can be applied to the truss so that none of the members are subjected to a force exceeding either 1.5 kN in tension or 1 kN in compression.




**Method of Joints:** We will analyze the equilibrium of the joints in the following sequence: $A \rightarrow D \rightarrow F \rightarrow E \rightarrow C$.

**Joint $A$:** From the free - body diagram in Fig. $a$,

$+\uparrow \Sigma F_y = 0; \qquad F_{AF}\ \sin 45° - P = 0$

$F_{AF} = 1.4142P$ (T)

$\xrightarrow{+} \Sigma F_x = 0; \qquad 1.4142P \cos 45° - F_{AB} = 0$

$F_{AB} = P$ (C)

**Joint $D$:** From the free - body diagram in Fig. $b$,

$+\uparrow \Sigma F_y = 0; \qquad F_{DE}\ \sin 45° - P = 0$

$F_{DE} = 1.4142P$ (T)

$\xrightarrow{+} \Sigma F_x = 0; \qquad F_{DC} - 1.4142P \cos 45° = 0$

$F_{DC} = P$ (C)

**Joint $F$:** From the free - body diagram in Fig. $c$,

$\xrightarrow{+} \Sigma F_x = 0; \qquad F_{FE} - 1.4142P \sin 45° = 0$

$F_{FE} = P$ (T)

$+\uparrow \Sigma F_y = 0; \qquad F_{FB} - 1.4142P \cos 45° = 0$

$F_{FB} = P$ (C)

**Joint $E$:** From the free - body diagram in Fig. $d$,

$\xrightarrow{+} \Sigma F_x = 0; \qquad 1.4142P \sin 45° - P - F_{EB}\ \sin 45° = 0$

$F_{EB} = 0$

$+\uparrow \Sigma F_y = 0; \qquad F_{EC} - 1.4142P \cos 45° = 0$

$F_{EC} = P$ (C)

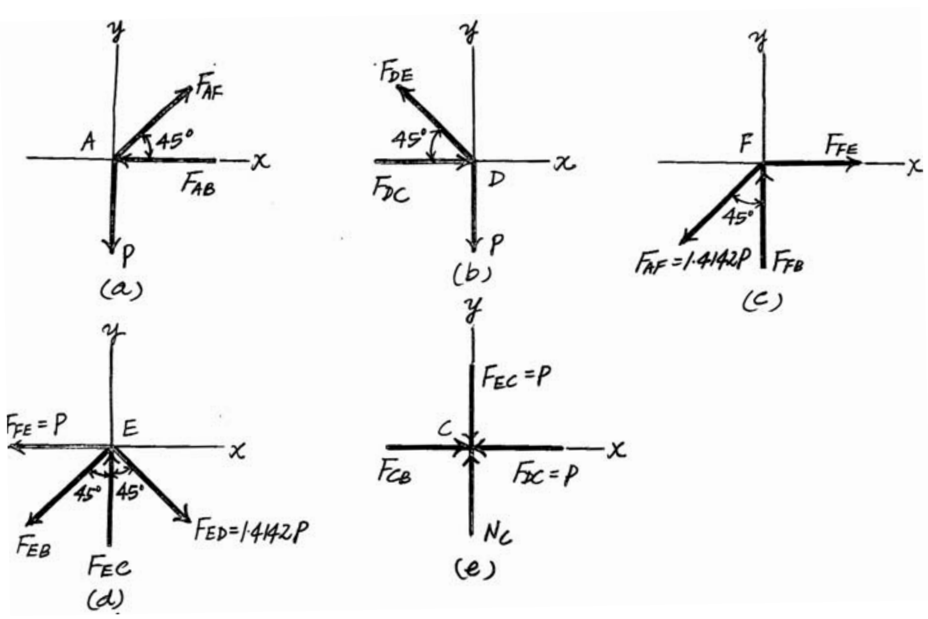
**Joint $C$:** From the free - body diagram in Fig. $e$,

$F_{CB} = P$(C)

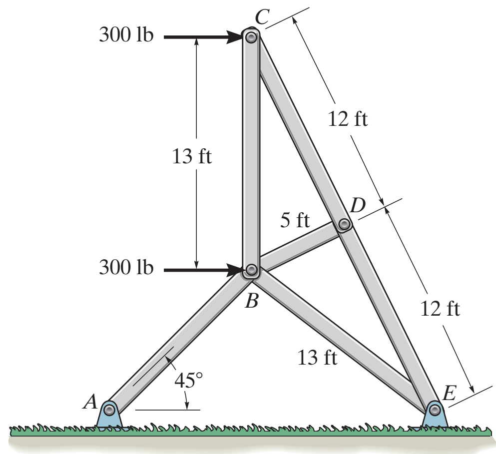
From the above results, the greatest compressive and tensile forces developed in the member are $P$ and $1.4142P$, respectively. Thus,

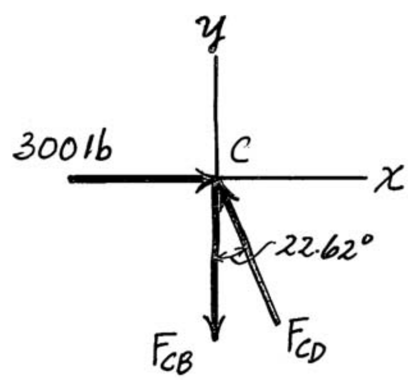
$P = 1\text{kN}$ (controls) **Ans.**

$1.4142P = 1.5 \qquad P = 1.06\text{kN}$



**6–26.** A sign is subjected to a wind loading that exerts horizontal forces of 300 lb on joints *B* and *C* of one of the side supporting trusses. Determine the force in each member of the truss and state if the members are in tension or compression.



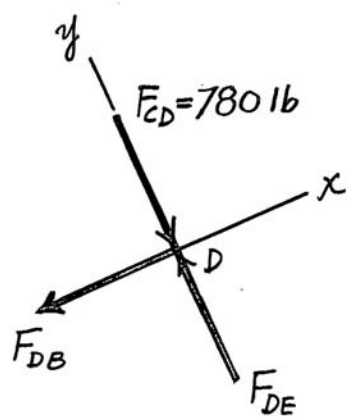

**Joint *C*:**

$\xrightarrow{+} \Sigma F_x = 0;\quad 300 - F_{CD} \sin 22.62° = 0$

$F_{CD} = 780 \text{ lb (C)}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad -F_{CB} + 780 \cos 22.62° = 0$

$F_{CB} = 720 \text{ lb (T)}$ **Ans**

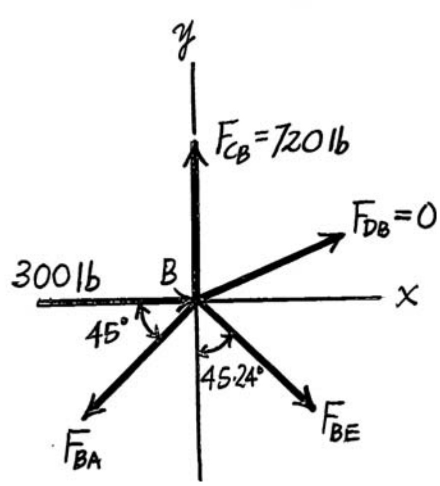



**Joint *D*:**

$+\nearrow \Sigma F_x = 0;\quad F_{DB} = 0$ **Ans**

$+\searrow \Sigma F_y = 0;\quad 780 - F_{DE} = 0$

$F_{DE} = 780 \text{ lb (C)}$ **Ans**




**Joint *B*:**

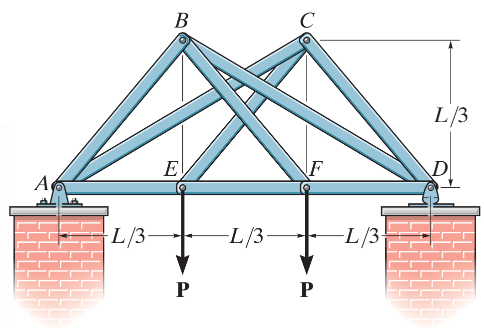
$\xrightarrow{+} \Sigma F_x = 0;\quad 300 - F_{BA} \cos 45° + F_{BE} \sin 45.24° = 0$

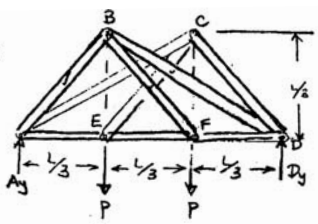
$+\uparrow \Sigma F_y = 0;\quad 720 - F_{BA} \sin 45° - F_{BE} \cos 45.24° = 0$

$F_{BE} = 297 \text{ lb (T)}$ **Ans**

$F_{BA} = 722 \text{ lb (T)}$ **Ans**

**6–27.** Determine the force in each member of the double scissors truss in terms of the load $P$ and state if the members are in tension or compression.




$$\curvearrowleft + \Sigma M_A = 0; \quad P\left(\frac{L}{3}\right) + P\left(\frac{2L}{3}\right) - (D_y)(L) = 0$$

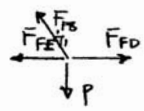
$$D_y = P$$

$$+\uparrow \Sigma F_y = 0; \quad A_y = P$$

Joint $F$:

$$+\uparrow \Sigma F_y = 0; \quad F_{FB}\left(\frac{1}{\sqrt{2}}\right) - P = 0$$

$$F_{FB} = \sqrt{2}P = 1.41P\,(\mathrm{T})$$




$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{FD} - F_{FE} - F_{FB}\left(\frac{1}{\sqrt{2}}\right) = 0$$

$$F_{FD} - F_{FE} = P \qquad (1)$$

Cont'd

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{CA}\left(\frac{2}{\sqrt{5}}\right) - \sqrt{2}P\left(\frac{1}{\sqrt{2}}\right) - F_{CD}\left(\frac{1}{\sqrt{2}}\right) = 0$$

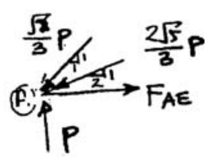
$$\frac{2}{\sqrt{5}}F_{CA} - \frac{1}{\sqrt{2}}F_{CD} = P$$

$$F_{CA} = \frac{2\sqrt{5}}{3}P = 1.4907P = 1.49P\,(\mathrm{C})$$

$$F_{CD} = \frac{\sqrt{2}}{3}P = 0.4714P = 0.471P\,(\mathrm{C})$$

Joint $A$:

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AE} - \frac{\sqrt{2}}{3}P\left(\frac{1}{\sqrt{2}}\right) - \frac{2\sqrt{5}}{3}P\left(\frac{2}{\sqrt{5}}\right) = 0$$




$$F_{AE} = \frac{5}{3}P = 1.67\,P\,(\mathrm{T})$$

From Eqs. (1) and (2):

$F_{FE} = 0.667\,P\,(\mathrm{T})$ **Ans**

$F_{FD} = 1.67\,P\,(\mathrm{T})$ **Ans**

$F_{AB} = 0.471\,P\,(\mathrm{C})$ **Ans**

$F_{AE} = 1.67\,P\,(\mathrm{T})$ **Ans**

$F_{AC} = 1.49P\,(\mathrm{C})$ **Ans**

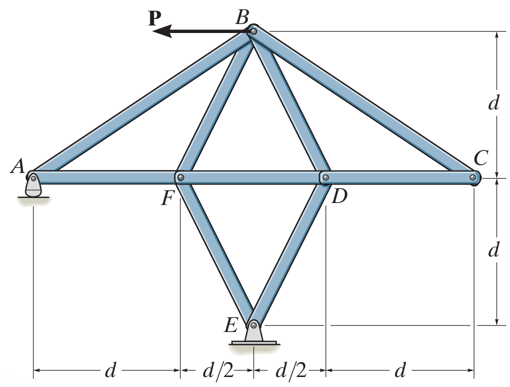
$F_{BF} = 1.41\,P\,(\mathrm{T})$ **Ans**

$F_{BD} = 1.49\,P\,(\mathrm{C})$ **Ans**

$F_{EC} = 1.41\,P\,(\mathrm{T})$ **Ans**

$F_{CD} = 0.471\,P\,(\mathrm{C})$ **Ans**

***6–28.** Determine the force in each member of the truss in terms of the load $P$, and indicate whether the members are in tension or compression.

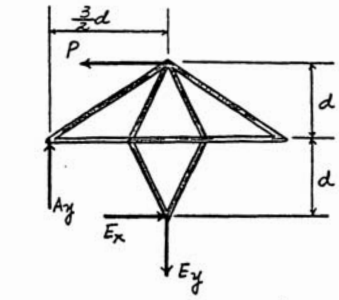



***Support Reactions :***

$$\curvearrowleft + \Sigma M_E = 0; \quad P(2d) - A_y\left(\frac{3}{2}d\right) = 0 \quad A_y = \frac{4}{3}P$$

$$+\uparrow \Sigma F_y = 0; \quad \frac{4}{3}P - E_y = 0 \quad E_y = \frac{4}{3}P$$

$$\xrightarrow{+} \Sigma F_x = 0 \quad E_x - P = 0 \quad E_x = P$$




***Method of Joints :*** By inspection of joint $C$, members $CB$ and $CD$ are zero force member. Hence

$$F_{CB} = F_{CD} = 0 \qquad \textbf{Ans}$$

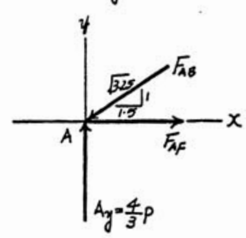
**Joint *A***

$$+\uparrow \Sigma F_y = 0; \quad F_{AB}\left(\frac{1}{\sqrt{3.25}}\right) - \frac{4}{3}P = 0$$

$$F_{AB} = 2.404P\ (C) = 2.40P\ (C) \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AF} - 2.404P\left(\frac{1.5}{\sqrt{3.25}}\right) = 0$$

$$F_{AF} = 2.00P\ (T) \qquad \textbf{Ans}$$



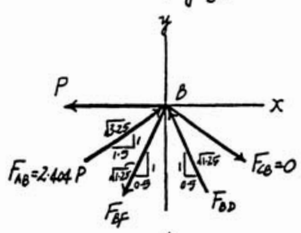

**Joint *B***

$$\xrightarrow{+} \Sigma F_x = 0; \quad 2.404P\left(\frac{1.5}{\sqrt{3.25}}\right) - P - F_{BF}\left(\frac{0.5}{\sqrt{1.25}}\right) - F_{BD}\left(\frac{0.5}{\sqrt{1.25}}\right) = 0$$

$$1.00P - 0.4472F_{BF} - 0.4472F_{BD} = 0 \qquad [1]$$

$$+\uparrow \Sigma F_y = 0; \quad 2.404P\left(\frac{1}{\sqrt{3.25}}\right) + F_{BD}\left(\frac{1}{\sqrt{1.25}}\right) - F_{BF}\left(\frac{1}{\sqrt{1.25}}\right) = 0$$

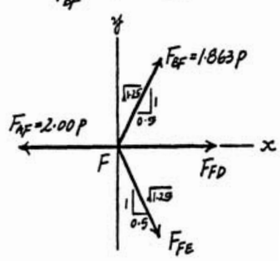
$$1.333P + 0.8944F_{BD} - 0.8944F_{BF} = 0 \qquad [2]$$




Solving Eqs. [1] and [2] yield,

$$F_{BF} = 1.863P(T) = 1.86P(T) \qquad \textbf{Ans}$$

$$F_{BD} = 0.3727P(C) = 0.373P(C) \qquad \textbf{Ans}$$



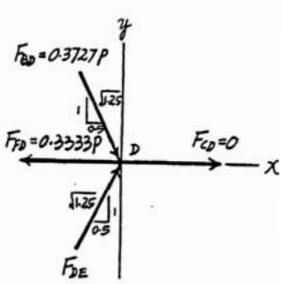

**Joint *F***

$$+\uparrow \Sigma F_y = 0; \quad 1.863P\left(\frac{1}{\sqrt{1.25}}\right) - F_{FE}\left(\frac{1}{\sqrt{1.25}}\right) = 0$$

$$F_{FE} = 1.863P(T) = 1.86P(T) \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{FD} + 2\left[1.863P\left(\frac{0.5}{\sqrt{1.25}}\right)\right] - 2.00P = 0$$

$$F_{FD} = 0.3333P(T) = 0.333P\ (T) \qquad \textbf{Ans}$$



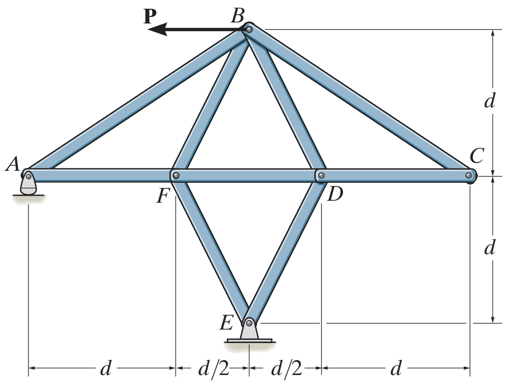

**Joint *D***

$$+\uparrow \Sigma F_y = 0; \quad F_{DE}\left(\frac{1}{\sqrt{1.25}}\right) - 0.3727P\left(\frac{1}{\sqrt{1.25}}\right) = 0$$

$$F_{DE} = 0.3727P\ (C) = 0.373P\ (C) \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad 2\left[0.3727P\left(\frac{0.5}{\sqrt{1.25}}\right)\right] - 0.3333P = 0 \ (\textit{Check!})$$

**•6–29.** If the maximum force that any member can support is 4 kN in tension and 3 kN in compression, determine the maximum force $P$ that can be applied at joint $B$. Take $d = 1$ m.




***Support Reactions :***

$$\circlearrowleft + \Sigma M_E = 0; \quad P(2d) - A_y\left(\frac{3}{2}d\right) = 0 \quad A_y = \frac{4}{3}P$$

$$+\uparrow \Sigma F_y = 0; \quad \frac{4}{3}P - E_y = 0 \quad E_y = \frac{4}{3}P$$

$$\xrightarrow{+} \Sigma F_x = 0 \quad E_x - P = 0 \quad E_x = P$$

***Method of Joints :*** By inspection of joint $C$, members $CB$ and $CD$ are zero force members. Hence

$$F_{CB} = F_{CD} = 0$$

**Joint *A***

$$+\uparrow \Sigma F_y = 0; \quad -F_{AB}\left(\frac{1}{\sqrt{3.25}}\right) + \frac{4}{3}P = 0 \quad F_{AB} = 2.404P \text{ (C)}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AF} - 2.404P\left(\frac{1.5}{\sqrt{3.25}}\right) = 0 \quad F_{AF} = 2.00P \text{ (T)}$$

**Joint *B***

$$\xrightarrow{+} \Sigma F_x = 0; \quad 2.404P\left(\frac{1.5}{\sqrt{3.25}}\right) - P - F_{BF}\left(\frac{0.5}{\sqrt{1.25}}\right) - F_{BD}\left(\frac{0.5}{\sqrt{1.25}}\right) = 0$$

$$1.00P - 0.4472F_{BF} - 0.4472F_{BD} = 0 \qquad [1]$$

$$+\uparrow \Sigma F_y = 0; \quad 2.404P\left(\frac{1}{\sqrt{3.25}}\right) + F_{BD}\left(\frac{1}{\sqrt{1.25}}\right) - F_{BF}\left(\frac{1}{\sqrt{1.25}}\right) = 0$$

$$1.333P + 0.8944F_{BD} - 0.8944F_{BF} = 0 \qquad [2]$$

Solving Eqs. [1] and [2] yield,

$$F_{BF} = 1.863P\text{(T)} \qquad F_{BD} = 0.3727P\text{(C)}$$

**Joint *F***

$$+\uparrow \Sigma F_y = 0; \quad 1.863P\left(\frac{1}{\sqrt{1.25}}\right) - F_{FE}\left(\frac{1}{\sqrt{1.25}}\right) = 0$$
$$F_{FE} = 1.863P\text{(T)}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{FD} + 2\left[1.863P\left(\frac{0.5}{\sqrt{1.25}}\right)\right] - 2.00P = 0$$
$$F_{FD} = 0.3333P\text{(T)}$$

**Joint *D***

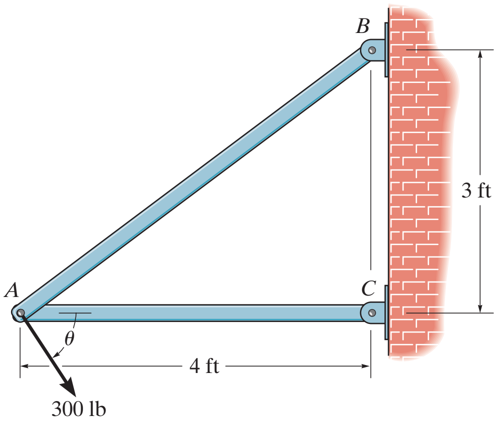
$$+\uparrow \Sigma F_y = 0; \quad F_{DE}\left(\frac{1}{\sqrt{1.25}}\right) - 0.3727P\left(\frac{1}{\sqrt{1.25}}\right) = 0$$
$$F_{DE} = 0.3727P \text{ (C)}$$

$$\xrightarrow{+} \Sigma F_y = 0; \quad 2\left[0.3727P\left(\frac{0.5}{\sqrt{1.25}}\right)\right] - 0.3333P = 0 \text{ (Check!)}$$

From the above analysis, the maximum compression and tension in the truss members are $2.404P$ and $2.00P$, respectively. For this case, compression controls which requires

$$2.404P = 3$$
$$P = 1.25 \text{ kN}$$

**6–30.** The two-member truss is subjected to the force of 300 lb. Determine the range of $\theta$ for application of the load so that the force in either member does not exceed 400 lb (T) or 200 lb (C).




Joint $A$:

$\xrightarrow{+} \Sigma F_x = 0;\quad 300\cos\theta + F_{AC} + F_{AB}\left(\frac{4}{5}\right) = 0$

$+\uparrow \Sigma F_y = 0;\quad -300\sin\theta + F_{AB}\left(\frac{3}{5}\right) = 0$

Thus,

$$F_{AB} = 500\sin\theta$$

$$F_{AC} = -300\cos\theta - 400\sin\theta$$

For $AB$ require:

$$-200 \le 500\sin\theta \le 400$$

$$-2 \le 5\sin\theta \le 4 \qquad (1)$$

For $AC$ require:

$$-200 \le -300\cos\theta - 400\sin\theta \le 400$$

$$-4 \le 3\cos\theta + 4\sin\theta \le 2 \qquad (2)$$

Solving Eqs. (1) and (2) simultaneously,

$$127° \le \theta \le 196° \qquad \textbf{Ans}$$

$$336° \le \theta \le 347° \qquad \textbf{Ans}$$

A possible hand solution:

$$\theta_2 = \theta_1 + \tan^{-1}\left(\frac{3}{4}\right) = \theta_1 + 36.870$$

Then

$$F_{AB} = 500\sin\theta_1$$

$$F_{AC} = -300\cos(\theta_2 - 36.870°) - 400\sin(\theta_2 - 36.870°)$$

$$= -300\,[\cos\theta_2\cos 36.870° + \sin\theta_2\sin 36.870°]$$

$$-400\,[\sin\theta_2\cos 36.870° - \cos\theta_2\sin 36.870°]$$

$$= -240\cos\theta_2 - 180\sin\theta_2 - 320\sin\theta_2 + 240\cos\theta_2$$

$$= -500\sin\theta_2$$

Thus, we require

$$-2 \le 5\sin\theta_1 \le 4 \quad\text{or}\quad -0.4 \le \sin\theta_1 \le 0.8 \qquad (1)$$

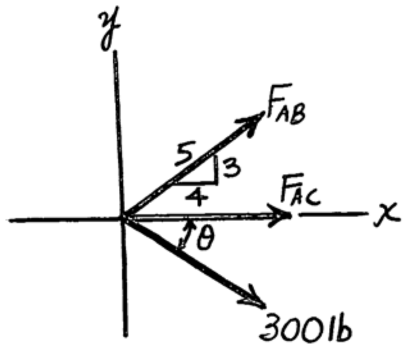
$$-4 \le 5\sin\theta_2 \le 2 \quad\text{or}\quad -0.8 \le \sin\theta_2 \le 0.4 \qquad (2)$$

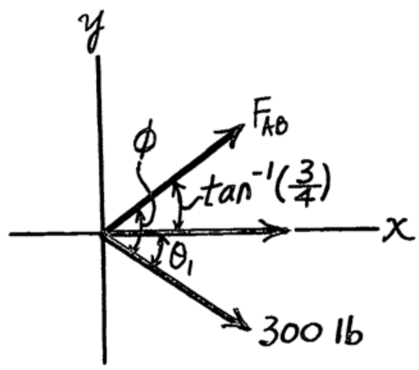
The range of values for Eqs. (1) and (2) are shown in the figures:

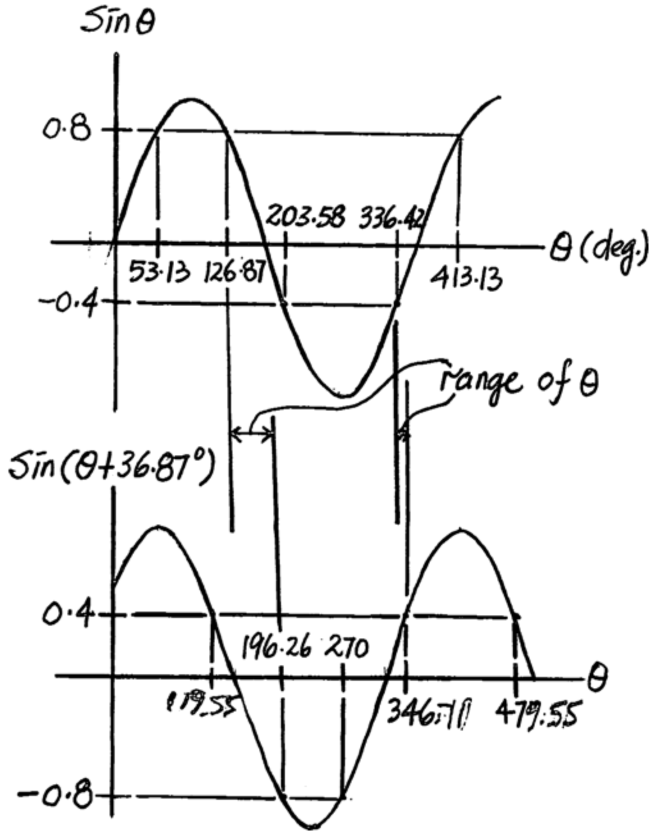
Since $\theta_1 = \theta_2 - 36.870°$, the range of acceptable values for $\theta = \theta_1$ is

$$127° \le \theta \le 196° \qquad \textbf{Ans}$$

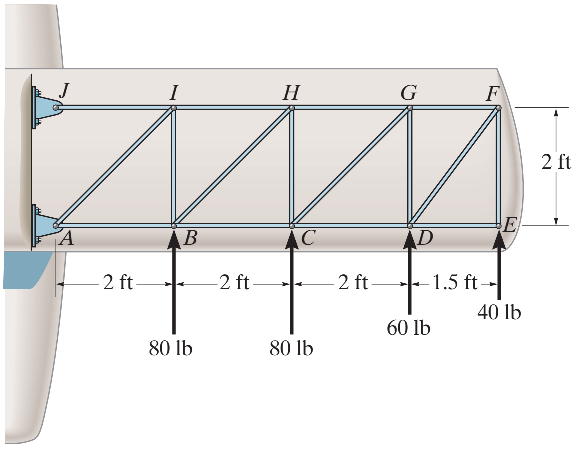
$$336° \le \theta \le 347° \qquad \textbf{Ans}$$

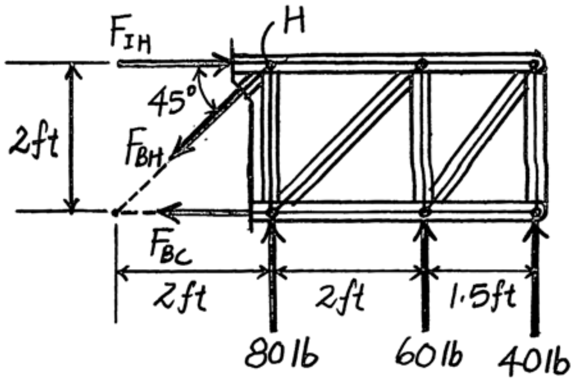

y
F_AB
5
3
4
F_AC
x
θ
300 lb


y
F_AB
φ
tan⁻¹(3/4)
x
θ₁
300 lb


sin θ
0.8
203.58
336.42
θ (deg.)
53.13
126.87
413.13
-0.4
range of θ
sin(θ+36.87°)
0.4
196.26
270
θ
119.55
346.10
479.55
-0.8

**6–31.** The internal drag truss for the wing of a light airplane is subjected to the forces shown. Determine the force in members *BC*, *BH*, and *HC*, and state if the members are in tension or compression.




$+\uparrow \Sigma F_y = 0;\quad 180 - F_{BH} \sin 45° = 0$

$F_{BH} = 255 \text{ lb (T)}$ **Ans**

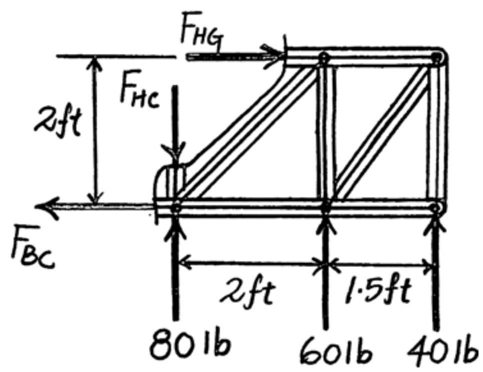
$\circlearrowleft + \Sigma M_H = 0;\quad -F_{BC}(2) + 60(2) + 40(3.5) = 0$

$F_{BC} = 130 \text{ lb (T)}$ **Ans**

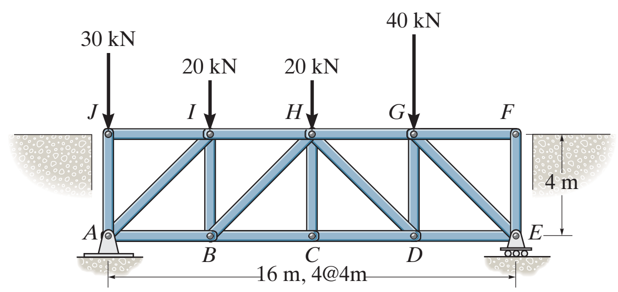
**Section 2 :**

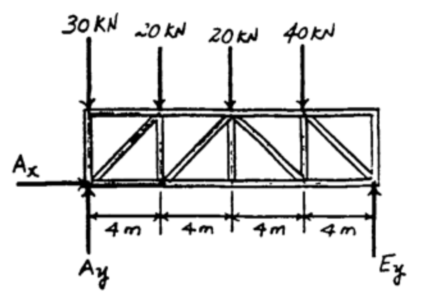
$+\uparrow \Sigma F_y = 0;\quad 80 + 60 + 40 - F_{HC} = 0$

$F_{HC} = 180 \text{ lb (C)}$ **Ans**



***6–32.** The *Howe bridge truss* is subjected to the loading shown. Determine the force in members *HD*, *CD*, and *GD*, and state if the members are in tension or compression.



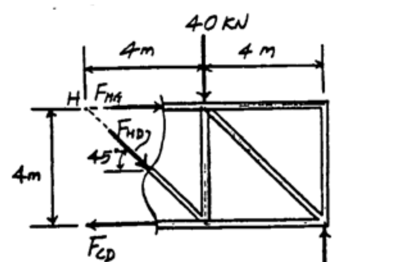

***Support Reactions :***

$$\circlearrowleft + \Sigma M_A = 0; \quad E_y(16) - 40(12) - 20(8) - 20(4) = 0$$
$$E_y = 45.0 \text{ kN}$$

***Method of Sections :***

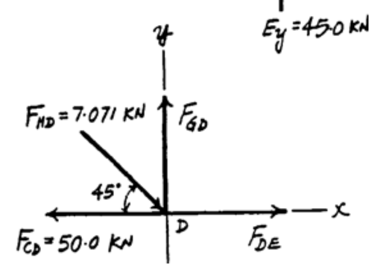
$$\circlearrowleft + \Sigma M_H = 0; \quad 45.0(8) - 40(4) - F_{CD}(4) = 0$$
$$F_{CD} = 50.0 \text{ kN (T)} \qquad \textbf{Ans}$$

$$+\uparrow \Sigma F_y = 0; \quad 45.0 - 40 - F_{HD} \sin 45° = 0$$
$$F_{HD} = 7.071 \text{ kN (C)} = 7.07 \text{ kN (C)} \qquad \textbf{Ans}$$

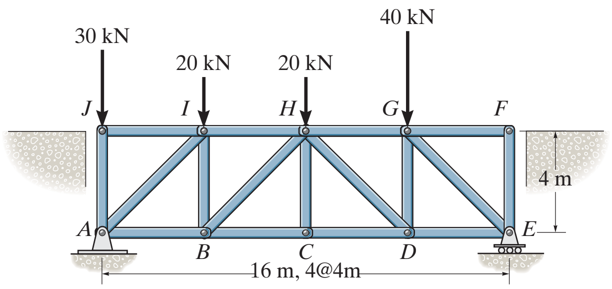


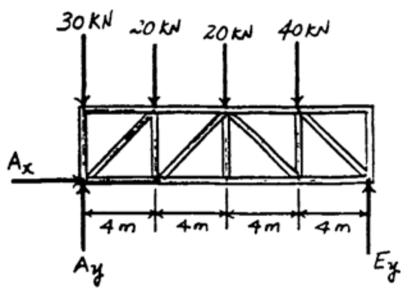

***Method of Joints :*** Analysing joint *D*, we have

$$+\uparrow \Sigma F_y = 0; \quad F_{GD} - 7.071 \sin 45° = 0$$
$$F_{GD} = 5.00 \text{ kN (T)} \qquad \textbf{Ans}$$



**•6–33.** The *Howe bridge truss* is subjected to the loading shown. Determine the force in members *HI*, *HB*, and *BC*, and state if the members are in tension or compression.




***Support Reactions :***

$\circlearrowleft + \Sigma M_E = 0;\quad 30(16) + 20(12) + 20(8) + 40(4) - A_y(16) = 0$

$A_y = 65.0 \text{ kN}$

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

***Method of Sections :***

$\circlearrowleft + \Sigma M_H = 0;\quad F_{BC}(4) + 20(4) + 30(8) - 65.0(8) = 0$

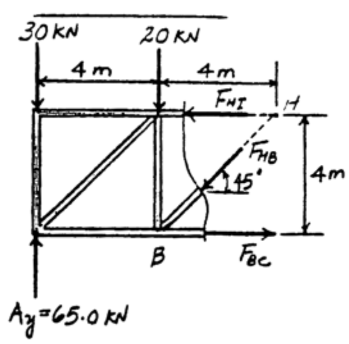
$F_{BC} = 50.0 \text{ kN (T)}$ **Ans**

$\circlearrowleft + \Sigma M_B = 0;\quad F_{HI}(4) + 30(4) - 65.0(4) = 0$

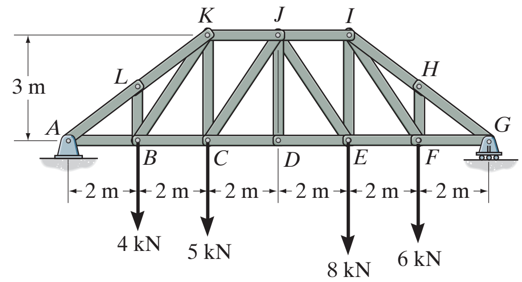
$F_{HI} = 35.0 \text{ kN (C)}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad 65.0 - 30 - 20 - F_{HB} \sin 45° = 0$

$F_{HB} = 21.2 \text{ kN (C)}$ **Ans**



**6–34.** Determine the force in members $JK$, $CJ$, and $CD$ of the truss, and state if the members are in tension or compression.




**Method of Joints:** Applying the equations of equilibrium to the free-body diagram of the truss, Fig. *a*,

$\overset{+}{\rightarrow}\Sigma F_x = 0;$ $\quad A_x = 0$

$\curvearrowleft + \Sigma M_G = 0$ $\quad 6(2) + 8(4) + 5(8) + 4(10) - A_y(12) = 0$

$A_y = 10.33 \text{ kN}$

**Method of Sections:** Using the left portion of the free-body diagram, Fig. *a*.

$\curvearrowleft + \Sigma M_C = 0;$ $\quad F_{JK}(3) + 4(2) - 10.33(4) = 0$

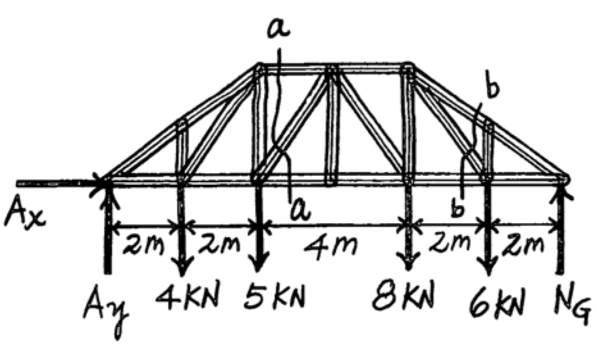
$F_{JK} = 11.111 \text{ kN} = 11.1 \text{ kN (C)}$ **Ans.**

$\curvearrowleft + \Sigma M_J = 0;$ $\quad F_{CD}(3) + 5(2) + 4(4) - 10.33(6) = 0$

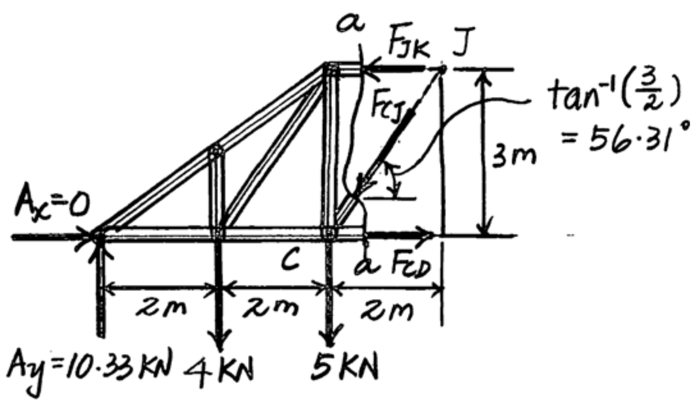
$F_{CD} = 12 \text{ kN (T)}$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad 10.33 - 4 - 5 - F_{CJ} \sin 56.31° = 0$

$F_{CJ} = 1.602 \text{ kN} = 1.60 \text{ kN (C)}$ **Ans.**

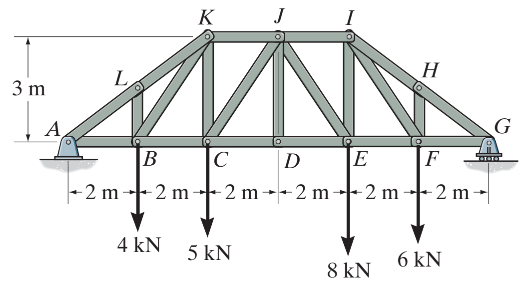



(a)




(b)

**6–35.** Determine the force in members *HI*, *FI*, and *EF* of the truss, and state if the members are in tension or compression.




**Support Reactions:** Applying the moment equation of equilibrium about point *A* to the free - body diagram of the truss, Fig. *a*,

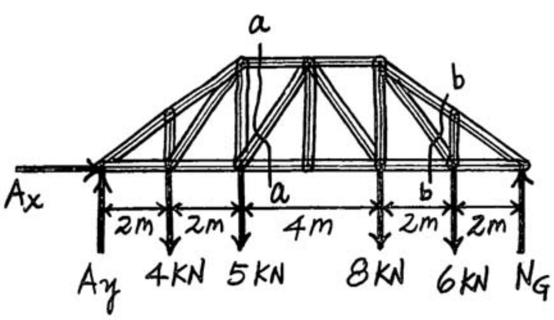
$$\circlearrowleft +\Sigma M_A = 0; \qquad N_G(2) - 4(2) - 5(4) - 8(8) - 6(10) = 0$$
$$N_G = 12.67\text{ kN}$$

**Method of Sections:** Using the right portion of the free - body diagram, Fig. *b*.

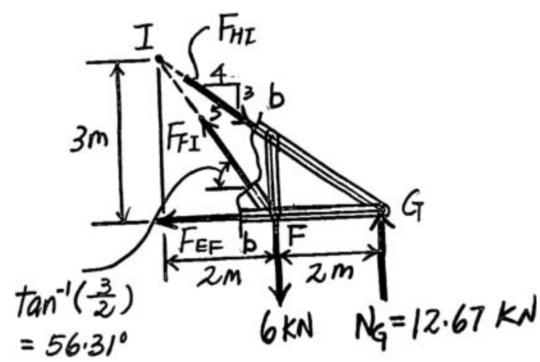
$$\circlearrowleft +\Sigma M_I = 0; \qquad 12.67(4) - 6(2) - F_{EF}(3) = 0$$
$$F_{EF} = 12.89\text{ kN} = 12.9\text{ kN (T)} \qquad \textbf{Ans.}$$

$$\circlearrowleft +\Sigma M_G = 0; \qquad -F_{FI}\sin 56.31°(2) + 6(2) = 0$$
$$F_{FI} = 7.211\text{ kN} = 7.21\text{ kN (T)} \qquad \textbf{Ans.}$$

$$\circlearrowleft +\Sigma M_F = 0; \qquad 12.67(2) - F_{HI}\left(\frac{3}{5}\right)(2) = 0$$
$$F_{HI} = 21.11\text{ kN} = 21.1\text{ kN (C)} \qquad \textbf{Ans.}$$

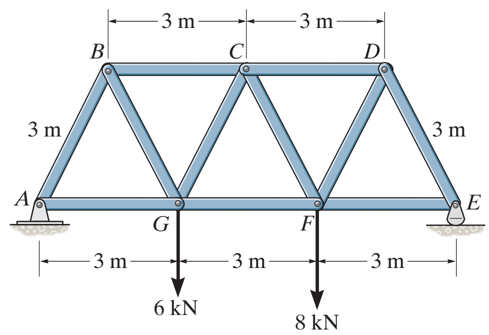



(a)

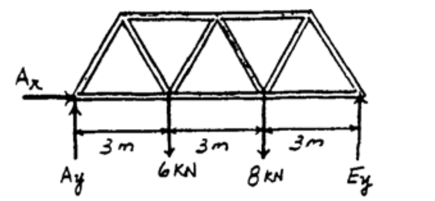



(b)

***6–36.** Determine the force in members *BC*, *CG*, and *GF* of the *Warren* truss. Indicate if the members are in tension or compression.



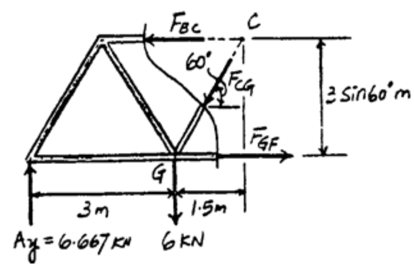

***Support Reactions :***




$\circlearrowleft + \Sigma M_E = 0; \quad 6(6) + 8(3) - A_y(9) = 0 \quad A_y = 6.667 \text{ kN}$

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

***Method of Sections :***




$\circlearrowleft + \Sigma M_C = 0; \quad F_{GF}(3\sin 60°) + 6(1.5) - 6.667(4.5) = 0$

$F_{GF} = 8.08 \text{ kN (T)}$ **Ans**

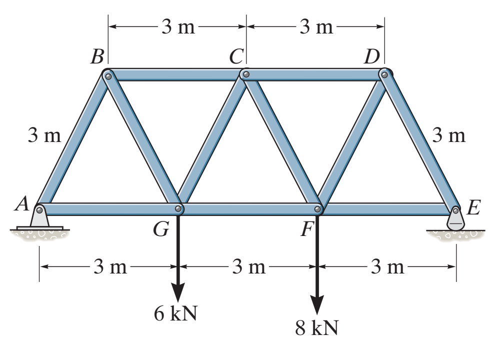
$\circlearrowleft + \Sigma M_G = 0; \quad F_{BC}(3\sin 60°) - 6.667(3) = 0$

$F_{BC} = 7.70 \text{ kN (C)}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad 6.667 - 6 - F_{CG}\sin 60° = 0$

$F_{CG} = 0.770 \text{ kN (C)}$ **Ans**

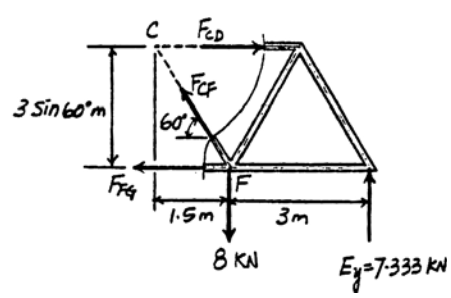
•**6–37.** Determine the force in members *CD*, *CF*, and *FG* of the *Warren truss*. Indicate if the members are in tension or compression.




***Support Reactions :***

$\circlearrowleft + \Sigma M_A = 0; \quad E_y(9) - 8(6) - 6(3) = 0 \quad E_y = 7.333 \text{ kN}$

***Method of Sections :***




$\circlearrowleft + \Sigma M_C = 0; \quad 7.333(4.5) - 8(1.5) - F_{FG}(3\sin 60°) = 0$

$F_{FG} = 8.08 \text{ kN (T)}$ **Ans**

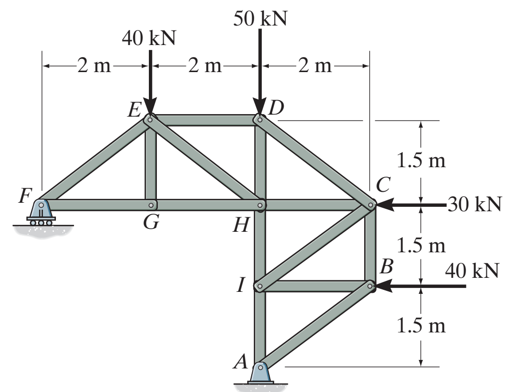
$\circlearrowleft + \Sigma M_G = 0; \quad 7.333(3) - F_{CD}(3\sin 60°) = 0$

$F_{CD} = 8.47 \text{ kN (C)}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad F_{CF}\sin 60° + 7.333 - 8 = 0$

$F_{CF} = 0.770 \text{ kN (T)}$ **Ans**

**6–38.** Determine the force in members *DC*, *HC*, and *HI* of the truss, and state if the members are in tension or compression.




**Support Reactions:** Applying the moment equation of equilibrium about point $A$ to the free - body diagram of the truss, Fig. $a$,

$$\circlearrowleft +\Sigma M_A = 0; \quad 40(1.5)+30(3)+40(2)-F_y(4)=0$$

$$F_y = 57.5\text{ kN}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - 30 - 40 = 0; \quad A_x = 70\text{ kN}$$

$$+\uparrow \Sigma F_y = 0; \quad 57.5 - 40 - 50 + A_y = 0; \quad A_y = 32.5\text{ kN}$$

**Method of Sections:** Using the bottom portion of the free - body diagram, Fig. $b$.

$$\circlearrowleft +\Sigma M_C = 0; \quad 70(3) - 32.5(2) - 40(1.5) - F_{HI}(2) = 0$$

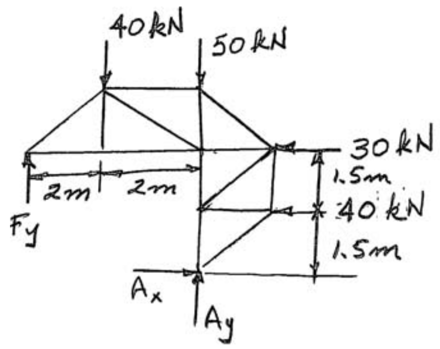
$$F_{HI} = 42.5\text{ kN (T)} \qquad \textbf{Ans.}$$

$$\circlearrowleft +\Sigma M_D = 0; \quad 70(4.5) - 40(3) - 30(1.5) - F_{HC}(1.5) = 0$$

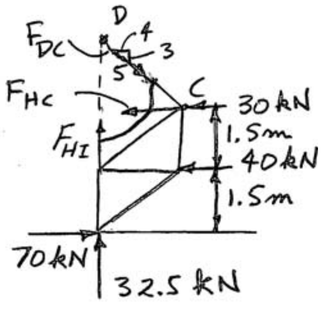
$$F_{HC} = 100\text{ kN (T)} \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \quad 32.5 + 42.5 - F_{DC}\left(\frac{3}{5}\right) = 0$$

$$F_{DC} = 125\text{ kN (C)} \qquad \textbf{Ans.}$$

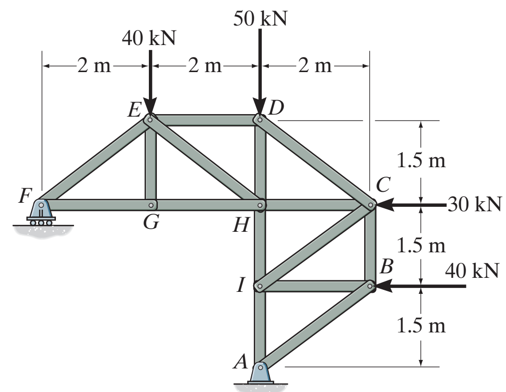



(a)




(b)

**6–39.** Determine the force in members *ED*, *EH*, and *GH* of the truss, and state if the members are in tension or compression.




**Support Reactions:** Applying the moment equation of equilibrium about point $A$ to the free - body diagram of the truss, Fig. *a*,

$\circlearrowleft + \Sigma M_A = 0;$ $\quad 40(1.5) + 30(3) + 40(2) - F_y(4) = 0$

$F_y = 57.5\text{ kN}$

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad A_x - 30 - 40 = 0;$ $\quad A_x = 70\text{ kN}$

$+\uparrow \Sigma F_y = 0;$ $\quad 57.5 - 40 - 50 + A_y = 0;$ $\quad A_y = 32.5\text{ kN}$

**Method of Sections:** Using the left portion of the free - body diagram, Fig. *b*.

$\circlearrowleft + \Sigma M_E = 0;$ $\quad -57.5(2) + F_{GH}(1.5) = 0$

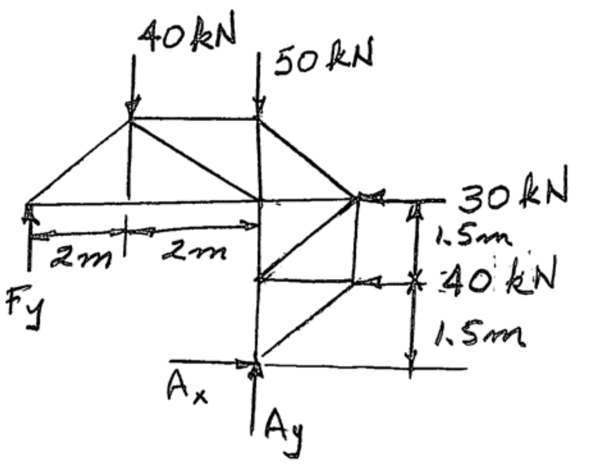
$F_{GH} = 76.7\text{ kN (T)}$ **Ans.**

$\circlearrowleft + \Sigma M_H = 0;$ $\quad -57.5(4) + F_{ED}(1.5) + 40(2) = 0$

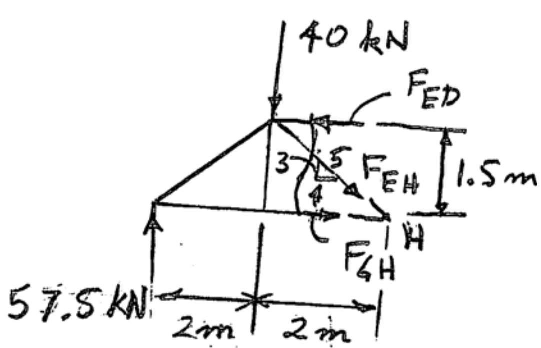
$F_{ED} = 100\text{ kN (C)}$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad 57.5 - F_{EH}\left(\frac{3}{5}\right) - 40 = 0$

$F_{EH} = 29.2\text{ kN (T)}$ **Ans.**

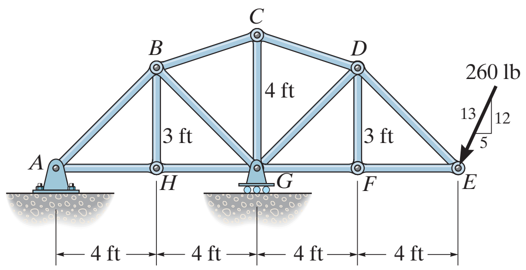



(a)




(b)

***6–40.** Determine the force in members $GF$, $GD$, and $CD$ of the truss and state if the members are in tension or compression.




$\curvearrowleft+\Sigma M_O = 0;\quad \left(\frac{12}{13}\right)260\,(8) - F_{GD}\sin 36.87^\circ\,(16) = 0$

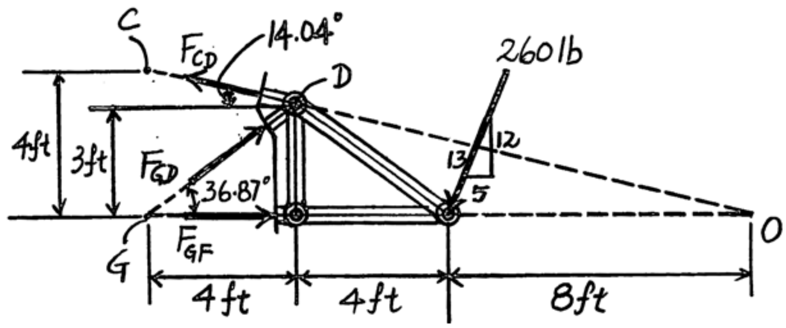
$F_{GD} = 200\text{ lb (C)}$ **Ans**

$\curvearrowleft+\Sigma M_D = 0;\quad F_{GF}(3) - \left(\frac{12}{13}\right)(260)(4) - \left(\frac{5}{13}\right)(260)(3) = 0$

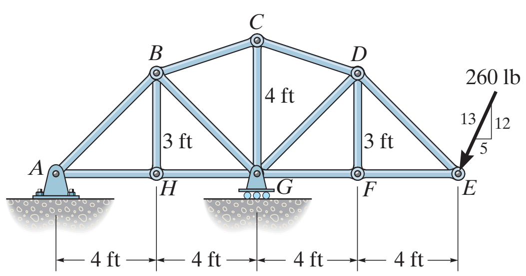
$F_{GF} = 420\text{ lb (C)}$ **Ans**

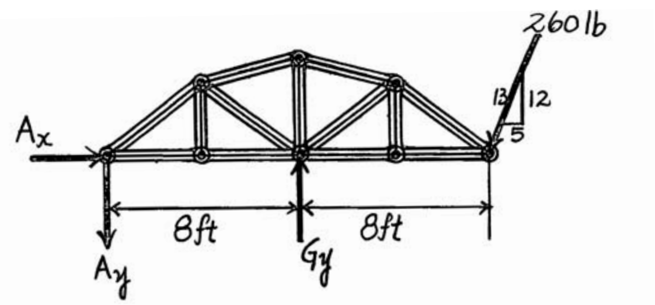
$\curvearrowleft+\Sigma M_G = 0;\quad F_{CD}\cos 14.04^\circ\,(4) - \left(\frac{12}{13}\right)(260)(8) = 0$

$F_{CD} = 495\text{ lb (T)}$ **Ans**




**•6–41.** Determine the force in members $BG$, $BC$, and $HG$ of the truss and state if the members are in tension or compression.




**Entire truss :**

$\curvearrowleft+\Sigma M_G = 0;\quad A_y(8) - \left(\frac{12}{13}\right)(260)(8) = 0$

$A_y = 240\text{ lb}$

$\xrightarrow{+}\Sigma F_x = 0;\quad A_x - \left(\frac{5}{13}\right)(260) = 0$

$A_x = 100\text{ lb}$

**Section :**

$\curvearrowleft+\Sigma M_G = 0;\quad 240(8) - F_{BC}\cos 14.04^\circ\,(4) = 0$

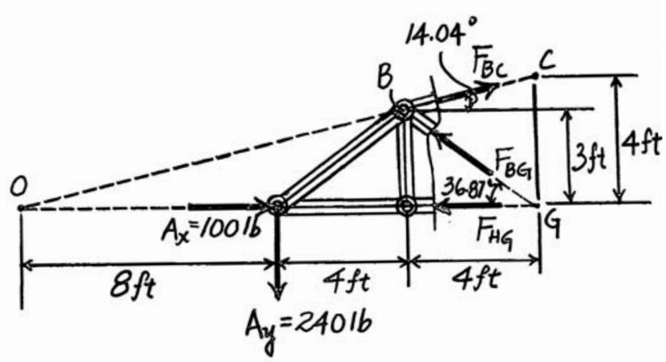
$F_{BC} = 495\text{ lb (T)}$ **Ans**

$\curvearrowleft+\Sigma M_B = 0;\quad 240(4) + 100(3) - F_{HG}(3) = 0$

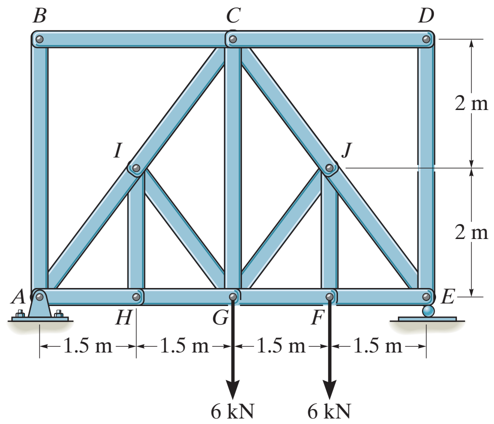
$F_{HG} = 420\text{ lb (C)}$ **Ans**

$\curvearrowleft+\Sigma M_O = 0;\quad -240(8) + F_{BG}\sin 36.87^\circ\,(16) = 0$

$F_{BG} = 200\text{ lb (C)}$ **Ans**



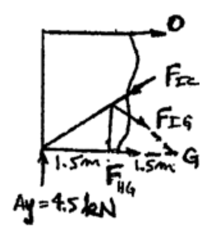
**6–42.** Determine the force in members *IC* and *CG* of the truss and state if these members are in tension or compression. Also, indicate all zero-force members.




**By inspection of joints *B, D, H* and *I*,**

***AB, BC, CD, DE, HI,* and *GI* are all zero-force members.** **Ans**

$\circlearrowleft +\Sigma M_G = 0; \quad -4.5(3) + F_{IC}(\frac{3}{5})(4) = 0$

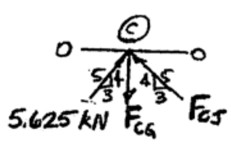



$F_{IC} = 5.62$ kN (C) **Ans**

**Joint *C*:**

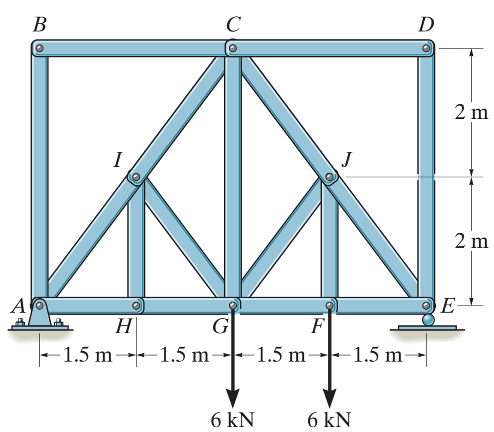
$\xrightarrow{+}\Sigma F_x = 0; \quad F_{CJ} = 5.625$ kN

$+\uparrow \Sigma F_y = 0; \quad \frac{4}{5}(5.625) + \frac{4}{5}(5.625) - F_{CG} = 0$




$F_{CG} = 9.00$ kN (T) **Ans**

**6–43.** Determine the force in members *JE* and *GF* of the truss and state if these members are in tension or compression. Also, indicate all zero-force members.



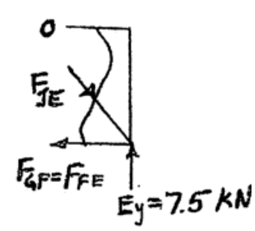

**By inspection of joints *B, D, H* and *I*,**

***AB, BC, CD, DE, HI,* and *GI* are zero-force members.** **Ans**

**Joint *E*:**

$+\uparrow \Sigma F_y = 0; \quad 7.5 - \frac{4}{5}F_{JE} = 0$

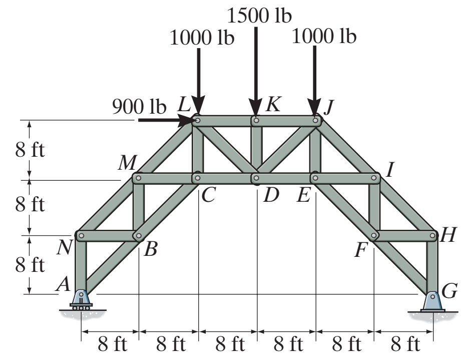
$F_{JE} = 9.375 = 9.38$ kN (C) **Ans**




$\xrightarrow{+}\Sigma F_x = 0; \quad \frac{3}{5}(9.375) - F_{GF} = 0$

$F_{GF} = 5.625$ kN (T) **Ans**

*6–44. Determine the force in members $JI$, $EF$, $EI$, and $JE$ of the truss, and state if the members are in tension or compression.




**Support Reactions:** Applying the equations of equilibrium to the free-body diagram of the truss, Fig. $a$,

$\xrightarrow{+}\Sigma F_x = 0;$ $\quad 900 - G_x = 0$

$G_x = 900$ lb

$\circlearrowleft + \Sigma M_A = 0;$ $\quad 1000(16) + 1500(24) + 1000(32) + 900(24) - G_y(48) = 0$

$G_y = 2200$ lb

**Method of Sections:** Using the right portion of the free-body diagram, Fig. $b$.

$\circlearrowleft + \Sigma M_E = 0;$ $\quad 2200(16) - 900(16) - F_{JI}\sin 45°(8) = 0$

$F_{JI} = 3676.96 \text{ lb} = 3677 \text{ lb (C)}$ **Ans.**

$\circlearrowleft + \Sigma M_I = 0;$ $\quad 2200(8) - 900(16) - F_{EF}\cos 45°(8) = 0$

$F_{EF} = 565.69 \text{ ln} = 566 \text{ lb (T)}$ **Ans.**

Using the above results and writing the force equation of equilibrium along the $x$ axis,

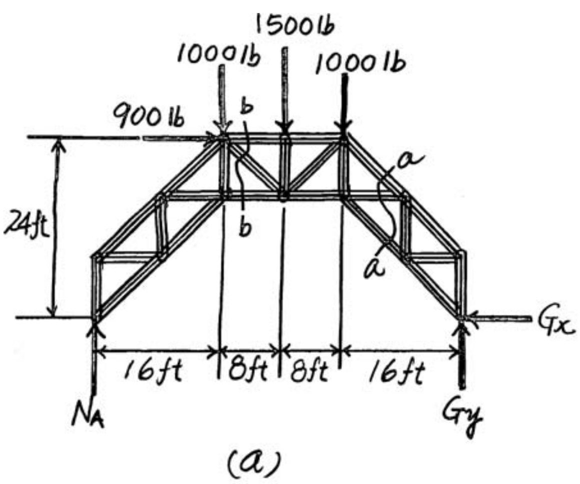
$\xrightarrow{+}\Sigma F_x = 0;$ $\quad 3676.96\cos 45° - 565.69\cos 45° - 900 - F_{EI} = 0$

$F_{EI} = 1300 \text{ lb (T)}$ **Ans.**

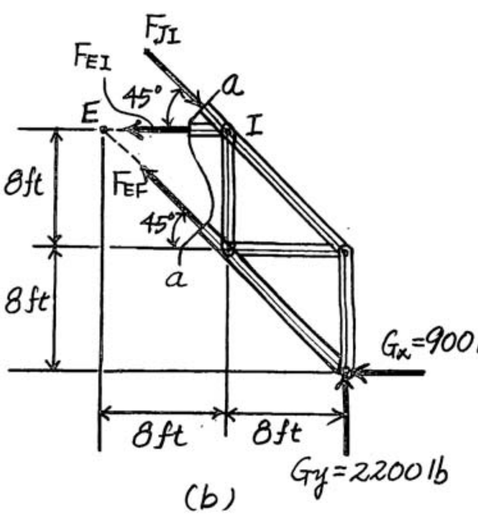
**Method of Joints:** From the free-body diagram of joint $E$, Fig. $c$,

$+\uparrow \Sigma F_y = 0;$ $\quad F_{JE} - 565.69\sin 45° = 0$

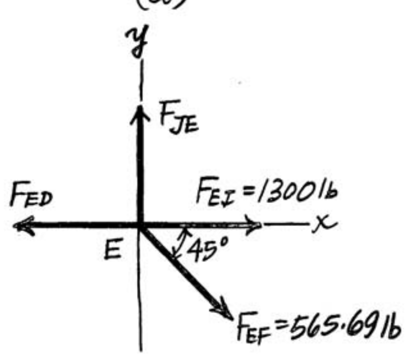
$F_{JE} = 400 \text{ lb (T)}$ **Ans.**




(a)

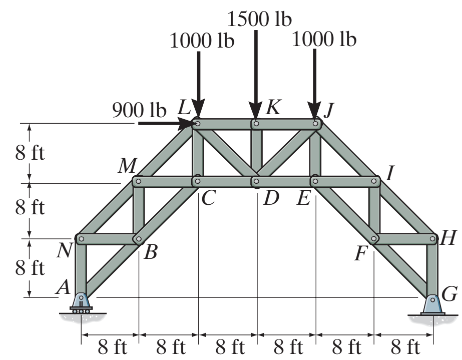



(b)




(c)

**•6–45.** Determine the force in members $CD$, $LD$, and $KL$ of the truss, and state if the members are in tension or compression.

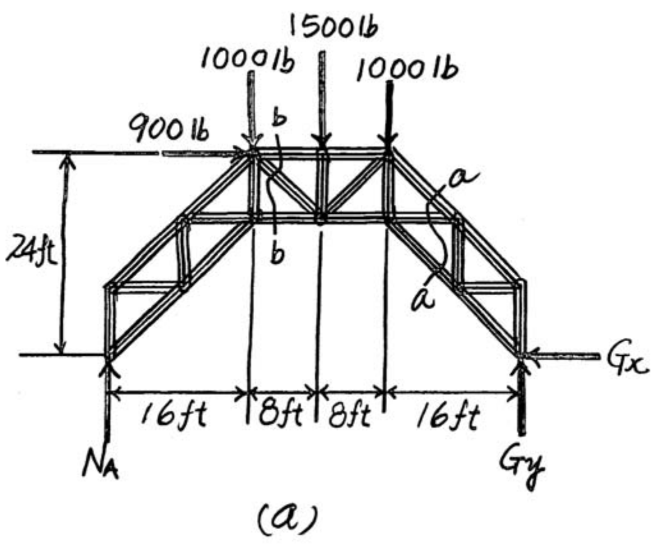



**Support Reactions:** Applying the equation of equilibrium about point $G$ to the free - body diagram of the truss, Fig. $a$,

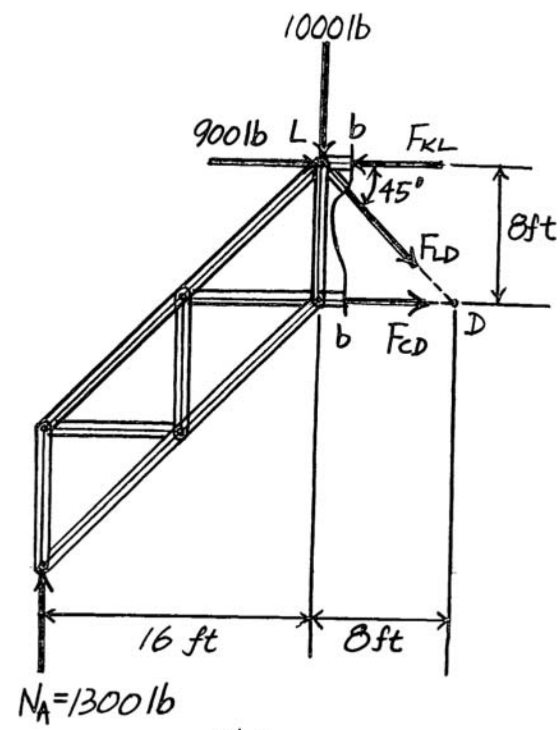
$$\circlearrowleft +\Sigma M_G = 0; \qquad 1000(16) + 1500(24) + 1000(32) - 900(24) - N_A(48) = 0$$
$$N_A = 1300 \text{ lb}$$

**Method of Sections:** Using the left portion of the free - body diagram, Fig. $b$.

$$\circlearrowleft +\Sigma M_D = 0; \qquad F_{KL}(8) + 1000(8) - 900(8) - 1300(24) = 0$$
$$F_{KL} = 3800 \text{ lb (C)} \qquad \textbf{Ans.}$$
$$\circlearrowleft +\Sigma M_L = 0; \qquad F_{CD}(8) - 1300(16) = 0$$
$$F_{CD} = 2600 \text{ lb (T)} \qquad \textbf{Ans.}$$
$$+\uparrow \Sigma F_y = 0; \qquad 1300 - 1000 - F_{LD}\sin 45^\circ = 0$$
$$F_{LD} = 424.26 \text{ lb} = 424 \text{ lb (T)} \qquad \textbf{Ans.}$$

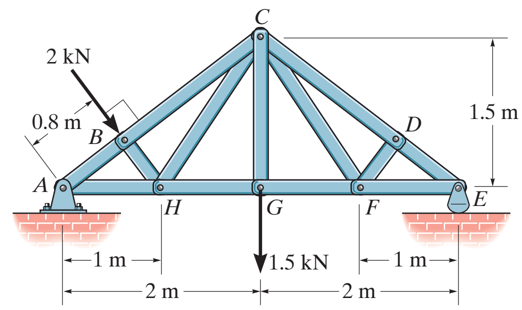



(a)




(b)

**6–46.** Determine the force developed in members *BC* and *CH* of the roof truss and state if the members are in tension or compression.



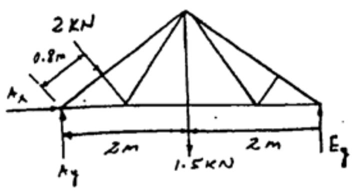

$\circlearrowleft + \Sigma M_A = 0; \quad E_y(4) - 2(0.8) - 1.5(2) = 0 \qquad E_y = 1.15 \text{ kN}$

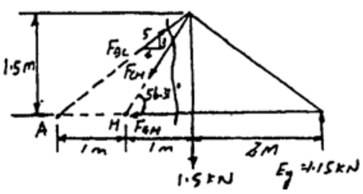
$\circlearrowleft + \Sigma M_H = 0; \quad 1.15(3) - 1.5(1) - \frac{3}{5}F_{BC}(1) = 0$

$F_{BC} = 3.25 \text{ kN (C)}$ **Ans**

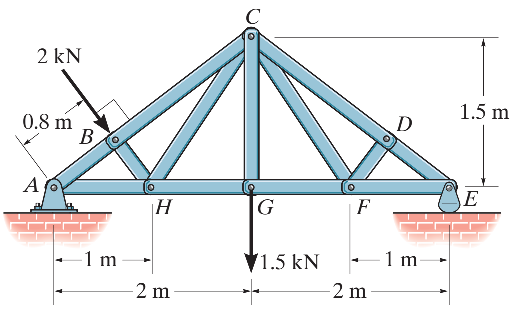
$\circlearrowleft + \Sigma M_A = 0; \quad 1.15(4) - 1.5(2) - F_{CH}\sin 56.31°(1) = 0$

$F_{CH} = 1.92 \text{ kN (T)}$ **An**



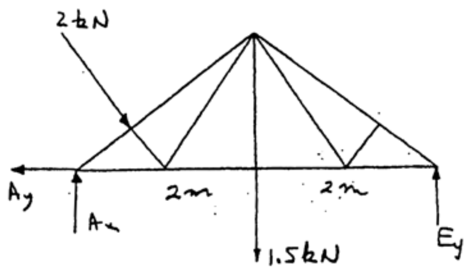
**6–47.** Determine the force in members *CD* and *GF* of the truss and state if the members are in tension or compression. Also indicate all zero-force members.




Entire truss:

$\circlearrowleft + \Sigma M_A = 0; \quad -2\,(0.8) - 1.5\,(2) + E_y\,(4) = 0$

$E_y = 1.15 \text{ kN}$



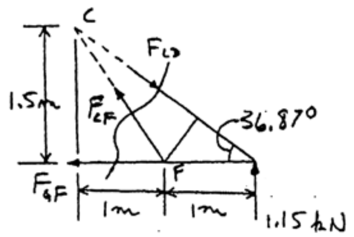

Section:

$\circlearrowleft + \Sigma M_F = 0; \quad 1.15\,(1) - F_{CD} \sin 36.87°\,(1) = 0$

$F_{CD} = 1.92 \text{ kN (C)}$ **Ans**

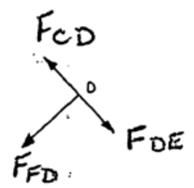
$\circlearrowleft + \Sigma M_C = 0; \quad -F_{GF}\,(1.5) + 1.15\,(2) = 0$

$F_{GF} = 1.53 \text{ kN (T)}$ **Ans**




Joint *D*:

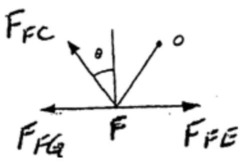
$+\nearrow \Sigma F_y = 0; \quad F_{FD} = 0$ **Ans**



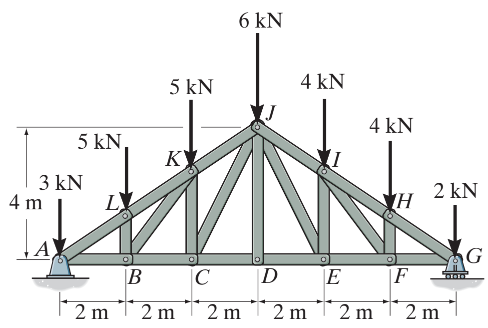

Joint *F*:

$+\uparrow \Sigma F_y = 0; \quad F_{FC} \cos\theta = 0$

$F_{FC} = 0$ **Ans**



***6–48.** Determine the force in members *IJ*, *EJ*, and *CD* of the *Howe* truss, and state if the members are in tension or compression.

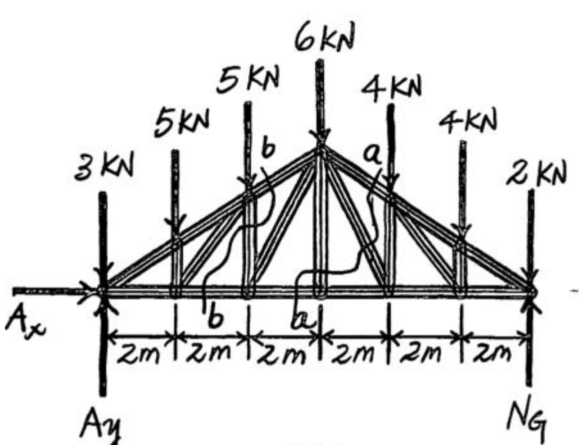



**Support Reactions:** Applying the moment equation of equilibrium about point $A$ to the free - body diagram of the truss, Fig. $a$,

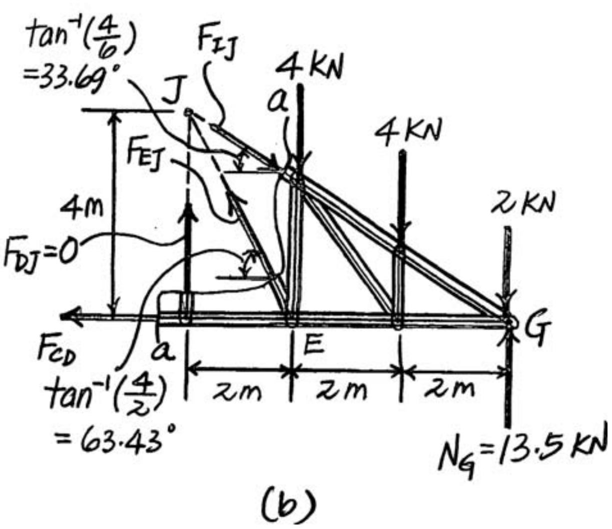
$$\circlearrowleft +\Sigma M_A = 0; \qquad N_G(12) - 2(12) - 4(10) - 4(8) - 6(6) - 5(4) - 5(2) = 0$$
$$N_G = 13.5\text{ kN}$$

**Method of Sections:** By inspecting joint $D$, we find that member $DJ$ is a zero - force member, thus $F_{DJ} = 0$. Using the right portion of the free - body diagram, Fig. $b$.

$$\circlearrowleft +\Sigma M_J = 0; \qquad 13.5(6) - 4(2) - 4(4) - 2(6) - F_{CD}(4) = 0$$
$$F_{CD} = 11.25\text{ kN (T)} \qquad \textbf{Ans.}$$
$$\circlearrowleft +\Sigma M_E = 0; \qquad 13.5(4) - 2(4) - 4(2) - F_{IJ}\sin 33.69°(4) = 0$$
$$F_{IJ} = 17.13\text{ kN} = 17.1\text{ kN (C)} \qquad \textbf{Ans.}$$
$$\circlearrowleft +\Sigma M_G = 0; \qquad 4(2) + 4(4) - F_{EJ}\sin 63.43°(4) = 0$$
$$F_{EJ} = 6.708\text{ kN} = 6.71\text{ kN (T)} \qquad \textbf{Ans.}$$

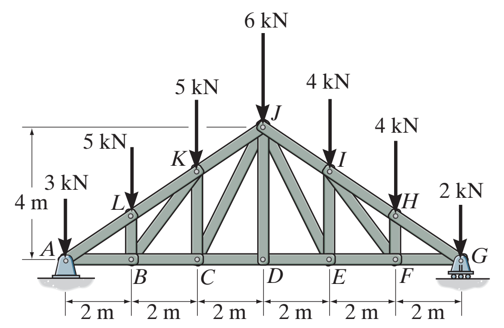



(a)




(b)

**•6–49.** Determine the force in members *KJ*, *KC*, and *BC* of the *Howe* truss, and state if the members are in tension or compression.




**Support Reactions:** Applying the equations of equilibrium to the free-body diagram of the truss, Fig. *a*,

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

$\curvearrowleft + \Sigma M_G = 0$ $\quad 3(12) + 5(10) + 5(8) + 6(6) + 4(4) + 4(2) - A_y(12) = 0$

$A_y = 15.5 \text{ kN}$

**Method of Sections:** Using the left portion of the free-body diagram, Fig. *a*.

$\curvearrowleft + \Sigma M_C = 0;$ $\quad F_{KJ} \sin 33.69°(4) + 5(2) + 3(4) - 15.5(4) = 0$

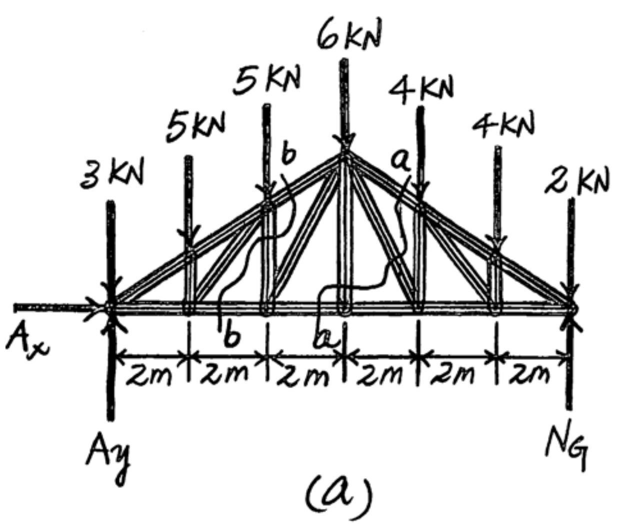
$F_{KJ} = 18.03 \text{ kN} = 18.0 \text{ kN (C)}$ **Ans.**

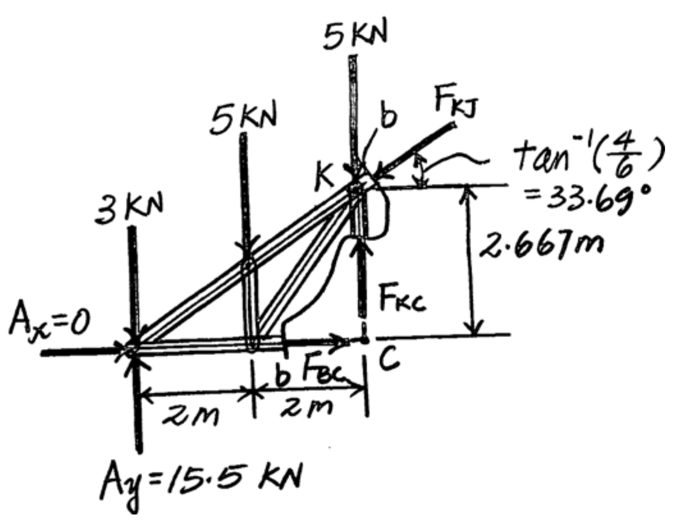
$\curvearrowleft + \Sigma M_A = 0;$ $\quad F_{KC}(4) - 5(4) - 5(2) = 0$

$F_{KC} = 7.50 \text{ kN (C)}$ **Ans.**

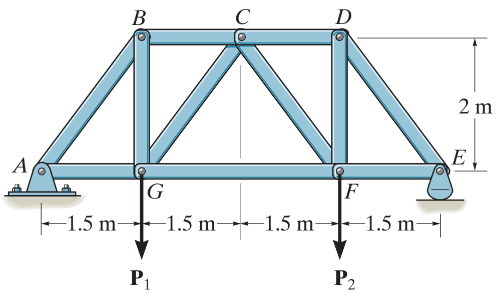
$\curvearrowleft + \Sigma M_K = 0;$ $\quad F_{BC}(2.667) + 5(2) + 3(4) - 15.5(4) = 0$

$F_{BC} = 15 \text{ kN (T)}$ **Ans.**



**6–50.** Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 20$ kN, $P_2 = 10$ kN.




**Entire truss :**

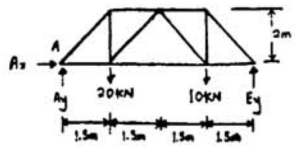
$\circlearrowleft + \Sigma M_A = 0;\quad -20\,(1.5) - 10\,(4.5) + E_y\,(6) = 0$

$E_y = 12.5$ kN

$+\uparrow \Sigma F_y = 0;\quad A_y - 20 - 10 + 12.5 = 0$

$A_y = 17.5$ kN

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



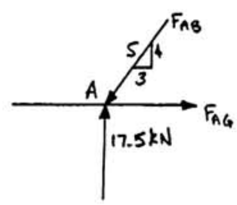

**Joint A :**

$+\uparrow \Sigma F_y = 0;\quad 17.5 - \frac{4}{5} F_{AB} = 0$

$F_{AB} = 21.875 = 21.9$ kN (C) **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad F_{AG} - \frac{3}{5}(21.875) = 0$

$F_{AG} = 13.125 = 13.1$ kN (T) **Ans**



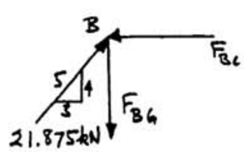

**Joint B :**

$\xrightarrow{+} \Sigma F_x = 0;\quad \frac{3}{5}(21.875) - F_{BC} = 0$

$F_{BC} = 13.125 = 13.1$ kN (C) **Ans**

$+\uparrow \Sigma F_y = 0;\quad \frac{4}{5}(21.875) - F_{BG} = 0$

$F_{BG} = 17.5$ kN (T) **Ans**



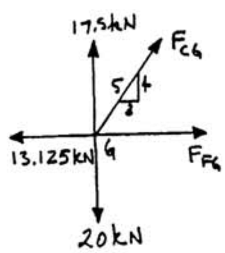

**Joint G :**

$+\uparrow \Sigma F_y = 0;\quad 17.5 - 20 + \frac{4}{5} F_{CG} = 0$

$F_{CG} = 3.125 = 3.12$ kN (T) **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad \frac{3}{5}(3.125) + F_{FG} - 13.125 = 0$

$F_{FG} = 11.25 = 11.2$ kN (T) **Ans**



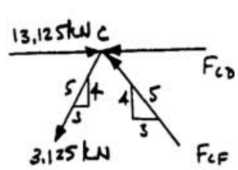

**Joint C :**

$+\uparrow \Sigma F_y = 0;\quad \frac{4}{5} F_{CF} - \frac{4}{5}(3.125) = 0$

$F_{CF} = 3.125 = 3.12$ kN (C) **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad 13.125 - \frac{3}{5}(3.125) - \frac{3}{5}(3.125) - F_{CD} = 0$

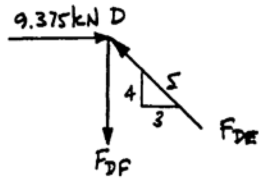
$F_{CD} = 9.375 = 9.38$ kN (C) **Ans**



Joint $D$ :

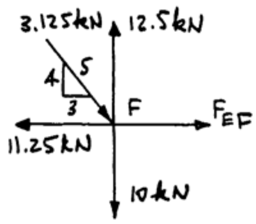
$\xrightarrow{+} \Sigma F_x = 0;\quad 9.375 - \frac{3}{5} F_{DE} = 0$

$F_{DE} = 15.625 = 15.6 \text{ kN (C)}$ **Ans**




$+\uparrow \Sigma F_y = 0;\quad \frac{4}{5}(15.625) - F_{DF} = 0$

$F_{DF} = 12.5 \text{ kN (T)}$ **Ans**



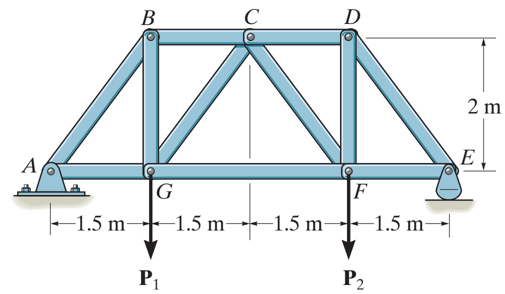

Joint $F$ :

$\xrightarrow{+} \Sigma F_x = 0;\quad \frac{3}{5}(3.125) - 11.25 + F_{EF} = 0$

$F_{EF} = 9.38 \text{ kN (T)}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad 12.5 - 10 - \frac{4}{5}(3.125) = 0$ **Check!**

**6–51.** Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 40$ kN, $P_2 = 20$ kN.




**Entire truss :**

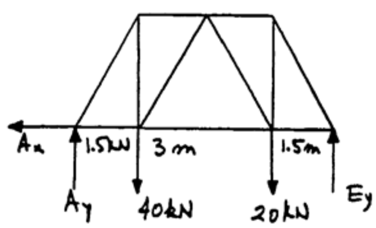
$\circlearrowleft + \Sigma M_A = 0; \quad -40\,(1.5) - 20\,(4.5) + E_y\,(6) = 0$

$E_y = 25$ kN

$+\uparrow \Sigma F_y = 0; \quad A_y - 40 - 20 + 25 = 0$

$A_y = 35$ kN

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



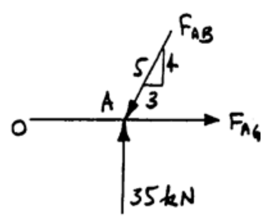

**Joint $A$ :**

$+\uparrow \Sigma F_y = 0; \quad 35 - \frac{4}{5} F_{AB} = 0$

$F_{AB} = 43.75 = 43.8$ kN (C) **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AG} - \frac{3}{5}(43.75) = 0$

$F_{AG} = 26.25 = 26.2$ kN (T) **Ans**



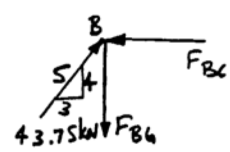

**Joint $B$ :**

$\xrightarrow{+} \Sigma F_x = 0; \quad \frac{3}{5}(43.75) - F_{BC} = 0$

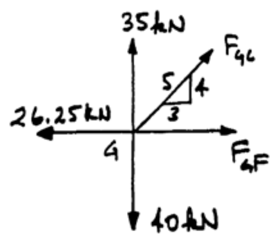
$F_{BC} = 26.25 = 26.2$ kN (C) **Ans**

$+\uparrow \Sigma F_y = 0; \quad \frac{4}{5}(43.75) - F_{BG} = 0$

$F_{BG} = 35.0$ kN (T) **Ans**



**Joint $G$:**



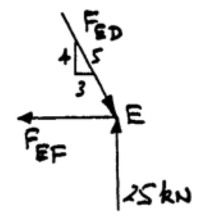

$+\uparrow \Sigma F_y = 0; \quad -40 + 35 + \frac{4}{5} F_{GC} = 0$

$F_{GC} = 6.25 \text{ kN (T)}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad \frac{3}{5}(6.25) + F_{GF} - 26.25 = 0$

$F_{GF} = 22.5 \text{ kN (T)}$ **Ans**

**Joint $E$:**



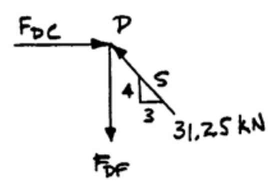

$+\uparrow \Sigma F_y = 0; \quad 25 - \frac{4}{5} F_{ED} = 0$

$F_{ED} = 31.25 = 31.2 \text{ kN (C)}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad -F_{EF} + \frac{3}{5}(31.25) = 0$

$F_{EF} = 18.75 = 18.8 \text{ kN (T)}$ **Ans**

**Joint $D$:**



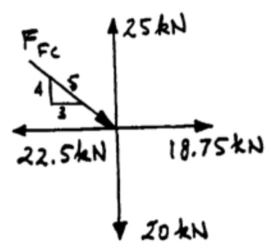

$\xrightarrow{+} \Sigma F_x = 0; \quad F_{DC} - \frac{3}{5}(31.25) = 0$

$F_{DC} = 18.75 = 18.8 \text{ kN (C)}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad \frac{4}{5}(31.25) - F_{DF} = 0$

$F_{DF} = 25.0 \text{ kN (T)}$ **Ans**

**Joint $F$:**

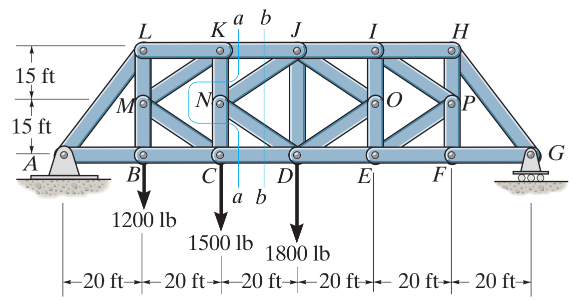



$+\uparrow \Sigma F_y = 0; \quad 25 - \frac{4}{5}(F_{FC}) - 20 = 0$

$F_{FC} = 6.25 \text{ kN (C)}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad -22.5 + 18.75 + \frac{3}{5}(6.25) = 0$ **Check!**

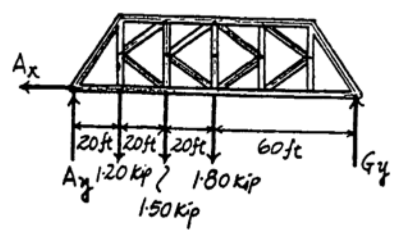
*6–52.** Determine the force in members *KJ*, *NJ*, *ND*, and *CD* of the *K truss*. Indicate if the members are in tension or compression. *Hint:* Use sections *aa* and *bb*.




***Support Reactions :***

$$\curvearrowleft + \Sigma M_G = 0; \qquad 1.20(100) + 1.50(80) + 1.80(60) - A_y\,(120) = 0$$
$$A_y = 2.90 \text{ kip}$$

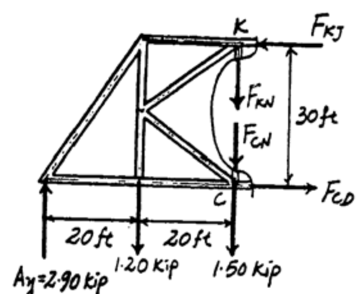
$$\xrightarrow{+} \Sigma F_x = 0; \qquad A_x = 0$$




***Method of Sections :*** From section $a-a$, $F_{KJ}$ and $F_{CD}$ can be obtained directly by summing moment about points $C$ and $K$ respectively.

$$\curvearrowleft + \Sigma M_C = 0; \qquad F_{KJ}\,(30) + 1.20(20) - 2.90(40) = 0$$
$$F_{KJ} = 3.067 \text{ kip (C)} = 3.07 \text{ kip (C)} \qquad \textbf{Ans}$$

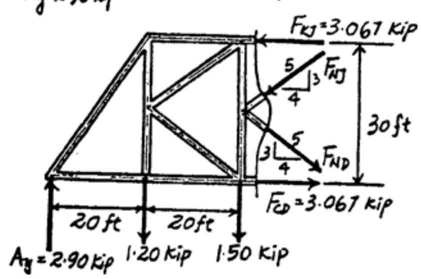
$$\curvearrowleft + \Sigma M_K = 0; \qquad F_{CD}\,(30) + 1.20(20) - 2.90(40) = 0$$
$$F_{CD} = 3.067 \text{ kip (T)} = 3.07 \text{ kip (T)} \qquad \textbf{Ans}$$




From sec $b-b$, summing forces along $x$ and $y$ axes yields

$$\xrightarrow{+} \Sigma F_x = 0; \qquad F_{ND}\left(\frac{4}{5}\right) - F_{NJ}\left(\frac{4}{5}\right) + 3.067 - 3.067 = 0$$
$$F_{ND} = F_{NJ} \qquad [1]$$

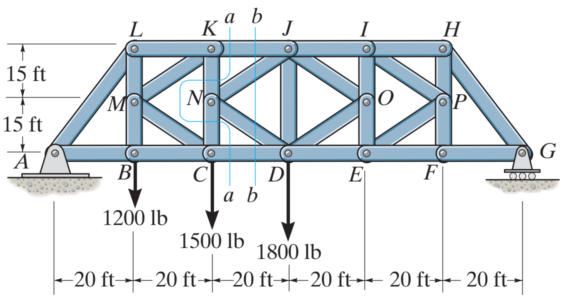
$$+\uparrow \Sigma F_y = 0; \qquad 2.90 - 1.20 - 1.50 - F_{ND}\left(\frac{3}{5}\right) - F_{NJ}\left(\frac{3}{5}\right) = 0$$
$$F_{ND} + F_{NJ} = 0.3333 \qquad [2]$$

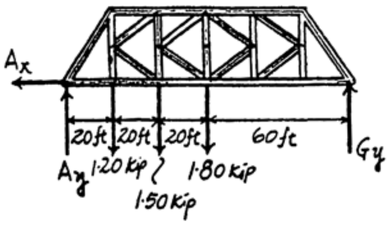



Solving Eqs. [1] and [2] yields

$$F_{ND} = 0.167 \text{ kip (T)} \qquad F_{NJ} = 0.167 \text{ kip (C)} \qquad \textbf{Ans}$$

**•6–53.** Determine the force in members *JI* and *DE* of the *K truss*. Indicate if the members are in tension or compression.



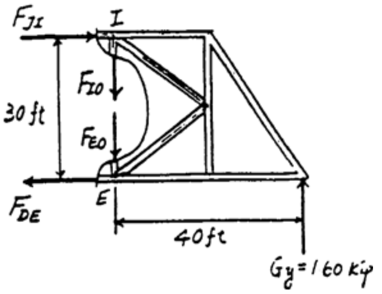




***Support Reactions :***

$\curvearrowleft + \Sigma M_A = 0;\quad G_y(120) - 1.80(60) - 1.50(40) - 1.20(20) = 0$

$G_y = 1.60 \text{ kip}$

***Method of Sections :***



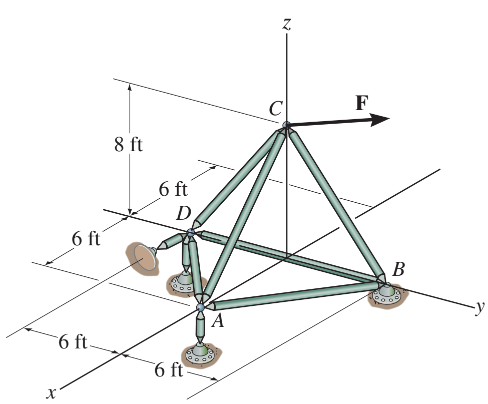

$\curvearrowleft + \Sigma M_E = 0;\quad 1.60(40) - F_{JI}(30) = 0$

$F_{JI} = 2.13 \text{ kip (C)}$ **Ans**

$\curvearrowleft + \Sigma M_I = 0;\quad 1.60(40) - F_{DE}(30) = 0$

$F_{DE} = 2.13 \text{ kip (T)}$ **Ans**

**6–54.** The space truss supports a force $\mathbf{F} = \{-500\mathbf{i} + 600\mathbf{j} + 400\mathbf{k}\}$ lb. Determine the force in each member, and state if the members are in tension or compression.




**Method of Joints:** In this case, there is no need to compute the support reactions. We will begin by analyzing the equilibrium of joint $C$, and then that of joints $A$ and $D$.

**Joint** $C$: From the free - body diagram, Fig. $a$,

$$\Sigma F_x = 0; \quad F_{CA}\left(\frac{3}{5}\right) - 500 = 0$$

$$F_{CA} = 833.33 \text{ lb} = 833 \text{ lb (T)} \qquad \textbf{Ans.}$$

$$\Sigma F_y = 0; \quad F_{CB}\left(\frac{3}{5}\right) - F_{CD}\left(\frac{3}{5}\right) + 600 = 0 \qquad (1)$$

$$\Sigma F_z = 0; \quad 400 - 833.33\left(\frac{4}{5}\right) - F_{CD}\left(\frac{4}{5}\right) - F_{CB}\left(\frac{4}{5}\right) = 0 \qquad (2)$$

Solving Eqs. (1) and (2) yields

$$F_{CB} = -666.67 \text{ lb} = 667 \text{ lb (C)} \qquad \textbf{Ans.}$$

$$F_{CD} = 333.33 \text{ lb} = 333 \text{ lb (T)} \qquad \textbf{Ans.}$$

**Joint** $A$: From the free - body diagram, Fig. $b$,

$$\Sigma F_x = 0; \quad F_{AD} \cos 45° - F_{AB} \cos 45° = 0$$

$$F_{AD} = F_{AB} = F$$

$$\Sigma F_y = 0; \quad F \sin 45° + F \sin 45° - 833.33\left(\frac{3}{5}\right) = 0$$

$$F = 353.55 \text{ lb}$$

Thus, $F_{AD} = F_{AB} = 353.55 \text{ lb} = 354 \text{ lb (C)}$ **Ans.**

$$\Sigma F_z = 0; \quad 833.33\left(\frac{4}{5}\right) - A_z = 0$$

$$A_z = 666.67 \text{ lb}$$

**Joint** $D$: From the free - body diagram, Fig. $c$,

$$\Sigma F_y = 0; \quad F_{DB} + 333.33\left(\frac{3}{5}\right) - 353.55 \cos 45° = 0$$

$$F_{DB} = 50 \text{ lb (T)} \qquad \textbf{Ans.}$$

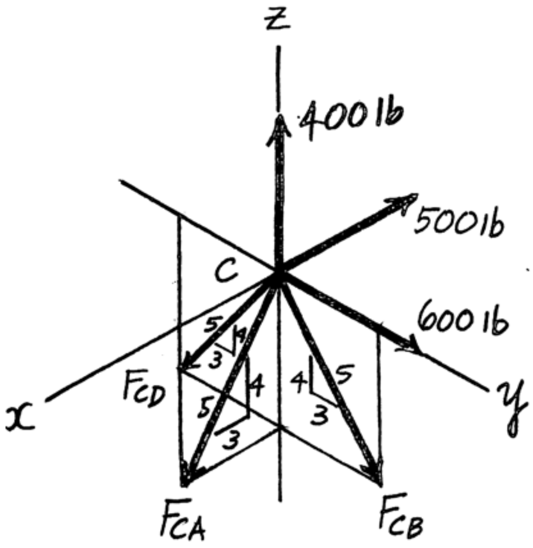
$$\Sigma F_x = 0; \quad D_x - 353.55 \sin 45° = 0$$

$$D_x = 250 \text{ lb}$$

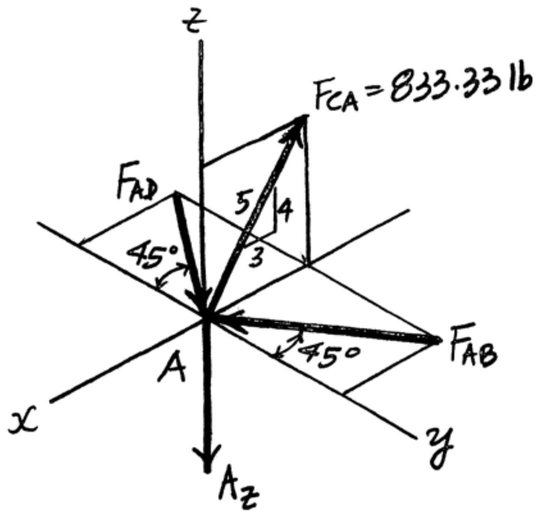
$$\Sigma F_z = 0; \quad 333.33\left(\frac{4}{5}\right) - D_z = 0$$

$$D_z = 266.67 \text{ lb}$$

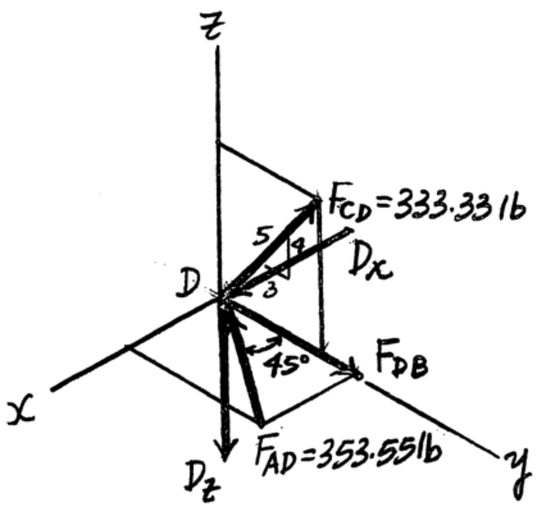
*Note:* The equilibrium analysis of joint $B$ can be used to determine the components of support reaction of the ball and socket support at $B$.


z
400 lb
500 lb
600 lb
C
5
4
3
$F_{CD}$
5
4
3
4
5
3
x
y
$F_{CA}$
$F_{CB}$

(a)

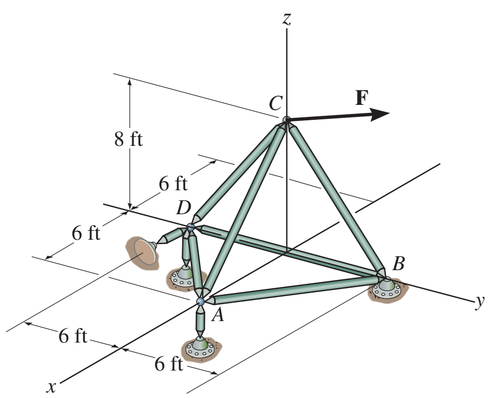

z
$F_{CA}$ = 833.33 lb
$F_{AD}$
5
4
3
45°
A
45°
$F_{AB}$
x
y
$A_z$

(b)


z
$F_{CD}$ = 333.33 lb
5
4
3
D
$D_x$
45°
$F_{DB}$
x
$F_{AD}$ = 353.55 lb
$D_z$
y

(c)

**6–55.** The space truss supports a force $\mathbf{F} = \{600\mathbf{i} + 450\mathbf{j} - 750\mathbf{k}\}$ lb. Determine the force in each member, and state if the members are in tension or compression.




**Method of Joints:** In this case, there is no need to compute the support reactions. We will begin by analyzing the equilibrium of joint $C$, and then that of joints $A$ and $D$.

**Joint $C$:** From the free - body diagram, Fig. $a$,

$$\Sigma F_x = 0; \quad 600 + F_{CA}\left(\frac{3}{5}\right) = 0$$

$$F_{CA} = -1000 \text{ lb} = 1000 \text{ lb (C)} \qquad \textbf{Ans.}$$

$$\Sigma F_y = 0; \quad F_{CB}\left(\frac{3}{5}\right) - F_{CD}\left(\frac{3}{5}\right) + 450 = 0 \qquad (1)$$

$$\Sigma F_z = 0; \quad -F_{CB}\left(\frac{4}{5}\right) - F_{CD}\left(\frac{4}{5}\right) - (-1000)\left(\frac{4}{5}\right) - 750 = 0 \qquad (2)$$

Solving Eqs. (1) and (2) yields

$$F_{CD} = 406.25 \text{ lb} = 406 \text{ lb (T)} \qquad \textbf{Ans.}$$

$$F_{CB} = -343.75 \text{ lb} = 344 \text{ lb (C)} \qquad \textbf{Ans.}$$

**Joint $A$:** From the free - body diagram, Fig. $b$,

$$\Sigma F_y = 0; \quad F_{AB}\cos 45° - F_{AD}\cos 45° = 0$$

$$F_{AB} = F_{AD} = F$$

$$\Sigma F_x = 0; \quad 1000\left(\frac{3}{5}\right) - F\sin 45° - F\sin 45° = 0$$

$$F = 424.26 \text{ lb}$$

Thus, $F_{AB} = F_{AD} = 424.26 \text{ lb} = 424 \text{ lb (T)}$ **Ans.**

$$\Sigma F_z = 0; \quad A_z - 1000\left(\frac{4}{5}\right) = 0$$

$$A_z = 800 \text{ lb}$$

**Joint $D$:** From the free - body diagram, Fig. $c$,

$$\Sigma F_y = 0; \quad 406.25\left(\frac{3}{5}\right) + 406.25\cos 45° - F_{DB} = 0$$

$$F_{DB} = 543.75 \text{ lb} = 544 \text{ lb (C)} \qquad \textbf{Ans.}$$

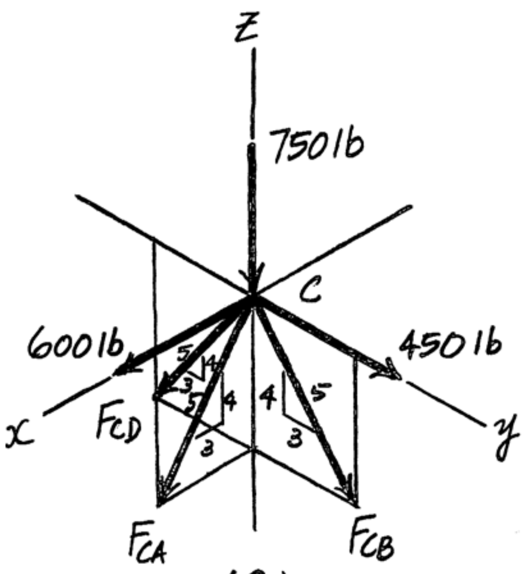
$$\Sigma F_x = 0; \quad 424.26\sin 45° - D_x = 0$$

$$D_x = 300 \text{ lb}$$

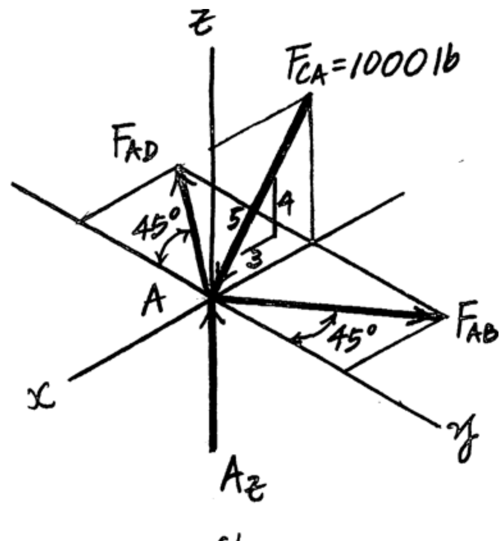
$$\Sigma F_z = 0; \quad 406.25\left(\frac{4}{5}\right) - D_z = 0$$

$$D_z = 325 \text{ lb}$$

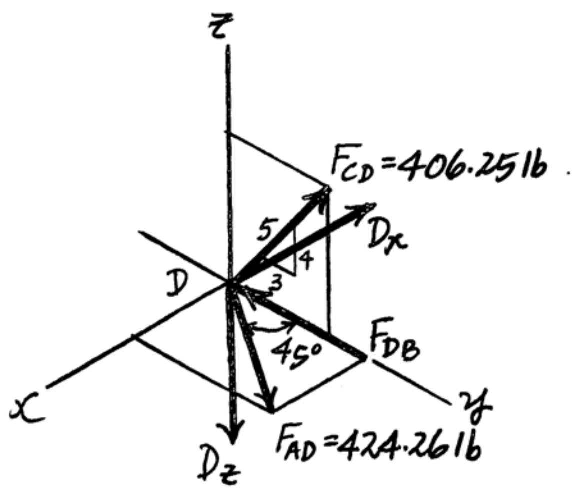
*Note:* The equilibrium analysis of joint $B$ can be used to determine the components of support reaction of the ball and socket support at $B$.


z
750 lb
C
600 lb
450 lb
x
$F_{CD}$
y
$F_{CA}$
$F_{CB}$

(a)

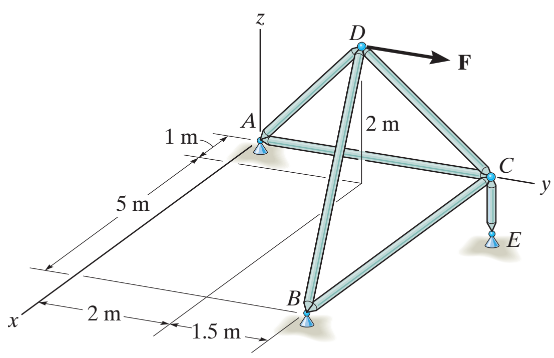

z
$F_{CA}$ = 1000 lb
$F_{AD}$
45°
A
$F_{AB}$
45°
x
y
$A_z$

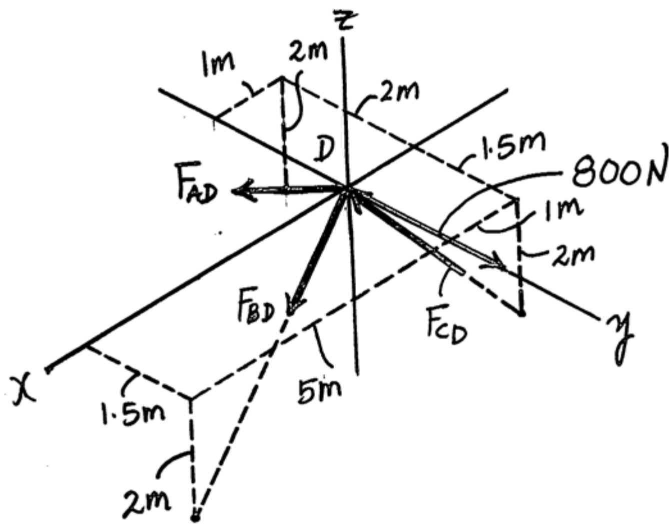
(b)


z
$F_{CD}$ = 406.25 lb
$D_x$
D
$F_{DB}$
45°
x
y
$F_{AD}$ = 424.26 lb
$D_z$

(c)

***6–56.** Determine the force in each member of the space truss and state if the members are in tension or compression. The truss is supported by ball-and-socket joints at $A$, $B$, and $E$. Set $\mathbf{F} = \{800\mathbf{j}\}$ N. *Hint:* The support reaction at $E$ acts along member $EC$. Why?




**Joint $D$:**

$\Sigma F_x = 0;$ $\quad -\frac{1}{3}F_{AD} + \frac{5}{\sqrt{31.25}}F_{BD} + \frac{1}{\sqrt{7.25}}F_{CD} = 0$

$\Sigma F_y = 0;$ $\quad -\frac{2}{3}F_{AD} + \frac{1.5}{\sqrt{31.25}}F_{BD} - \frac{1.5}{\sqrt{7.25}}F_{CD} + 800 = 0$

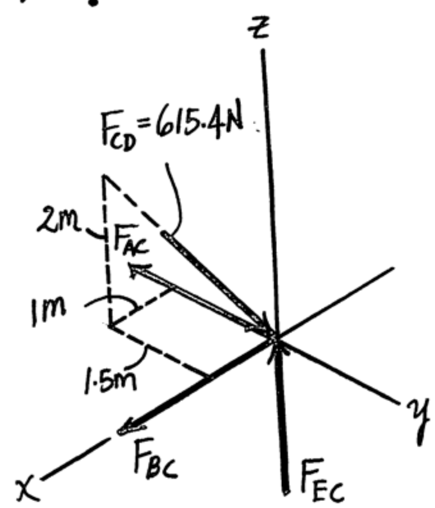
$\Sigma F_z = 0;$ $\quad -\frac{2}{3}F_{AD} - \frac{2}{\sqrt{31.25}}F_{BD} + \frac{2}{\sqrt{7.25}}F_{CD} = 0$

$F_{AD} = 686$ N (T) **Ans**

$F_{BD} = 0$ **Ans**

$F_{CD} = 615.4 = 615$ N (C) **Ans**

**Joint $C$:**




$\Sigma F_x = 0;$ $\quad F_{BC} - \frac{1}{\sqrt{7.25}}(615.4) = 0$

$F_{BC} = 229$ N (T) **Ans**

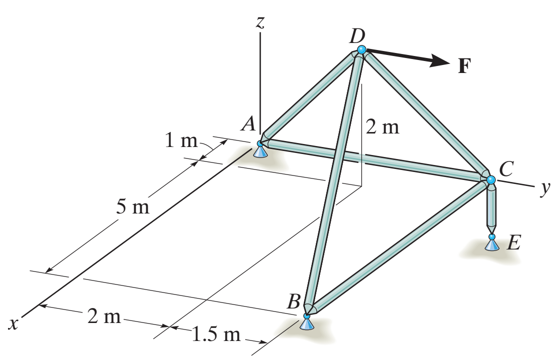
$\Sigma F_y = 0;$ $\quad \frac{1.5}{\sqrt{7.25}}(615.4) - F_{AC} = 0$

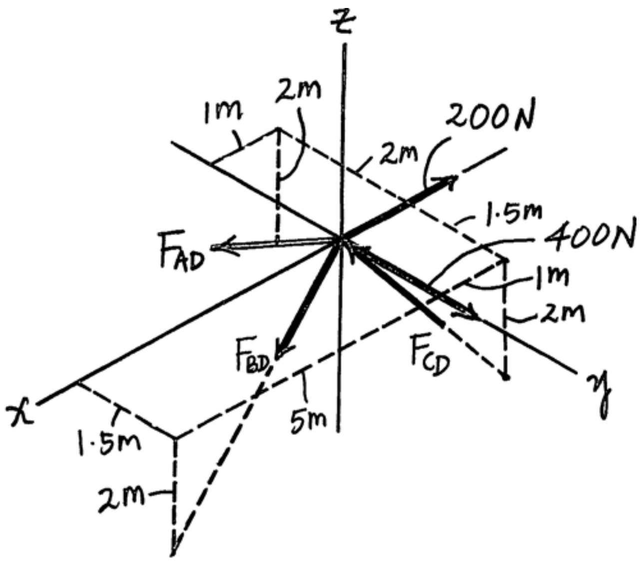
$F_{AC} = 343$ N (T) **Ans**

$\Sigma F_z = 0;$ $\quad F_{EC} - \frac{2}{\sqrt{7.25}}(615.4) = 0$

$F_{EC} = 457$ N (C) **Ans**

**•6–57.** Determine the force in each member of the space truss and state if the members are in tension or compression. The truss is supported by ball-and-socket joints at $A$, $B$, and $E$. Set $\mathbf{F} = \{-200\mathbf{i} + 400\mathbf{j}\}$ N. *Hint:* The support reaction at $E$ acts along member $EC$. Why?




**Joint *D*:**

$\Sigma F_x = 0;\quad -\frac{1}{3}F_{AD} + \frac{5}{\sqrt{31.25}}F_{BD} + \frac{1}{\sqrt{7.25}}F_{CD} - 200 = 0$

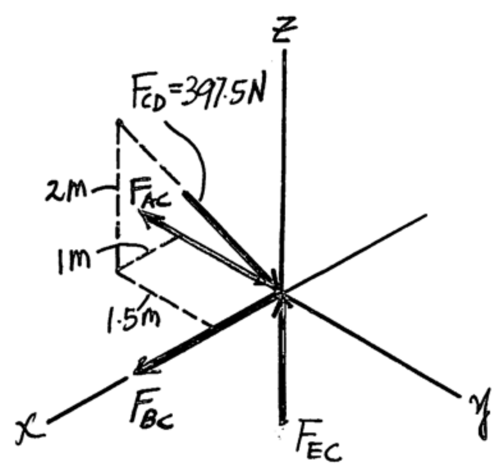
$\Sigma F_y = 0;\quad -\frac{2}{3}F_{AD} + \frac{1.5}{\sqrt{31.25}}F_{BD} - \frac{1.5}{\sqrt{7.25}}F_{CD} + 400 = 0$

$\Sigma F_z = 0;\quad -\frac{2}{3}F_{AD} - \frac{2}{\sqrt{31.25}}F_{BD} + \frac{2}{\sqrt{7.25}}F_{CD} = 0$

$F_{AD} = 343$ N (T) **Ans**

$F_{BD} = 186$ N (T) **Ans**

$F_{CD} = 397.5 = 397$ N (C) **Ans**




**Joint *C*:**

$\Sigma F_x = 0;\quad F_{BC} - \frac{1}{\sqrt{7.25}}(397.5) = 0$

$F_{BC} = 148$ N (T) **Ans**

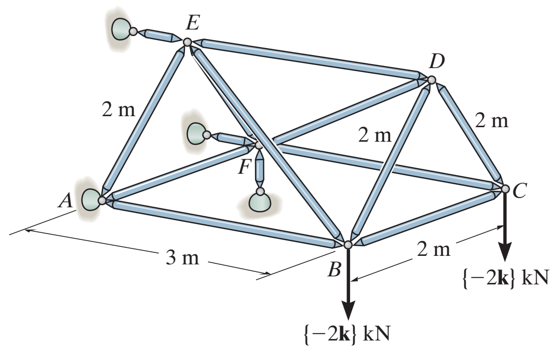
$\Sigma F_y = 0;\quad \frac{1.5}{\sqrt{7.25}}(397.5) - F_{AC} = 0$

$F_{AC} = 221$ N (T) **Ans**

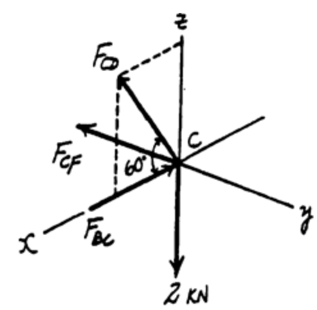
$\Sigma F_z = 0;\quad F_{EC} - \frac{2}{\sqrt{7.25}}(397.5) = 0$

$F_{EC} = 295$ N (C) **Ans**

**6–58.** Determine the force in members $BE$, $DF$, and $BC$ of the space truss and state if the members are in tension or compression.




***Method of Joints :*** **In this case, the support reactions are not required for determining the member forces.**

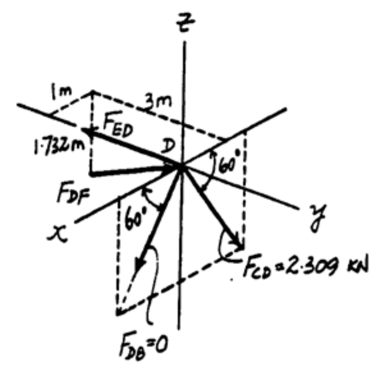



**Joint *C***

$$\Sigma F_z = 0; \quad F_{CD}\sin 60° - 2 = 0 \qquad F_{CD} = 2.309 \text{ kN (T)}$$

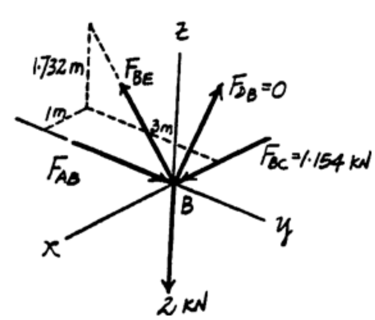
$$\Sigma F_x = 0; \quad 2.309\cos 60° - F_{BC} = 0$$
$$F_{BC} = 1.154 \text{ kN (C)} = 1.15 \text{ kN (C)} \qquad \textbf{Ans}$$

**Joint *D*** Since $F_{CD}$, $F_{DF}$ and $F_{DE}$ lie within the same plane and $F_{DB}$ is out of this plane, then $F_{DB} = 0$.



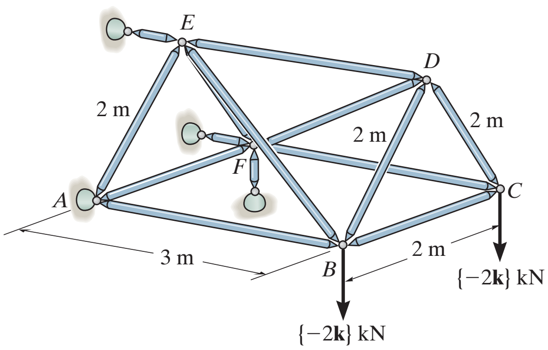

$$\Sigma F_x = 0; \quad F_{DF}\left(\frac{1}{\sqrt{13}}\right) - 2.309\cos 60° = 0$$
$$F_{DF} = 4.16 \text{ kN (C)} \qquad \textbf{Ans}$$

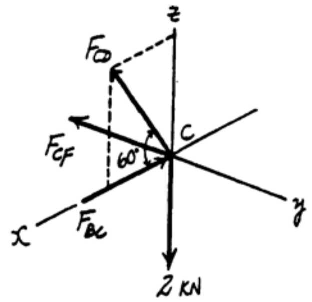
**Joint *B***




$$\Sigma F_z = 0; \quad F_{BE}\left(\frac{1.732}{\sqrt{13}}\right) - 2 = 0$$
$$F_{BE} = 4.16 \text{ kN (T)} \qquad \textbf{Ans}$$

**6–59.** Determine the force in members *AB*, *CD*, *ED*, and *CF* of the space truss and state if the members are in tension or compression.



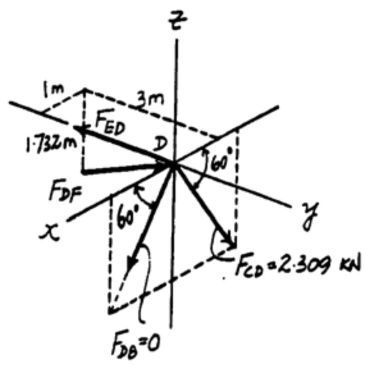

***Method of Joints :*** **In this case, the support reactions are not required for determining the member forces.**

**Joint *C*** Since $F_{CD}$, $F_{BC}$ and 2 kN force lie within the same plane and $F_{CF}$ is out of this plane, then

$$F_{CF} = 0 \qquad \textbf{Ans}$$

$$\Sigma F_z = 0; \quad F_{CD} \sin 60° - 2 = 0$$
$$F_{CD} = 2.309 \text{ kN (T)} = 2.31 \text{ kN (T)} \qquad \textbf{Ans}$$

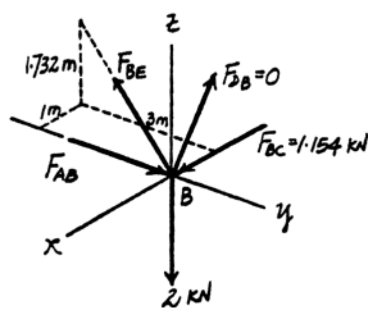
$$\Sigma F_x = 0; \quad 2.309 \cos 60° - F_{BC} = 0 \qquad F_{BC} = 1.154 \text{ kN (C)}$$




**Joint *D*** Since $F_{CD}$, $F_{DE}$ and $F_{DF}$ lie within the same plane and $F_{DB}$ is out of this plane, then $F_{DB} = 0$.

$$\Sigma F_x = 0; \quad F_{DF}\left(\frac{1}{\sqrt{13}}\right) - 2.309 \cos 60° = 0$$
$$F_{DF} = 4.163 \text{ kN (C)}$$

$$\Sigma F_y = 0; \quad 4.163\left(\frac{3}{\sqrt{13}}\right) - F_{ED} = 0$$
$$F_{ED} = 3.46 \text{ kN (T)} \qquad \textbf{Ans}$$

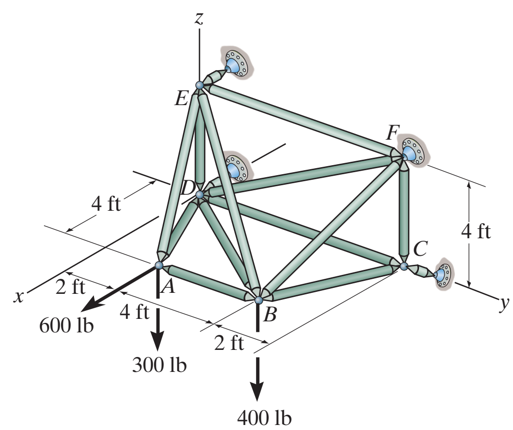



**Joint *B***

$$\Sigma F_z = 0; \quad F_{BE}\left(\frac{1.732}{\sqrt{13}}\right) - 2 = 0 \qquad F_{BE} = 4.163 \text{ kN (T)}$$

$$\Sigma F_y = 0; \quad F_{AB} - 4.163\left(\frac{3}{\sqrt{13}}\right) = 0$$
$$F_{AB} = 3.46 \text{ kN (C)} \qquad \textbf{Ans}$$

*6–60. Determine the force in the members $AB$, $AE$, $BC$, $BF$, $BD$, and $BE$ of the space truss, and state if the members are in tension or compression.




**Method of Joints:** In this case, there is no need to compute the support reactions. We will begin by analyzing the equilibrium of joint $A$, and then that of joints $C$ and $B$.

**Joint $A$:** From the free - body diagram, Fig. $a$,

$$\Sigma F_z = 0; \qquad F_{AE}\left(\frac{4}{6}\right) - 300 = 0$$

$$F_{AE} = 450 \text{ lb (T)} \qquad \textbf{Ans.}$$

$$\Sigma F_x = 0; \quad 600 - 450\left(\frac{4}{6}\right) - F_{AD}\left(\frac{4}{\sqrt{20}}\right) = 0$$

$$F_{AD} = 335.41 \text{ lb (T)}$$

$$\Sigma F_y = 0; \quad F_{AB} - 335.41\left(\frac{2}{\sqrt{20}}\right) - 450\left(\frac{2}{6}\right) = 0$$

$$F_{AB} = 300 \text{ lb (T)} \qquad \textbf{Ans.}$$

**Joint $C$:** From the free - body diagram of the joint in Fig. $b$, notice that $\mathbf{F}_{CD}$, $\mathbf{F}_{CF}$, and $\mathbf{C}_y$ lie in the $y - z$ plane (shown shaded). Thus, if we write the force equation of equilibrium along the $x$ axis, we have

$$\Sigma F_x = 0; \quad F_{BC}\left(\frac{4}{\sqrt{20}}\right) = 0$$

$$F_{BC} = 0 \qquad \textbf{Ans.}$$

**Joint $B$:** From the free - body diagram, Fig. $c$,

$$\Sigma F_x = 0; \quad -F_{BF}\left(\frac{4}{6}\right) - F_{BE}\left(\frac{4}{\sqrt{68}}\right) - F_{BD}\left(\frac{4}{\sqrt{52}}\right) = 0 \qquad (1)$$

$$\Sigma F_y = 0; \quad F_{BF}\left(\frac{2}{6}\right) - F_{BE}\left(\frac{6}{\sqrt{68}}\right) - F_{BD}\left(\frac{6}{\sqrt{52}}\right) - 300 = 0 \qquad (2)$$

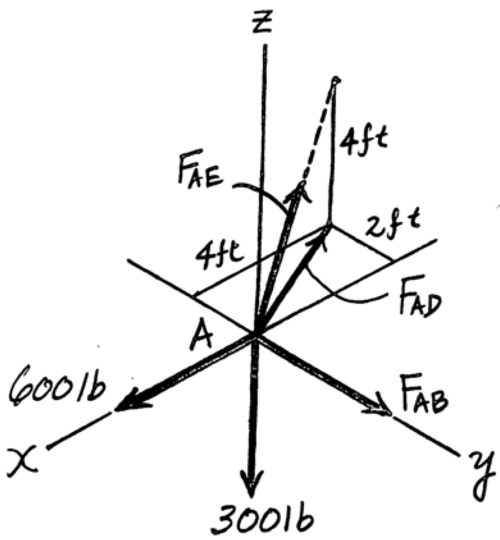
$$\Sigma F_z = 0; \qquad F_{BE}\left(\frac{4}{\sqrt{68}}\right) + F_{BF}\left(\frac{4}{6}\right) - 400 = 0 \qquad (3)$$

Solving Eqs. (1) through (3) yields

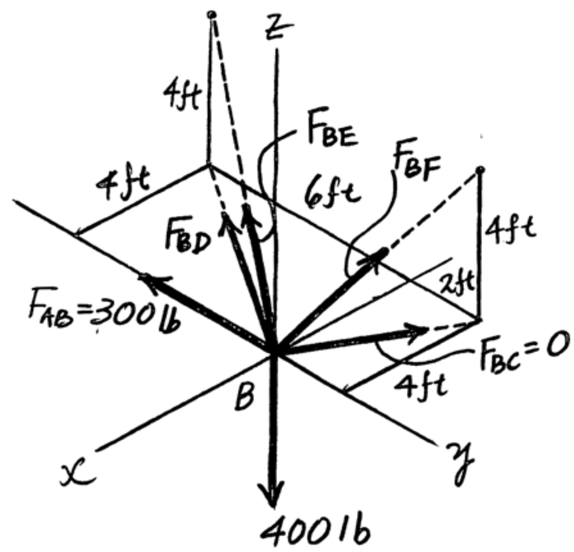
$$F_{BF} = 225 \text{ lb (T)} \qquad \textbf{Ans.}$$

$$F_{BE} = 515.39 \text{ lb} = 515 \text{ lb (T)} \qquad \textbf{Ans.}$$

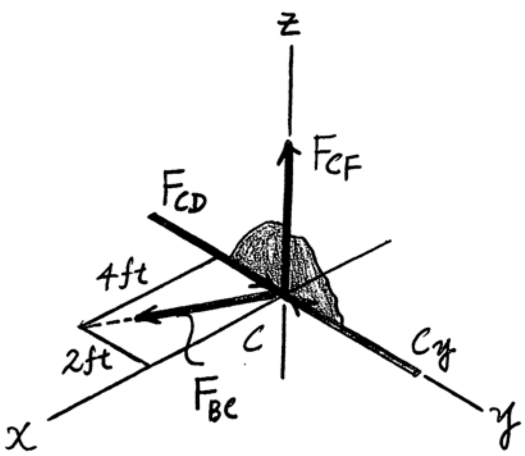
$$F_{BD} = -721.11 \text{ lb} = 721 \text{ lb (C)} \qquad \textbf{Ans.}$$


z
4ft
$F_{AE}$
2ft
4ft
$F_{AD}$
A
600 lb
$F_{AB}$
x
y
300 lb

(a)

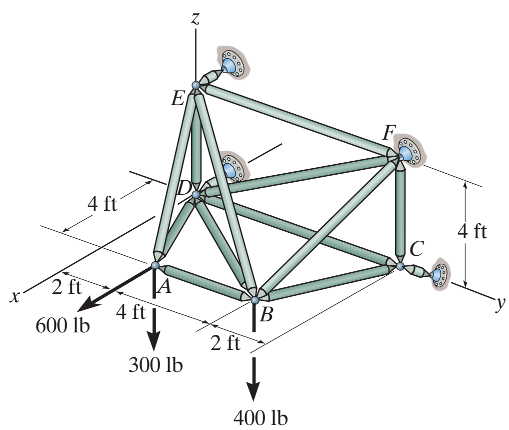

z
4ft
$F_{BE}$
$F_{BF}$
4ft
6ft
4ft
$F_{BD}$
2ft
$F_{AB} = 300$ lb
$F_{BC} = 0$
4ft
B
x
y
400 lb

(c)


z
$F_{CF}$
$F_{CD}$
4ft
2ft
C
$C_y$
$F_{BC}$
x
y

(b)

**•6–61.** Determine the force in the members *EF*, *DF*, *CF*, and *CD* of the space truss, and state if the members are in tension or compression.




**Support Reactions:** In this case, it is easier to compute the support reactions first. From the free - body diagram of the truss, Fig. *a*, and writing the equations of equilibrium,

$\Sigma M_{y'} = 0;\quad 400(4) + 300(4) - 600(4) - D_x(4) = 0$

$D_x = 100 \text{ lb}$

$\Sigma M_{x'} = 0;\quad 400(2) + 300(6) - C_y(4) = 0$

$C_y = 650 \text{ lb}$

$\Sigma M_{z'} = 0;\quad 600(6) + 100(8) - E_x(8) = 0$

$E_x = 550 \text{ lb}$

$\Sigma F_x = 0;\quad -F_x + 600 + 100 - 550 = 0$

$F_x = 150 \text{ lb}$

$\Sigma F_y = 0;\quad F_y - 650 = 0$

$F_y = 650 \text{ lb}$

$\Sigma F_z = 0;\quad F_z - 300 - 400 = 0$

$F_z = 700 \text{ lb}$

**Method of Joints:** Using the above results, we will begin by analyzing the equilibrium of joint *C*, and then proceed to analyzing that of joint *F*.

**Joint** ***C*****:** From the free - body diagram in Fig. *b*,

$\Sigma F_x = 0;\quad F_{CB}\left(\frac{4}{\sqrt{20}}\right) = 0 \qquad F_{CB} = 0$

$\Sigma F_y = 0;\quad F_{CD} - 650 = 0 \qquad F_{CD} = 650 \text{ lb (C)}$ **Ans.**

$\Sigma F_z = 0;\quad F_{CF} = 0$ **Ans.**

**Joint** ***F*****:** From the free - body diagram in Fig. *c*,

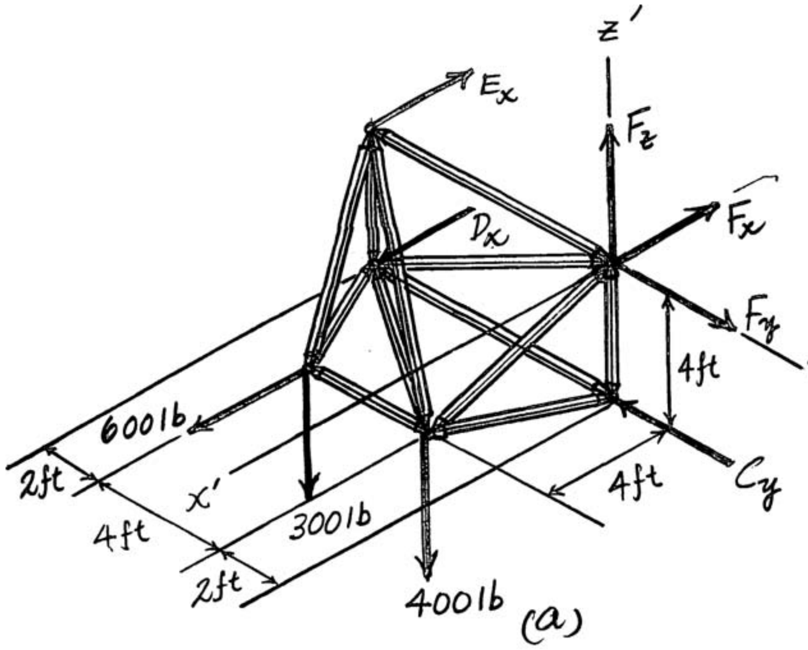
$\Sigma F_x = 0;\quad F_{FB}\left(\frac{4}{6}\right) - 150 = 0 \qquad F_{BF} = 225 \text{ lb (T)}$

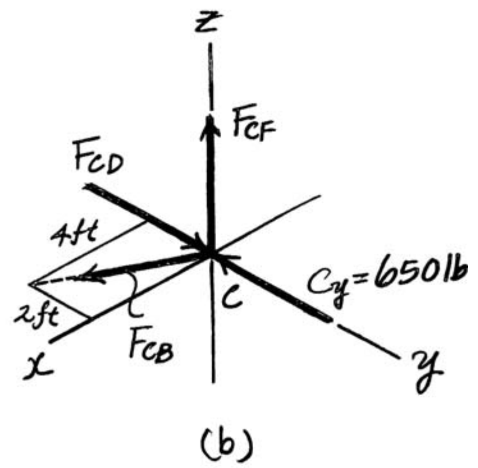
$\Sigma F_z = 0;\quad 700 - 225\left(\frac{4}{6}\right) - F_{DF}\left(\frac{4}{\sqrt{80}}\right) = 0$

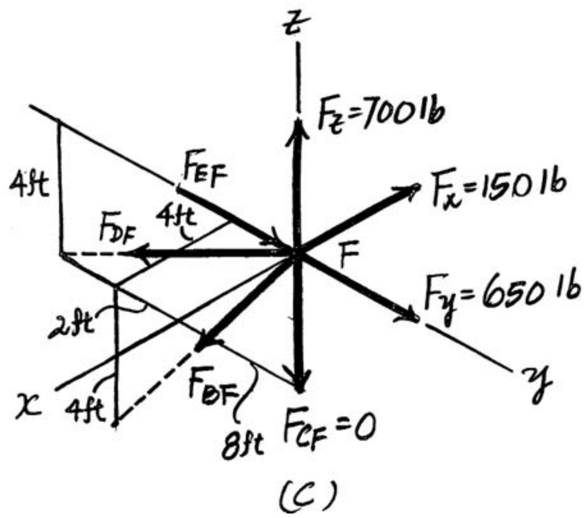
$F_{DF} = 1229.84 \text{ lb} = 1230 \text{ lb (T)}$ **Ans.**

$\Sigma F_y = 0;\quad F_{EF} + 650 - 225\left(\frac{2}{6}\right) - 1229.84\left(\frac{8}{\sqrt{80}}\right) = 0$

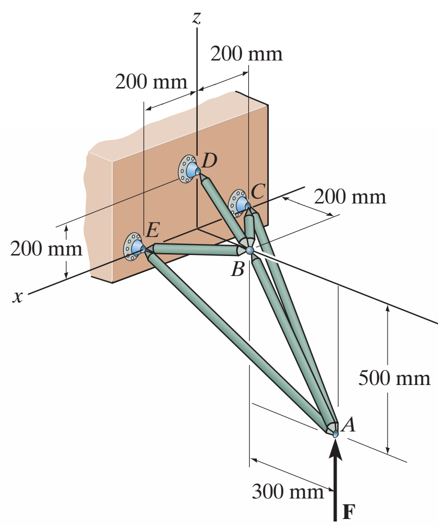
$F_{EF} = 525 \text{ lb (C)}$ **Ans.**


z'
$E_x$
$F_z$
$F_x$
$D_x$
$F_y$
4ft
y'
600 lb
2ft
x'
300 lb
4ft
2ft
4ft
$C_y$
400 lb
(a)


z
$F_{CF}$
$F_{CD}$
4ft
2ft
C
$C_y$ = 650 lb
x
$F_{CB}$
y
(b)


z
$F_z$ = 700 lb
4ft
$F_{EF}$
$F_{DF}$
4ft
$F_x$ = 150 lb
F
$F_y$ = 650 lb
2ft
x
4ft
$F_{BF}$
8ft
$F_{CF}$ = 0
y
(c)

**6–62.** If the truss supports a force of $F = 200$ N, determine the force in each member and state if the members are in tension or compression.




**Method of Joints:** We will begin by analyzing the equilibrium of joint *A*, and then proceed to analyzing that of joint *B*.

**Joint *A*:** From the free-body diagram in Fig. *b*,

$$\Sigma F_x = 0; \quad F_{AE}\left(\frac{0.2}{\sqrt{0.54}}\right) - F_{AC}\left(\frac{0.2}{\sqrt{0.54}}\right) = 0 \qquad (1)$$

$$\Sigma F_y = 0; \quad F_{AB}\left(\frac{0.3}{\sqrt{0.34}}\right) - F_{AE}\left(\frac{0.5}{\sqrt{0.54}}\right) - F_{AC}\left(\frac{0.5}{\sqrt{0.54}}\right) = 0 \qquad (2)$$

$$\Sigma F_z = 0; \quad F_{AC}\left(\frac{0.5}{\sqrt{0.54}}\right) + F_{AE}\left(\frac{0.5}{\sqrt{0.54}}\right) - F_{AB}\left(\frac{0.5}{\sqrt{0.34}}\right) + 200 = 0 \qquad (3)$$

Solving Eqs. (1) through (3) yields

$F_{AE} = F_{AC} = 220.45\text{ N} = 220\text{ N (T)}$ **Ans.**

$F_{AB} = 583.10\text{ N} = 583\text{ N (C)}$ **Ans.**

**Joint *B*:** From the free-body diagram in Fig. *b*,

$$\Sigma F_z = 0; \quad 583.10\left(\frac{0.5}{\sqrt{0.34}}\right) - F_{BD}\sin 45^\circ = 0$$

$F_{BD} = 707.11\text{ N} = 707\text{ N (C)}$ **Ans.**

$$\Sigma F_x = 0; \quad F_{BE}\cos 45^\circ - F_{BC}\cos 45^\circ = 0$$

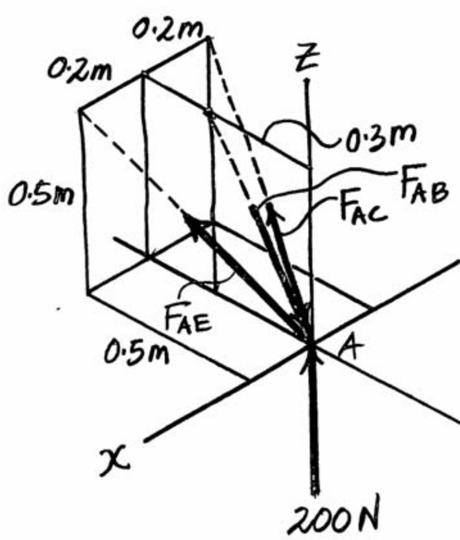
$$F_{BE} = F_{BC} = F$$

$$\Sigma F_y = 0; \quad 707.11\cos 45^\circ - 583.10\left(\frac{0.3}{\sqrt{0.34}}\right) - 2F\sin 45^\circ = 0$$

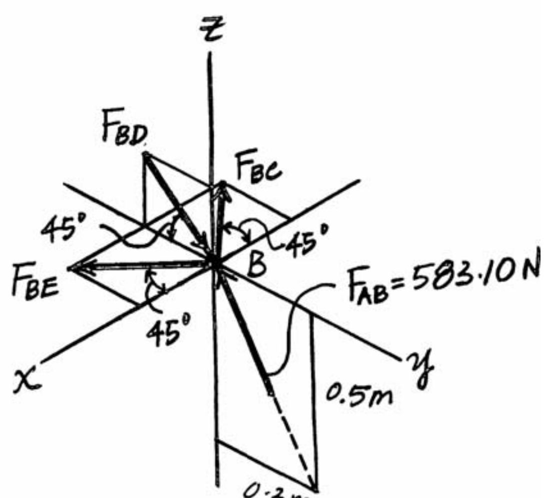
$F = 141.42\text{ N}$ **Ans.**

Thus,

$F_{BE} = F_{BC} = 141.42\text{ N} = 141\text{ N (T)}$ **Ans.**

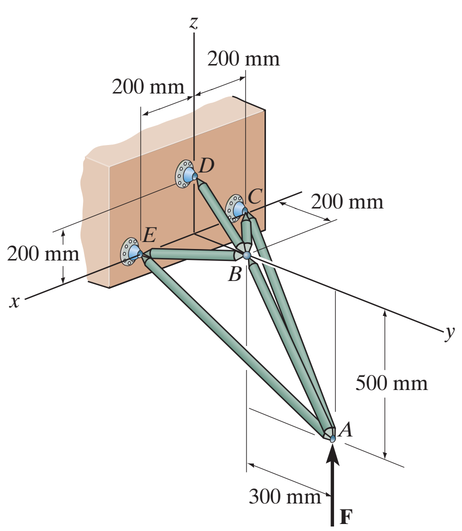


(a)



(b)

**6–63.** If each member of the space truss can support a maximum force of 600 N in compression and 800 N in tension, determine the greatest force $F$ the truss can support.




**Method of Joints:** We will begin by analyzing the equilibrium of joint $A$, and then proceed to analyzing that of joint $B$.

**Joint $A$:** From the free - body diagram in Fig. $b$,

$$\Sigma F_x = 0;\quad F_{AE}\left(\frac{0.2}{\sqrt{0.54}}\right) - F_{AC}\left(\frac{0.2}{\sqrt{0.54}}\right) = 0 \qquad (1)$$

$$\Sigma F_y = 0;\quad F_{AB}\left(\frac{0.3}{\sqrt{0.34}}\right) - F_{AE}\left(\frac{0.5}{\sqrt{0.54}}\right) - F_{AC}\left(\frac{0.5}{\sqrt{0.54}}\right) = 0 \qquad (2)$$

$$\Sigma F_z = 0;\quad F_{AE}\left(\frac{0.5}{\sqrt{0.54}}\right) + F_{AC}\left(\frac{0.5}{\sqrt{0.54}}\right) - F_{AB}\left(\frac{0.5}{\sqrt{0.34}}\right) + F = 0 \qquad (3)$$

Solving Eqs. (1) through (3) yields

$F_{AB} = 2.9155F$ (C)

$F_{AC} = F_{AE} = 1.1023F$ (T)

**Joint $B$:** From the free - body diagram in Fig. $b$,

$$\Sigma F_z = 0;\quad 2.9155F\left(\frac{0.5}{\sqrt{0.34}}\right) - F_{BD}\sin 45° = 0$$

$$F_{BD} = 3.5355F \text{ (C)} \qquad \textbf{Ans.}$$

$$\Sigma F_x = 0;\quad F_{BE}\cos 45° - F_{BC}\cos 45° = 0$$

$$F_{BE} = F_{BC} = F'$$

$$\Sigma F_y = 0;\quad 3.5355F\cos 45° - 2.9155F\left(\frac{0.3}{\sqrt{0.34}}\right) - 2F'\sin 45° = 0$$

$$F' = 0.7071F \qquad \textbf{Ans.}$$

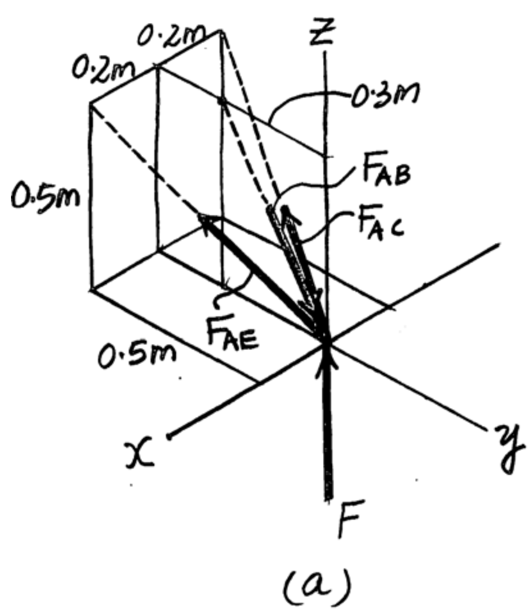
Thus,

$$F_{BE} = F_{BC} = 0.7071F \text{ (T)} \qquad \textbf{Ans.}$$

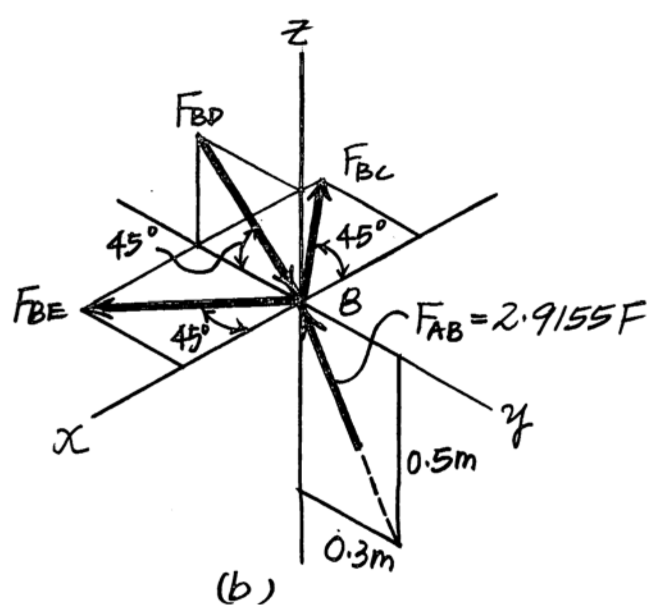
From the above results, the greatest tensile and compressive force developed in the members of the truss are $1.1023F$ and $3.5355F$, respectively. Thus,

$1.1023F = 800 \qquad F = 725.77$ N

$3.5355F = 600 \qquad F = 169.71$ N $= 170$ N (controls) **Ans.**

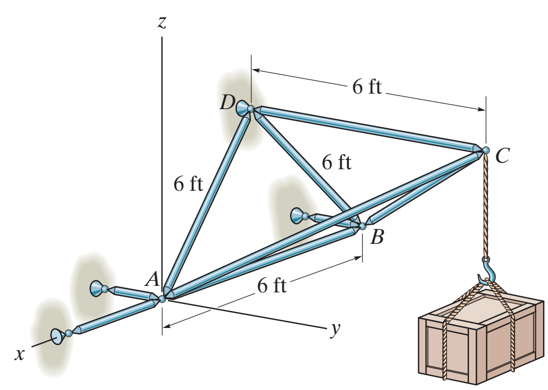


(a)



(b)

***6–64.** Determine the force developed in each member of the space truss and state if the members are in tension or compression. The crate has a weight of 150 lb.




$$\mathbf{F}_{CA} = F_{CA}\left[\frac{-1\mathbf{i} + 2\mathbf{j} + 2\sin 60^\circ\mathbf{k}}{\sqrt{8}}\right]$$

$$= -0.354\,F_{CA}\,\mathbf{i} + 0.707\,F_{CA}\,\mathbf{j} + 0.612\,F_{CA}\,\mathbf{k}$$

$$\mathbf{F}_{CB} = 0.354F_{CB}\,\mathbf{i} + 0.707F_{CB}\,\mathbf{j} + 0.612F_{CB}\,\mathbf{k}$$

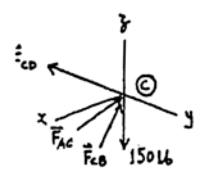
$$\mathbf{F}_{CD} = -F_{CD}\,\mathbf{j}$$

$$\mathbf{W} = -150\,\mathbf{k}$$

$\Sigma F_x = 0;\qquad -0.354F_{CA} + 0.354F_{CB} = 0$

$\Sigma F_y = 0;\qquad 0.707F_{CA} + 0.707F_{CB} - F_{CD} = 0$

$\Sigma F_z = 0;\qquad 0.612F_{CA} + 0.612F_{CB} - 150 = 0$




**Solving :**

$F_{CA} = F_{CB} = 122.5\text{ lb} = 122\text{ lb (C)}$ **Ans**

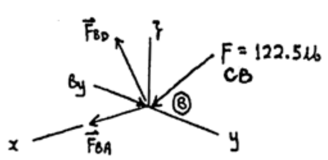
$F_{CD} = 173\text{ lb (T)}$ **Ans**

$$\mathbf{F}_{BA} = F_{BA}\,\mathbf{i}$$

$$\mathbf{F}_{BD} = F_{BD}\cos 60^\circ\mathbf{i} + F_{BD}\sin 60^\circ\,\mathbf{k}$$

$$\mathbf{F}_{CB} = 122.5\,(-0.354\mathbf{i} - 0.707\,\mathbf{j} - 0.612\mathbf{k})$$

$$= -43.3\mathbf{i} - 86.6\mathbf{j} - 75.0\mathbf{k}$$




$\Sigma F_x = 0;\qquad F_{BA} + F_{BD}\cos 60^\circ - 43.3 = 0$

$\Sigma F_z = 0;\qquad F_{BD}\sin 60^\circ - 75 = 0$

**Solving :**

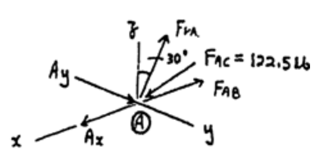
$F_{BD} = 86.6\text{ lb (T)}$ **Ans**

$F_{BA} = 0$ **Ans**

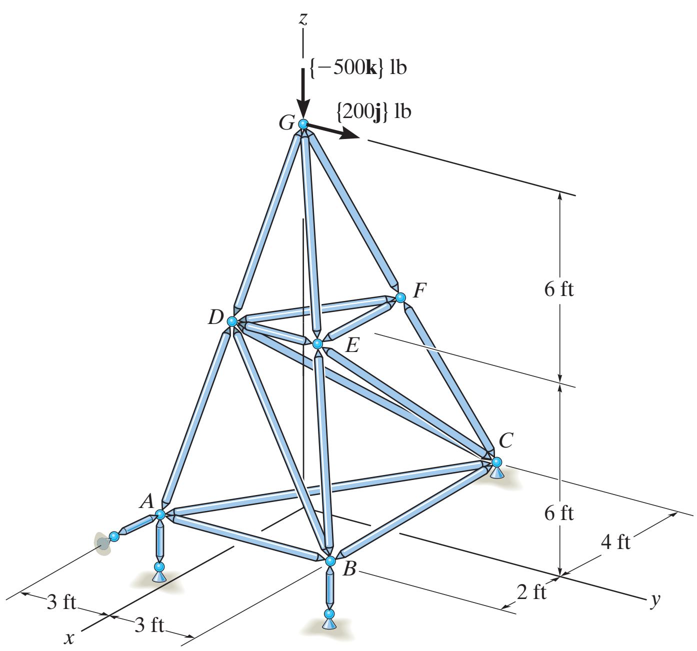
$$\mathbf{F}_{AC} = 122.5(0.354F_{AC}\mathbf{i} - 0.707F_{AC}\mathbf{j} - 0.612F_{AC}\mathbf{k})$$

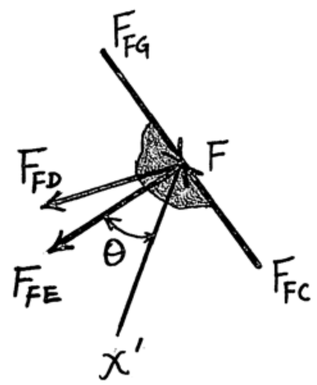
$\Sigma F_z = 0;\qquad F_{DA}\cos 30^\circ - 0.612(122.5) = 0$

$F_{DA} = 86.6\text{ lb (T)}$ **Ans**



**•6–65.** Determine the force in members *FE* and *ED* of the space truss and state if the members are in tension or compression. The truss is supported by a ball-and-socket joint at *C* and short links at *A* and *B*.



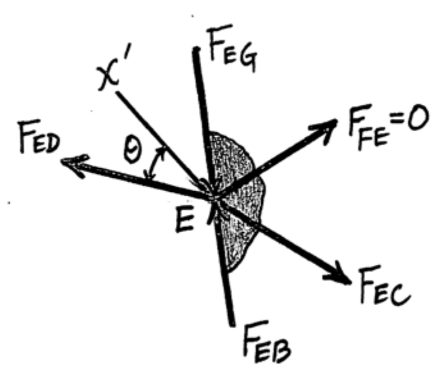




Joint F : $F_{FG}$, $F_{FD}$, and $F_{FC}$ are lying in the same plane and $x'$ axis is normal to that plane. Thus

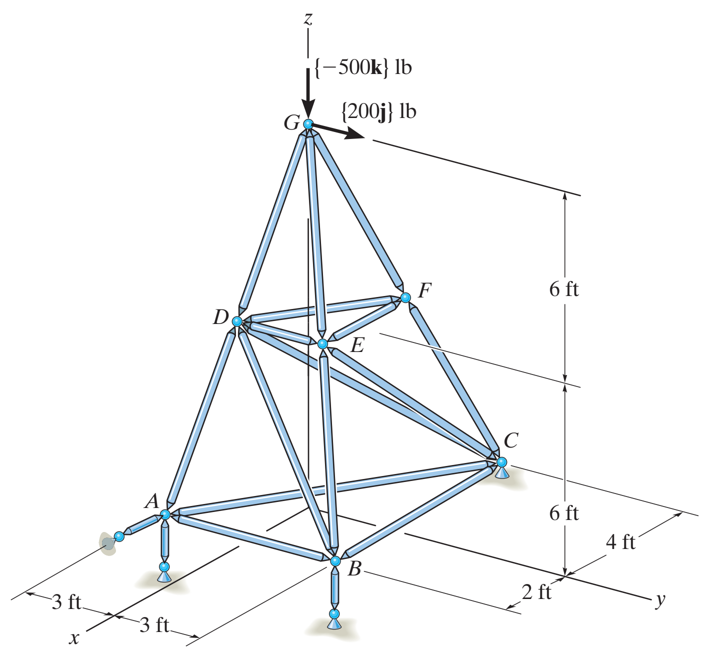
$\Sigma F_{x'} = 0;$ $F_{FE}\cos\theta = 0$ $F_{FE} = 0$ Ans

Joint E : $F_{EG}$, $F_{EC}$, and $F_{EB}$ are lying in the same plane and $x'$ axis is normal to that plane. Thus

$\Sigma F_{x'} = 0;$ $F_{ED}\cos\theta = 0$ $F_{ED} = 0$ Ans



**6–66.** Determine the force in members *GD*, *GE*, and *FD* of the space truss and state if the members are in tension or compression.




Joint $G$:

$$\mathbf{F}_{GD} = F_{GD}\left(-\frac{2}{12.53}\mathbf{i} + \frac{3}{12.53}\mathbf{j} + \frac{12}{12.53}\mathbf{k}\right)$$

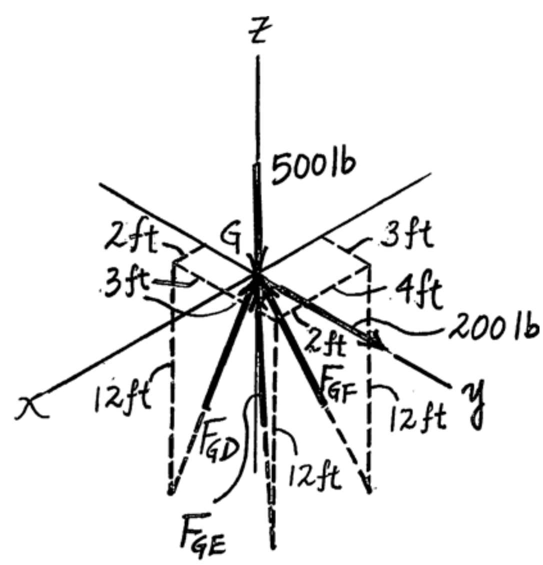
$$\mathbf{F}_{GF} = F_{GF}\left(\frac{4}{13}\mathbf{i} - \frac{3}{13}\mathbf{j} + \frac{12}{13}\mathbf{k}\right)$$

$$\mathbf{F}_{GE} = F_{GE}\left(-\frac{2}{12.53}\mathbf{i} - \frac{3}{12.53}\mathbf{j} + \frac{12}{12.53}\mathbf{k}\right)$$

$$\Sigma F_x = 0; \quad -F_{GD}\left(\frac{2}{12.53}\right) + F_{GF}\left(\frac{4}{13}\right) - F_{GE}\left(\frac{2}{12.53}\right) = 0$$

$$\Sigma F_y = 0; \quad F_{GD}\left(\frac{3}{12.53}\right) - F_{GF}\left(\frac{3}{13}\right) - F_{GE}\left(\frac{3}{12.53}\right) + 200 = 0$$

$$\Sigma F_z = 0; \quad F_{GD}\left(\frac{12}{12.53}\right) + F_{GF}\left(\frac{12}{13}\right) + F_{GE}\left(\frac{12}{12.53}\right) - 500 = 0$$

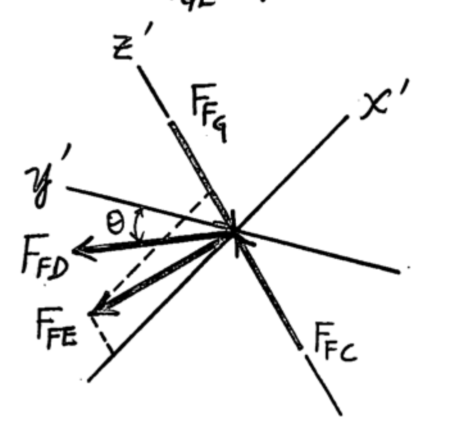



Solving,

$F_{GD} = -157 \text{ lb} = 157 \text{ lb (T)}$ **Ans**

$F_{GF} = 181 \text{ lb (C)}$

$F_{GE} = 505 \text{ lb (C)}$ **Ans**

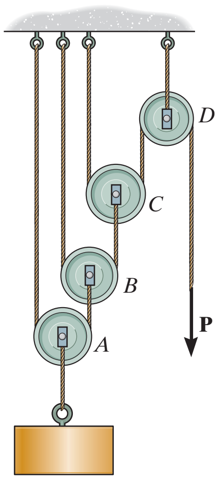



Joint $F$:

Orient the $x'$, $y'$, $z'$ axes as shown.

$\Sigma F_{y'} = 0; \quad F_{FD} = 0$ **Ans**

**6–67.** Determine the force **P** required to hold the 100-lb weight in equilibrium.




**Equations of Equilibrium:** Applying the force equation of equilibrium along the $y$ axis of pulley $A$ on the free-body diagram, Fig. $a$,

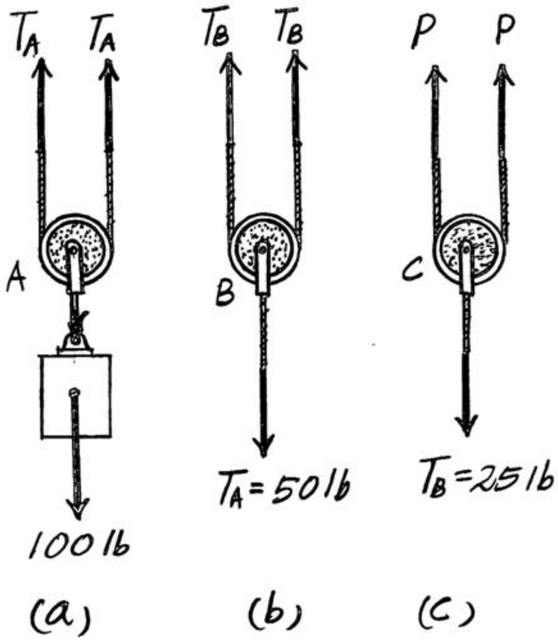
$+\uparrow \Sigma F_y = 0; \qquad 2T_A - 100 = 0 \qquad T_A = 50 \text{ lb}$

Applying $\Sigma F_y = 0$ to the free-body diagram of pulley $B$, Fig. $b$,

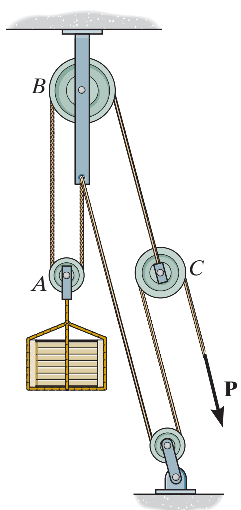
$+\uparrow \Sigma F_y = 0; \qquad 2T_B - 50 = 0 \qquad T_B = 25 \text{ lb}$

From the free-body diagram of pulley $C$, Fig. $c$,

$+\uparrow \Sigma F_y = 0; \qquad 2P - 25 = 0 \qquad P = 12.5 \text{ lb}$ **Ans.**



*6–68. Determine the force **P** required to hold the 150-kg crate in equilibrium.

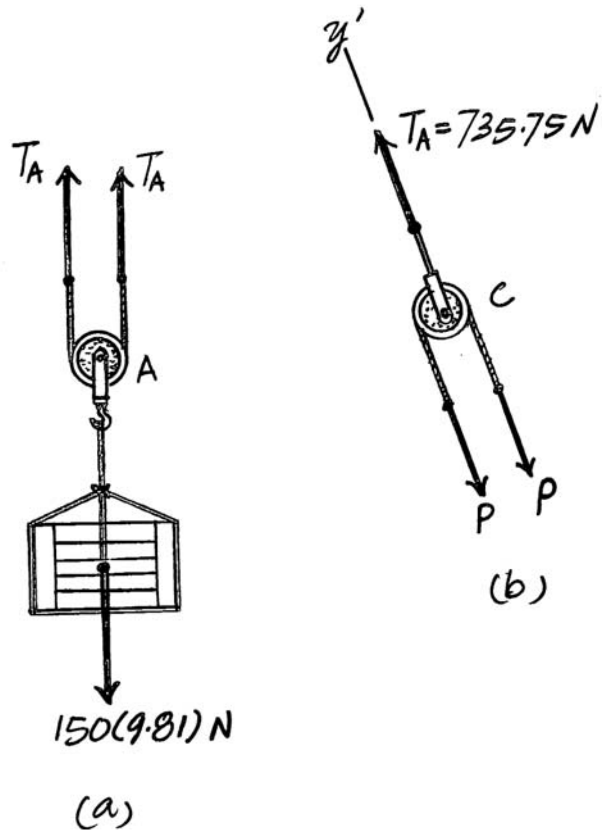



**Equations of Equilibrium:** Applying the force equation of equilibrium along the $y$ axis of pulley $A$ on the free-body diagram, Fig. $a$,

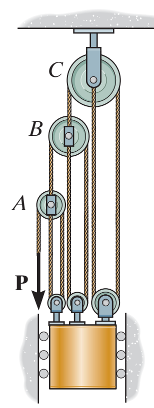
$+\uparrow \Sigma F_y = 0;\qquad 2T_A - 150(9.81) = 0 \quad T_A = 735.75\text{ N}$

Using the above result and writing the force equation of equilibrium along the $y'$ axis of pulley $C$ on the free-body diagram in Fig. $b$,

$\Sigma F_{y'} = 0;\quad 735.75 - 2P = 0 \qquad P = 367.88\text{ N} = 368\text{ N}$ **Ans.**



**•6–69.** Determine the force **P** required to hold the 50-kg mass in equilibrium.




**Equations of Equilibrium:** Applying the force equation of equilibrium along the $y$ axis of each pulley.

$+\uparrow \Sigma F_y = 0; \qquad R - 3P = 0; \qquad R = 3P$

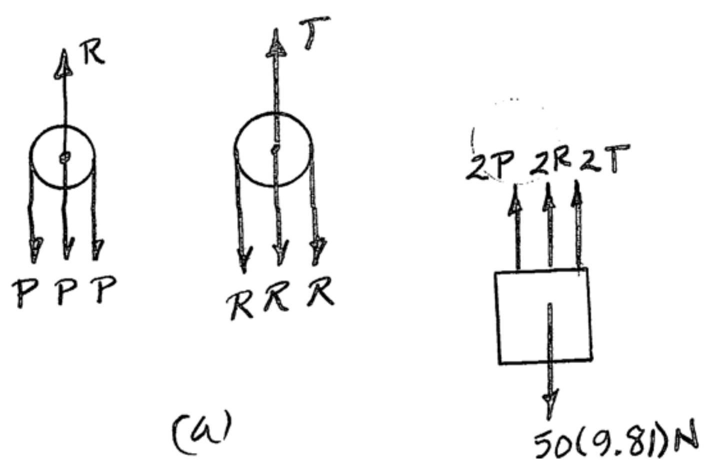
$+\uparrow \Sigma F_y = 0; \qquad T - 3R = 0; \qquad T = 3R = 9P$

$+\uparrow \Sigma F_y = 0; \qquad 2P + 2R + 2T - 50(9.81) = 0$ **Ans.**

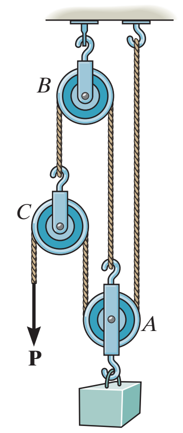
Substituting Eqs.(1) and (2) into Eq.(3) and solving for $P$,

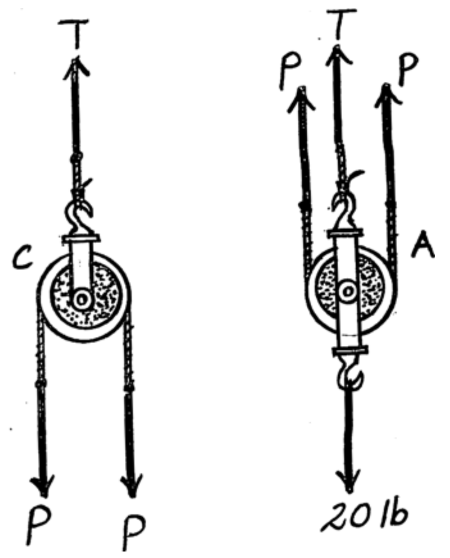
$$2P + 2(3P) + 2(9P) = 50(9.81)$$

$$P = 18.9\,\text{N}$$ **Ans.**



**6–70.** Determine the force **P** needed to hold the 20-lb block in equilibrium.




**Pulley $C$:**

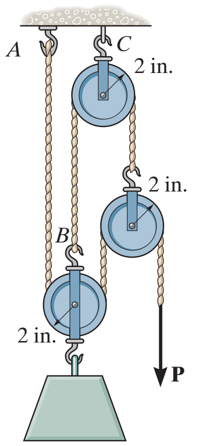
$+\uparrow \Sigma F_y = 0; \quad T - 2P = 0$

**Pulley $A$:**

$+\uparrow \Sigma F_y = 0; \quad 2P + T - 20 = 0$

$P = 5 \text{ lb}$ **Ans**

**6–71.** Determine the force **P** needed to support the 100-lb weight. Each pulley has a weight of 10 lb. Also, what are the cord reactions at $A$ and $B$?




***Equations of Equilibrium :*** From FBD (a),

$$+\uparrow \Sigma F_y = 0; \quad P' - 2P - 10 = 0 \qquad [1]$$

From FBD (b),

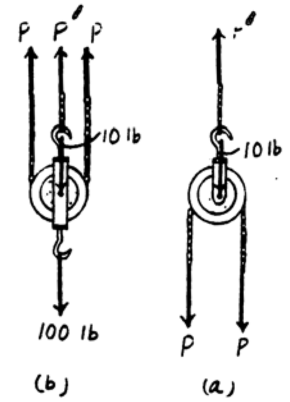
$$+\uparrow \Sigma F_y = 0; \quad 2P + P' - 100 - 10 = 0 \qquad [2]$$

Solving Eqs. [1] and [2] yields,

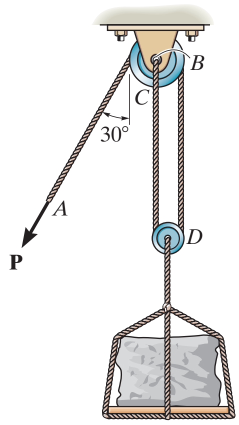
$$P = 25.0 \text{ lb} \qquad \textbf{Ans}$$
$$P' = 60.0 \text{ lb}$$

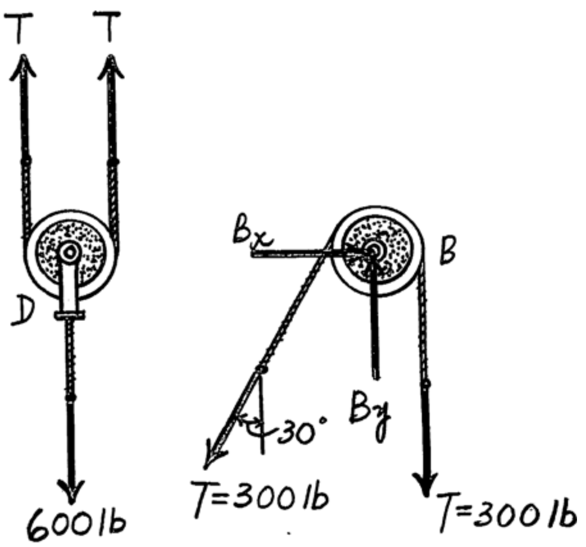
The cord reactions at $A$ and $B$ are

$$F_A = P = 25.0 \text{ lb} \qquad F_B = P' = 60.0 \text{ lb} \qquad \textbf{Ans}$$



***6–72.** The cable and pulleys are used to lift the 600-lb stone. Determine the force that must be exerted on the cable at $A$ and the corresponding magnitude of the resultant force the pulley at $C$ exerts on pin $B$ when the cables are in the position shown.




**Pulley $D$:**

$+\uparrow \Sigma F_y = 0;\quad 2T - 600 = 0$

$T = 300\text{ lb}$ **Ans**

**Pulley $B$:**

$\xrightarrow{+} \Sigma F_x = 0;\quad B_x - 300 \sin 30^\circ = 0$

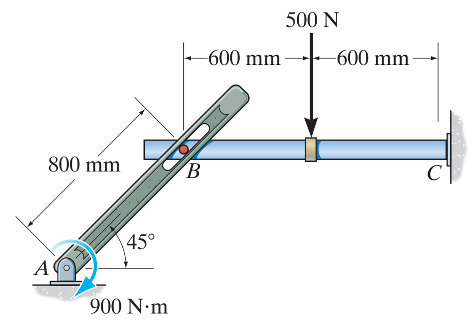
$B_x = 150\text{ lb}$

$+\uparrow \Sigma F_y = 0;\quad B_y - 300 - 300 \cos 30^\circ = 0$

$B_y = 559.8\text{ lb}$

$F_B = \sqrt{(150)^2 + (559.8)^2} = 580\text{ lb}$ **Ans**

**•6–73.** If the peg at $B$ is smooth, determine the components of reaction at the pin $A$ and fixed support $C$.




**Equations of Equilibrium:** From the free-body diagram of member $AB$, Fig. $a$,

$\curvearrowleft + \Sigma M_A = 0;\quad N_B(0.8) - 900 = 0 \qquad N_B = 1125\text{ N}$

$\xrightarrow{+} \Sigma F_x = 0;\quad A_x - 1125\cos 45° = 0 \qquad A_x = 795.50\text{ N} = 795\text{ N}$ **Ans.**

$+\uparrow \Sigma F_y = 0;\quad 1125\sin 45° - A_y = 0 \qquad A_y = 795.50\text{ N} = 795\text{ N}$ **Ans.**

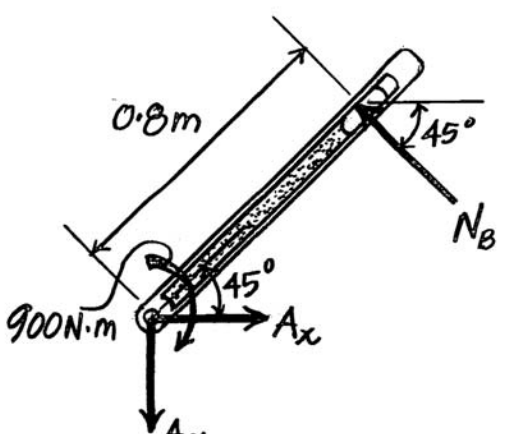
Applying the equations of equilibrium to the free-body diagram of member $BC$, Fig. $b$,

$\xrightarrow{+} \Sigma F_x = 0;\quad 1125\cos 45° - C_x = 0 \qquad C_x = 795.50\text{ N} = 795\text{ N}$ **Ans.**

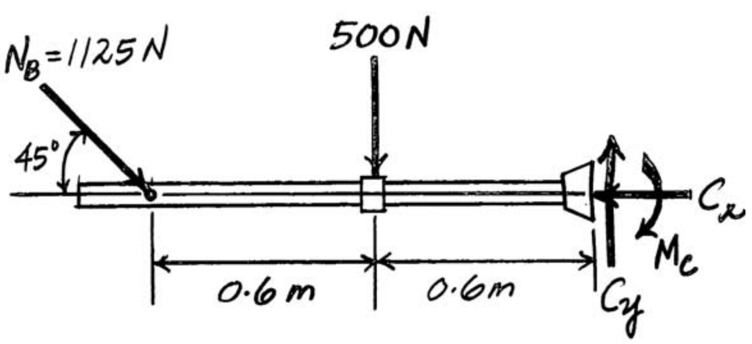
$+\uparrow \Sigma F_y = 0;\quad C_y - 1125\sin 45° - 500 = 0 \qquad C_y = 1295.50\text{ N} = 1.30\text{ kN}$ **Ans.**

$\curvearrowleft + \Sigma M_C = 0;\quad 1125\sin 45°(1.2) + 500(0.6) - M_C = 0$

$M_C = 1254.59\text{ N}\cdot\text{m} = 1.25\text{ kN}\cdot\text{m}$ **Ans.**

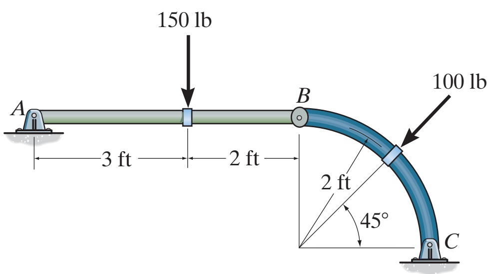



(a)




(b)

**6–74.** Determine the horizontal and vertical components of reaction at pins *A* and *C*.




**Equations of Equilibrium:** From the free-body diagram of member *AB* in Fig. *a*, we have

$\circlearrowleft + \Sigma M_A = 0;$ $\quad B_y(5) - 150(3) = 0 \quad B_y = 90 \text{ lb}$

$\circlearrowleft + \Sigma M_B = 0;$ $\quad 150(2) - A_y(5) = 0 \quad A_y = 60 \text{ lb}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad A_x - B_x = 0$ (1)

From the free-body diagram of the member *BC* in Fig. *b* and using the result for $B_y$, we can write

$\circlearrowleft + \Sigma M_C = 0;$ $\quad 90(2) + 100 \sin 45°(2) - B_x(2) = 0$

$B_x = 160.71 \text{ lb}$

$+\uparrow \Sigma F_y = 0;$ $\quad C_y - 90 - 100 \sin 45° = 0$

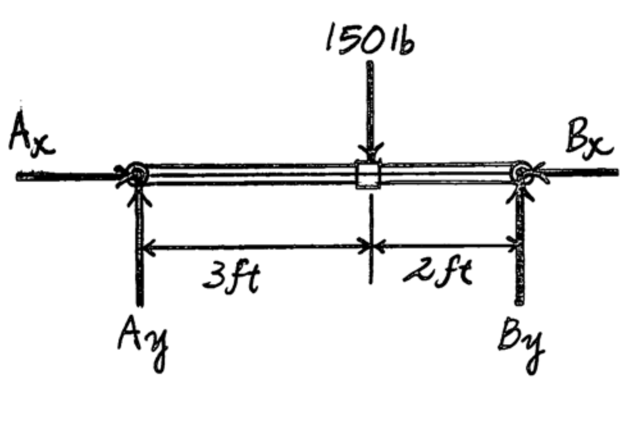
$C_y = 160.71 \text{ lb} = 161 \text{ lb}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad 160.71 - 100 \cos 45° - C_x = 0$

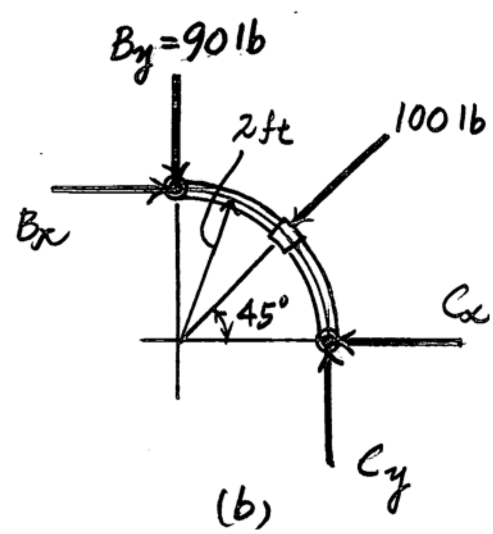
$C_x = 90 \text{ lb}$ **Ans.**

Substituting $B_x = 160.71$ lb into Eq. (1) yields

$A_x = 160.71 \text{ lb} = 161 \text{ lb}$ **Ans.**

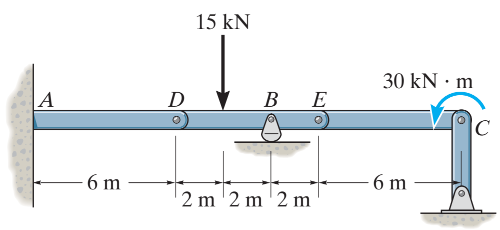



(a)




(b)

**6–75.** The compound beam is fixed at $A$ and supported by rockers at $B$ and $C$. There are hinges (pins) at $D$ and $E$. Determine the components of reaction at the supports.




***Equations of Equilibrium :*** **From FBD(a),**

$\circlearrowleft + \Sigma M_E = 0;\quad 30 - C_y(6) = 0 \qquad C_y = 5.00 \text{ kN}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad E_y - 5.00 = 0 \qquad E_y = 5.00 \text{ kN}$

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

**From FBD(b),**

$\circlearrowleft + \Sigma M_D = 0;\quad B_y(4) - 15(2) - 5.00(6) = 0$
$B_y = 15.0 \text{ kN}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad D_y + 15.0 - 15 - 5.00 = 0$
$D_y = 5.00 \text{ kN}$

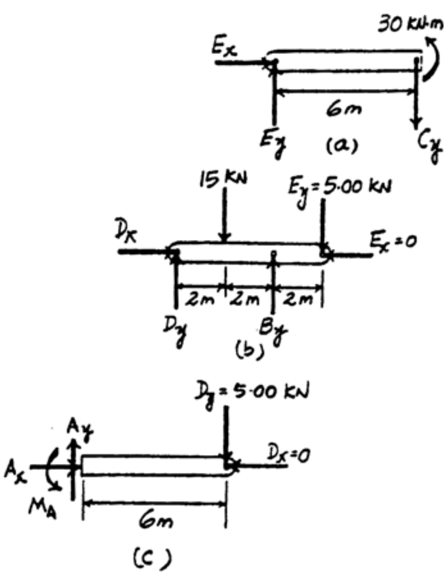
$\xrightarrow{+} \Sigma F_x = 0;\quad D_x = 0$

**From FBD(c),**

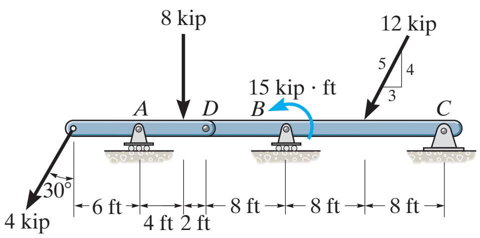
$\circlearrowleft + \Sigma M_A = 0;\quad M_A - 5.00(6) = 0$
$M_A = 30.0 \text{ kN} \cdot \text{m}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad A_y - 5.00 = 0 \qquad A_y = 5.00 \text{ kN}$ **Ans**

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



*6–76. The compound beam is pin-supported at $C$ and supported by rollers at $A$ and $B$. There is a hinge (pin) at $D$. Determine the components of reaction at the supports. Neglect the thickness of the beam.




***Equations of Equilibrium :*** From FBD(a),

$$\curvearrowleft + \Sigma M_D = 0; \quad 4\cos 30°(12) + 8(2) - A_y(6) = 0$$
$$A_y = 9.595 \text{ kip} = 9.59 \text{ kip} \qquad \textbf{Ans}$$

$$+\uparrow \Sigma F_y = 0; \quad D_y + 9.595 - 4\cos 30° - 8 = 0$$
$$D_y = 1.869 \text{ kip}$$

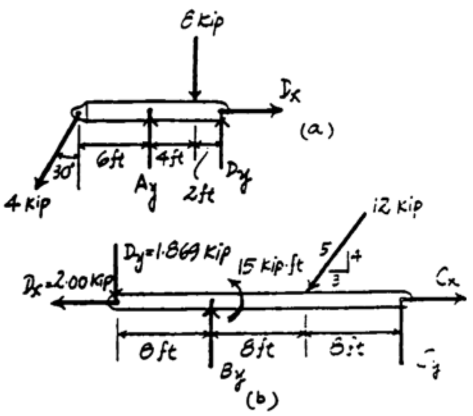
$$\xrightarrow{+} \Sigma F_x = 0; \quad D_x - 4\sin 30° = 0 \qquad D_x = 2.00 \text{ kip}$$

From FBD(b),

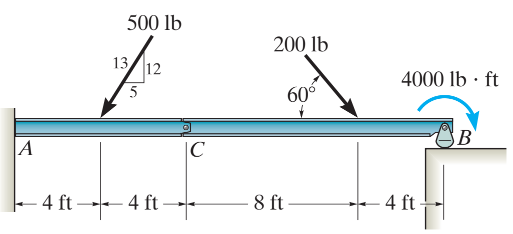
$$\curvearrowleft + \Sigma M_C = 0; \quad 1.869(24) + 15 + 12\left(\frac{4}{5}\right)(8) - B_y(16) = 0$$
$$B_y = 8.541 \text{ kip} = 8.54 \text{ kip} \qquad \textbf{Ans}$$

$$+\uparrow \Sigma F_y = 0; \quad C_y + 8.541 - 1.869 - 12\left(\frac{4}{5}\right) = 0$$
$$C_y = 2.93 \text{ kip} \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad C_x - 2.00 - 12\left(\frac{3}{5}\right) = 0$$
$$C_x = 9.20 \text{ kip} \qquad \textbf{Ans}$$



**•6–77.** The compound beam is supported by a rocker at $B$ and is fixed to the wall at $A$. If it is hinged (pinned) together at $C$, determine the components of reaction at the supports. Neglect the thickness of the beam.




**Member *CB*:**

$\xrightarrow{+} \Sigma F_x = 0;\quad -C_x + 200\cos 60° = 0$

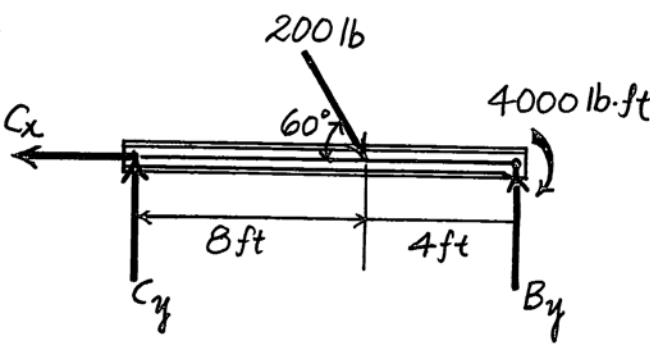
$C_x = 100 \text{ lb}$

$\circlearrowleft + \Sigma M_C = 0;\quad -200\sin 60°(8) + B_y(12) - 4000 = 0$

$B_y = 448.8 \text{ lb} = 449 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad C_y - 200\sin 60° + 448.8 = 0$

$C_y = -275.6 \text{ lb}$




**Member *AC*:**

$\xrightarrow{+} \Sigma F_x = 0;\quad A_x - 500\left(\frac{5}{13}\right) + 100 = 0$

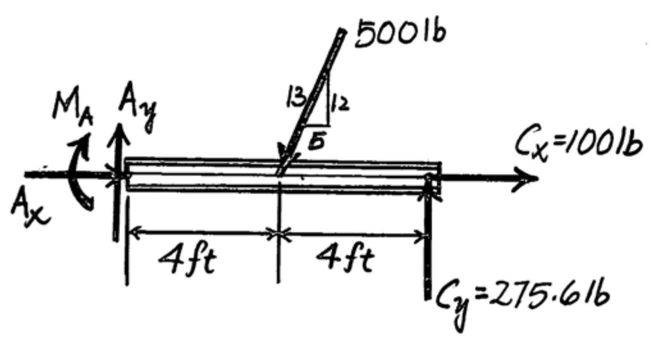
$A_x = 92.3 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad A_y - 500\left(\frac{12}{13}\right) + 275.6 = 0$

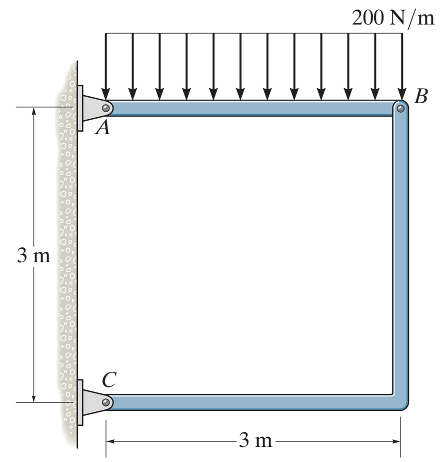
$A_y = 186 \text{ lb}$ **Ans**

$\circlearrowleft + \Sigma M_A = 0;\quad -M_A - 500\left(\frac{12}{13}\right)(4) + 275.6(8) = 0$

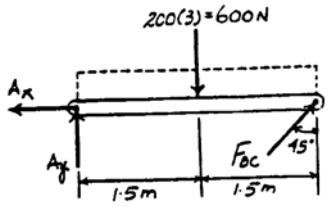
$M_A = 359 \text{ lb} \cdot \text{ft}$ **Ans**



**6–78.** Determine the horizontal and vertical components of reaction at pins $A$ and $C$ of the two-member frame.




***Free Body Diagram :*** The solution for this problem will be simplified if one realizes that member $BC$ is a two force member.




***Equations of Equilibrium :***

$\circlearrowleft + \Sigma M_A = 0;\quad F_{BC}\cos 45°(3) - 600(1.5) = 0$

$F_{BC} = 424.26\text{ N}$

$+\uparrow \Sigma F_y = 0;\quad A_y + 424.26\cos 45° - 600 = 0$

$A_y = 300\text{ N}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad 424.26\sin 45° - A_x = 0$

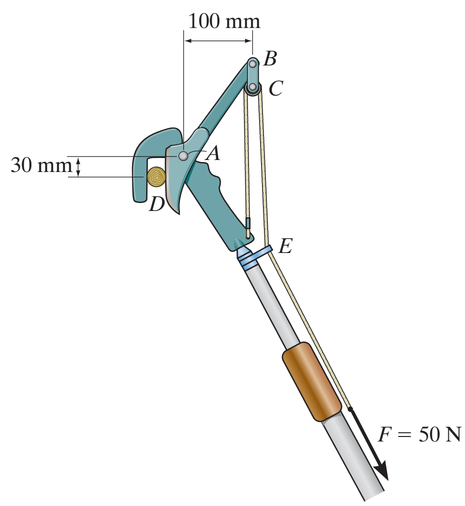
$A_x = 300\text{ N}$ **Ans**

For pin $C$,

$C_x = F_{BC}\sin 45° = 424.26\sin 45° = 300\text{ N}$ **Ans**

$C_y = F_{BC}\cos 45° = 424.26\cos 45° = 300\text{ N}$ **Ans**

**6–79.** If a force of $F = 50$ N acts on the rope, determine the cutting force on the smooth tree limb at $D$ and the horizontal and vertical components of force acting on pin $A$. The rope passes through a small pulley at $C$ and a smooth ring at $E$.




**Equations of Equilibrium:** From the free - body diagram of pulley $C$ in Fig. $a$,

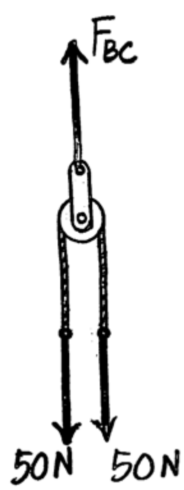
$+\uparrow \Sigma F_y = 0;\quad F_{BC} - 50 - 50 = 0 \qquad F_{BC} = 100\text{ N}$

From the free - body diagram of segment $BAD$ in Fig. $b$ and using the result $F_{BC} = 100$ N,

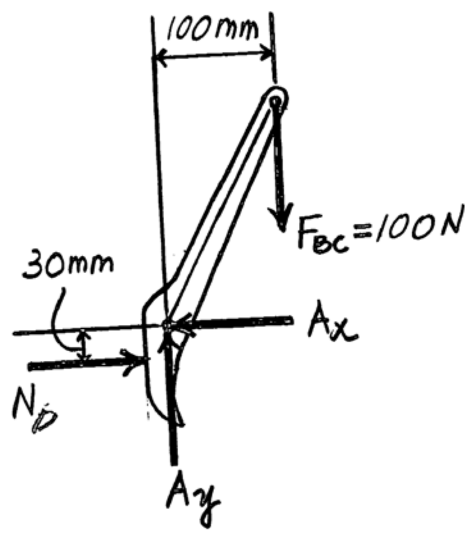
$\circlearrowleft + \Sigma M_A = 0;\quad N_D(30) - 100(100) = 0 \qquad N_D = 333.33\text{ N} = 333\text{ N}$ **Ans.**

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad 333.33 - A_x = 0 \qquad A_x = 333.33\text{ N} = 333\text{ N}$ **Ans.**

$+\uparrow \Sigma F_y = 0;\quad A_y - 100 = 0 \qquad A_y = 100\text{ N}$ **Ans.**

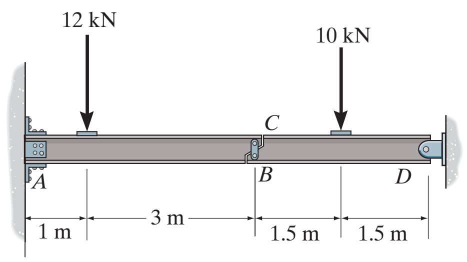



(a)




(b)

***6–80.** Two beams are connected together by the short link $BC$. Determine the components of reaction at the fixed support $A$ and at pin $D$.




**Equations of Equilibrium:** First, we will consider the free-body diagram of member $BD$ in Fig. $a$.

$\curvearrowleft +\Sigma M_D = 0;\quad 10(1.5) - F_{BC}(3) = 0$

$F_{BC} = 5\text{ kN}$

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

$\curvearrowleft +\Sigma M_B = 0;\quad D_y(3) - 10(1.5) = 0$

$D_y = 5\text{ kN}$ **Ans.**

Subsequently, the free-body diagram of member $AC$ in Fig. $b$ will be considered using the result $F_{BC} = 5\text{ kN}$.

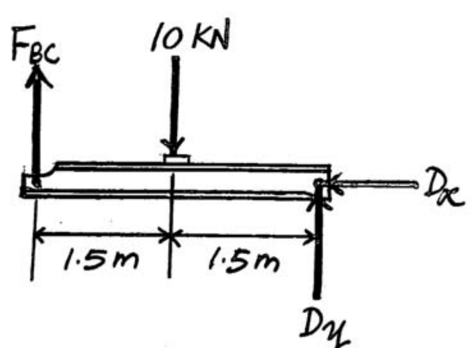
$\xrightarrow{+} \Sigma F_x = 0;\quad A_x = 0$ **Ans.**

$+\uparrow \Sigma F_y = 0;\quad A_y - 12 - 5 = 0$

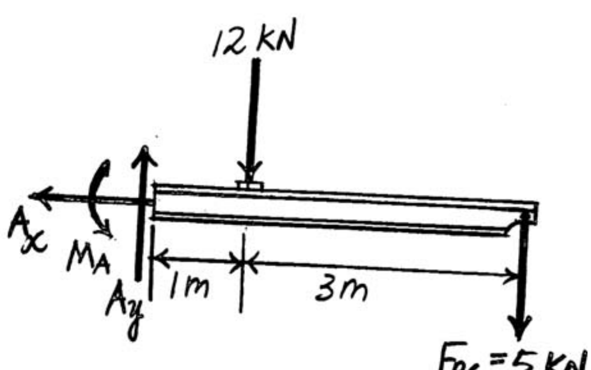
$A_y = 17\text{ kN}$ **Ans.**

$\curvearrowleft +\Sigma M_A = 0;\quad M_A - 12(1) - 5(4) = 0$

$M_A = 32\text{ kN}\cdot\text{m}$ **Ans.**

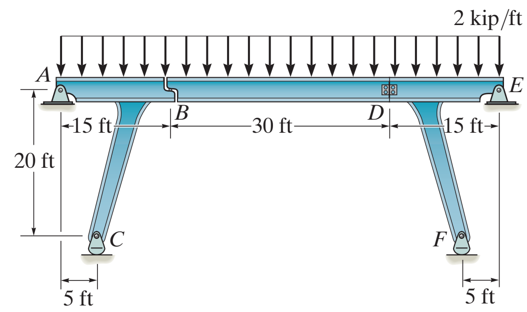


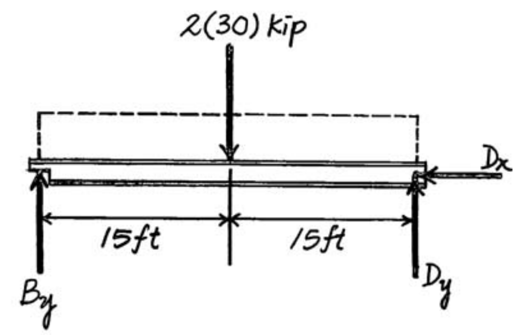

(a)

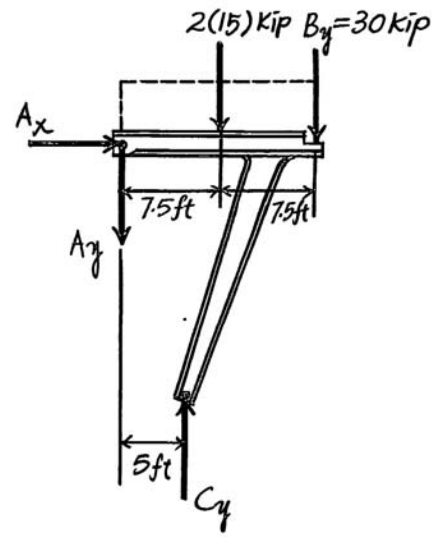



(b)

**•6–81.** The bridge frame consists of three segments which can be considered pinned at $A$, $D$, and $E$, rocker supported at $C$ and $F$, and roller supported at $B$. Determine the horizontal and vertical components of reaction at all these supports due to the loading shown.




For segment $BD$:

$\circlearrowleft +\Sigma M_D = 0;\quad 2(30)(15) - B_y(30) = 0\quad B_y = 30$ kip **Ans**

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

$+\uparrow \Sigma F_y = 0;\quad D_y + 30 - 2(30) = 0\quad D_y = 30$ kip **Ans**

For segment $ABC$:

$\circlearrowleft +\Sigma M_A = 0;\quad C_y(5) - 2(15)(7.5) - 30(15) = 0\quad C_y = 135$ kip **Ans**

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

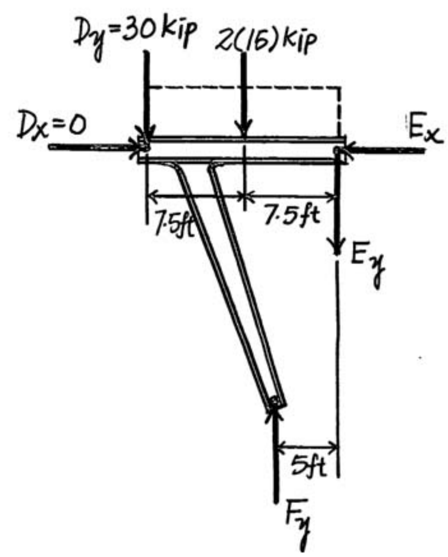
$+\uparrow \Sigma F_y = 0;\quad -A_y + 135 - 2(15) - 30 = 0\quad A_y = 75$ kip **Ans**

For segment $DEF$:

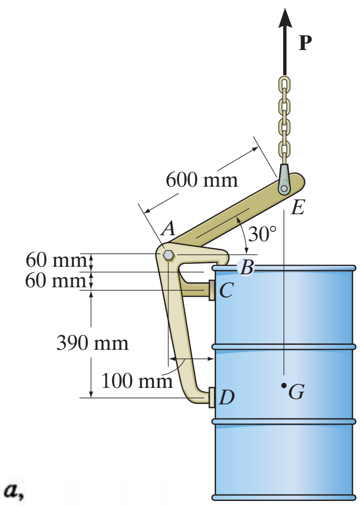
$\circlearrowleft +\Sigma M_E = 0;\quad -F_y(5) + 2(15)(7.5) + 30(15) = 0\quad F_y = 135$ kip **Ans**

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

$+\uparrow \Sigma F_y = 0;\quad -E_y + 135 - 2(15) - 30 = 0\quad E_y = 75$ kip **Ans**



**6–82.** If the 300-kg drum has a center of mass at point $G$, determine the horizontal and vertical components of force acting at pin $A$ and the reactions on the smooth pads $C$ and $D$. The grip at $B$ on member $DAB$ resists both horizontal and vertical components of force at the rim of the drum.




**Equations of Equilibrium:** From the free - body diagram of segment $CAE$ in Fig. $a$,

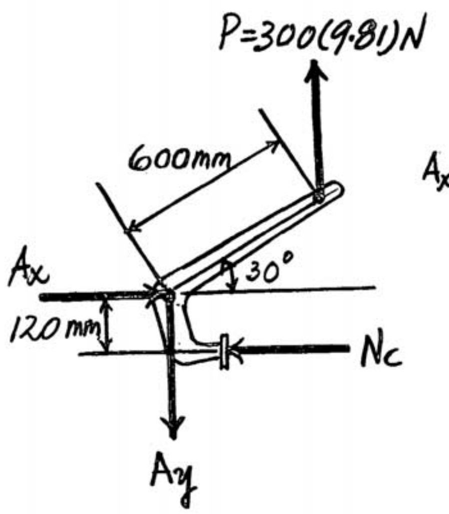
$$\circlearrowleft +\Sigma M_A = 0; \qquad 300(9.81)(600\cos 30°) - N_C(120) = 0$$
$$N_C = 12\,743.56\text{ N} = 12.7\text{ kN} \qquad \textbf{Ans.}$$

$$\overset{+}{\rightarrow}\Sigma F_x = 0; \qquad A_x - 12\,743.56 = 0$$
$$A_x = 12\,743.56\text{ N} = 12.7\text{ kN} \qquad \textbf{Ans.}$$

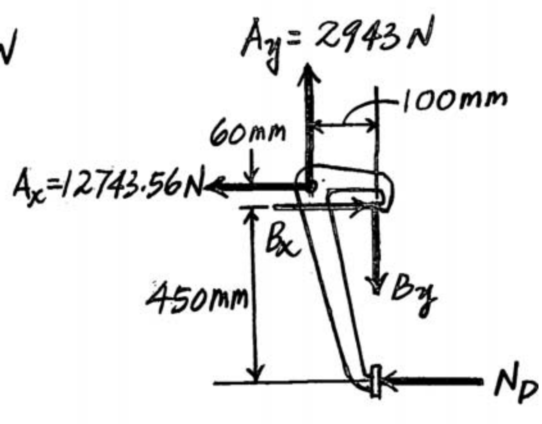
$$+\uparrow \Sigma F_y = 0; \qquad 300(9.81) - A_y = 0$$
$$A_y = 2943\text{ N} = 2.94\text{ kN} \qquad \textbf{Ans.}$$

Using the results for $A_x$ and $A_y$ obtained above and applying the moment equation of equilibrium about point $B$ on the free- body diagram of segment $BAD$, Fig. $b$,

$$\circlearrowleft +\Sigma M_B = 0; \qquad 12\,743.56(60) - 2943(100) - N_D(450) = 0$$
$$N_D = 1045.14\text{ N} = 1.05\text{ kN} \qquad \textbf{Ans.}$$

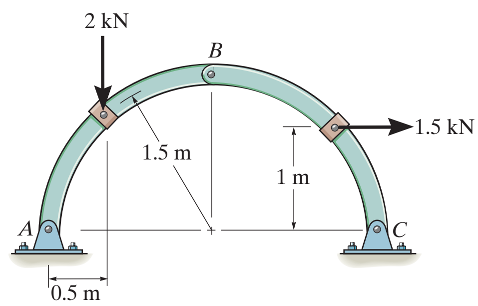



(a)




(b)

**6–83.** Determine the horizontal and vertical components of reaction that pins $A$ and $C$ exert on the two-member arch.




Member $AB$:

$\circlearrowleft + \Sigma M_A = 0; \quad -2(0.5) + B_y(1.5) - B_x(1.5) = 0$

Member $BC$:

$\circlearrowleft + \Sigma M_C = 0; \quad B_y(1.5) + B_x(1.5) - 1.5(1) = 0$

Solving:

$B_y = 0.8333\text{ kN} = 833\text{ N}$

$B_x = 0.1667\text{ kN} = 167\text{ N}$

Member $AB$:

$\xrightarrow{+} \Sigma F_x = 0; \quad -A_x + 167 = 0$

$A_x = 167\text{ N}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad A_y - 2000 + 833 = 0$

$A_y = 1.17\text{ kN}$ **Ans**

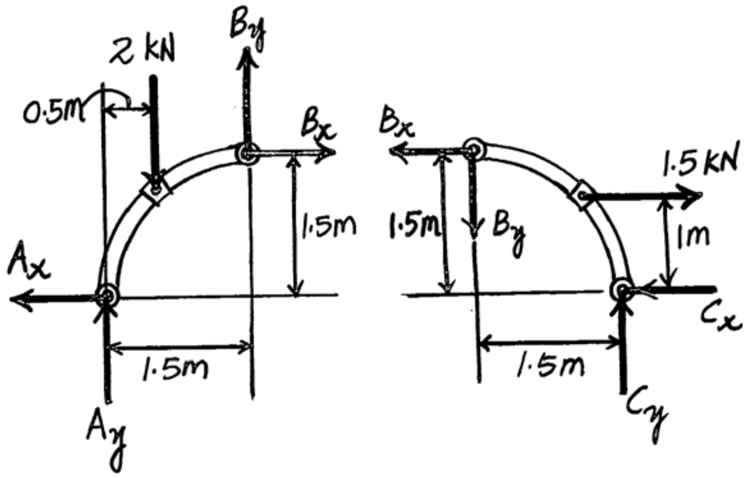
Member $BC$:

$\xrightarrow{+} \Sigma F_x = 0; \quad -C_x + 1500 - 167 = 0$

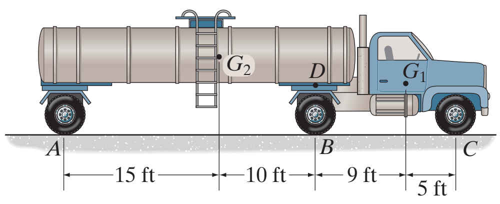
$C_x = 1.33\text{ kN}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad C_y - 833 = 0$

$C_y = 833\text{ N}$ **Ans**



*__6–84.__ The truck and the tanker have weights of 8000 lb and 20 000 lb respectively. Their respective centers of gravity are located at points $G_1$ and $G_2$. If the truck is at rest, determine the reactions on both wheels at $A$, at $B$, and at $C$. The tanker is connected to the truck at the turntable $D$ which acts as a pin.




**Equations of Equilibrium:** First, we will consider the free-body diagram of the tanker in Fig. *a*.

$\circlearrowleft +\Sigma M_D = 0;$ $\quad 20\,000(10) - N_A(25) = 0$

$N_A = 8000 \text{ lb}$ **Ans.**

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

$+\uparrow \Sigma F_y = 0;$ $\quad D_y + 8000 - 20\,000 = 0$

$D_y = 12\,000 \text{ lb}$

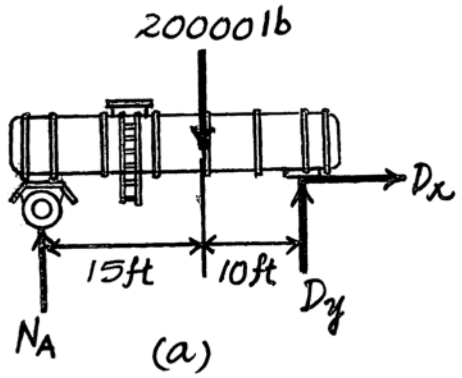
Using the results of $D_x$ and $D_y$ obtained above and considering the free-body diagram of the truck in Fig. *b*,

$\circlearrowleft +\Sigma M_D = 0;$ $\quad N_C(14) - 8000(9) = 0$

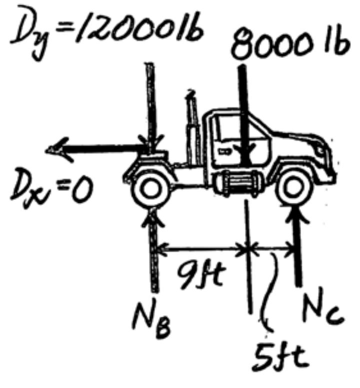
$N_C = 5142.86 \text{ lb} = 5143 \text{ lb}$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad N_B + 5142.86 - 8000 - 12000 = 0$

$N_B = 14\,857.14 \text{ lb} = 14\,857 \text{ lb}$ **Ans.**

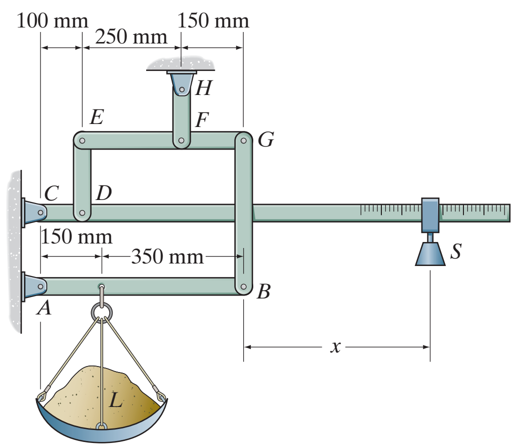


(a)



(b)

**•6–85.** The platform scale consists of a combination of third and first class levers so that the load on one lever becomes the effort that moves the next lever. Through this arrangement, a small weight can balance a massive object. If $x = 450$ mm, determine the required mass of the counterweight $S$ required to balance a 90-kg load, $L$.




**Equations of Equilibrium:** Applying the moment equation of equilibrium about point $A$ to the free - body diagram of member $AB$ in Fig. $a$,

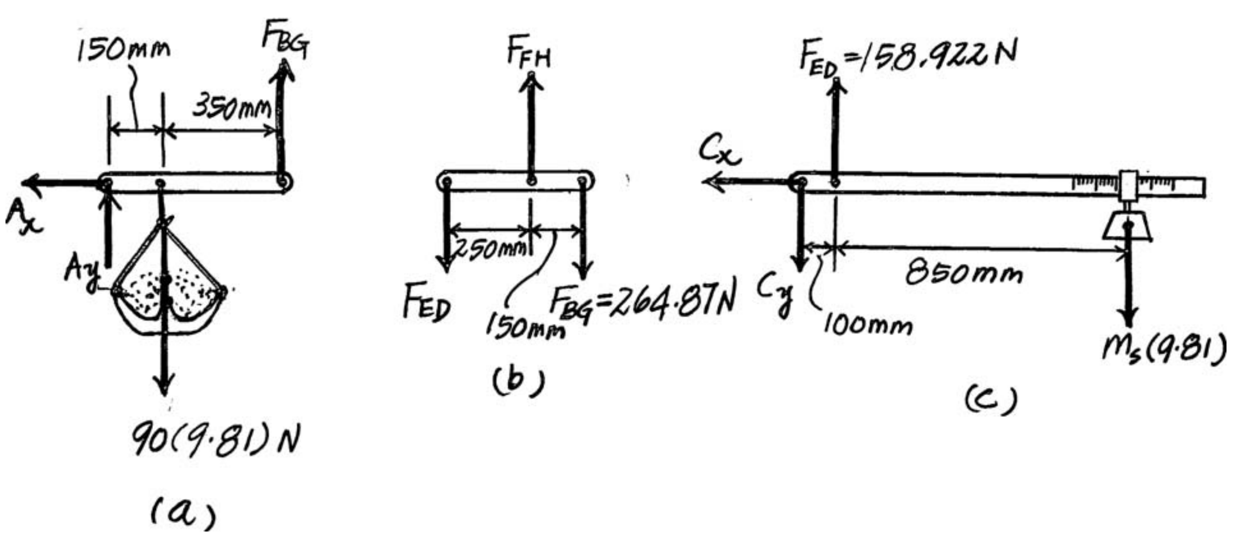
$$\circlearrowleft + \Sigma M_A = 0; \qquad F_{BG}(500) - 90(9.81)(150) = 0$$
$$F_{BG} = 264.87 \text{ N}$$

Using the result of $F_{BG}$ and writing the moment equation of equilibrium about point $F$ on the free- body diagram of member $EFG$ in Fig. $b$,

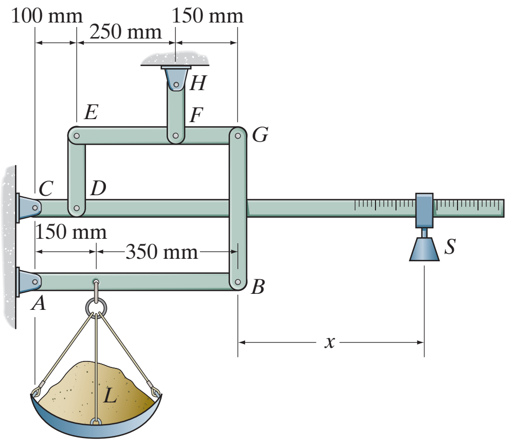
$$\circlearrowleft + \Sigma M_F = 0; \qquad F_{ED}(250) - 264.87(150) = 0$$
$$F_{ED} = 158.922 \text{ N}$$

Using the result of $F_{ED}$ and writing the moment equation of equilibrium about point $C$ on the free - body diagram of member $CDI$ in Fig. $c$,

$$\circlearrowleft + \Sigma M_C = 0; \qquad 158.922(100) - m_s(9.81)(950) = 0$$
$$m_s = 1.705 \text{ kg} = 1.71 \text{ kg} \qquad \textbf{Ans.}$$



**6–86.** The platform scale consists of a combination of third and first class levers so that the load on one lever becomes the effort that moves the next lever. Through this arrangement, a small weight can balance a massive object. If $x = 450$ mm and, the mass of the counterweight $S$ is 2 kg, determine the mass of the load $L$ required to maintain the balance.




**Equations of Equilibrium:** Applying the moment equation of equilibrium about point $A$ to the free - body diagram of member $AB$ in Fig. $a$,

$\circlearrowleft + \Sigma M_A = 0;$ $\quad F_{BG}(500) - M_L(9.81)(150) = 0$

$F_{BG} = 2.943$ lb

Using the result of $F_{BG}$ and writing the moment equation of equilibrium about point $F$ on the free - body diagram of member $EFG$ in Fig. $b$,

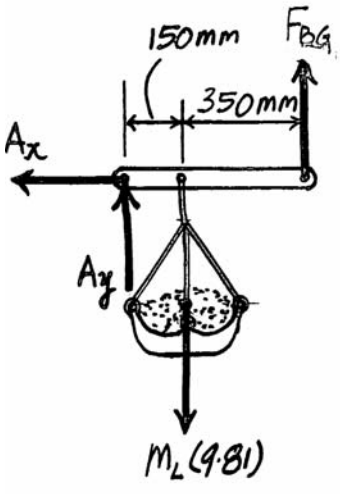
$\circlearrowleft + \Sigma M_F = 0;$ $\quad F_{ED}(250) - 2.943m_L(150) = 0$

$F_{ED} = 1.7658m_L$

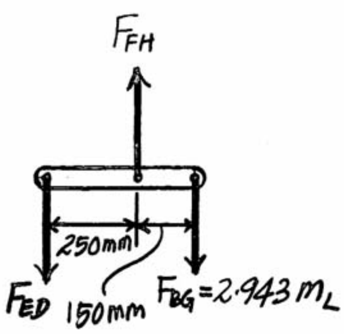
Using the result of $F_{ED}$ and writing the moment equation of equilibrium about point $C$ on the free - body diagram of member $CDI$ in Fig. $c$,

$\circlearrowleft + \Sigma M_C = 0;$ $\quad 1.7658m_L(100) - 2(9.81)(950) = 0$

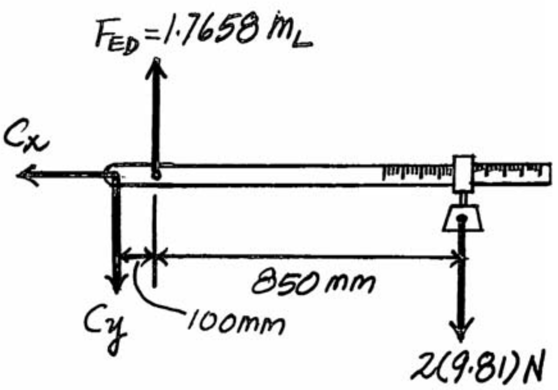
$m_L = 105.56$ kg $= 106$ kg **Ans.**




(a)

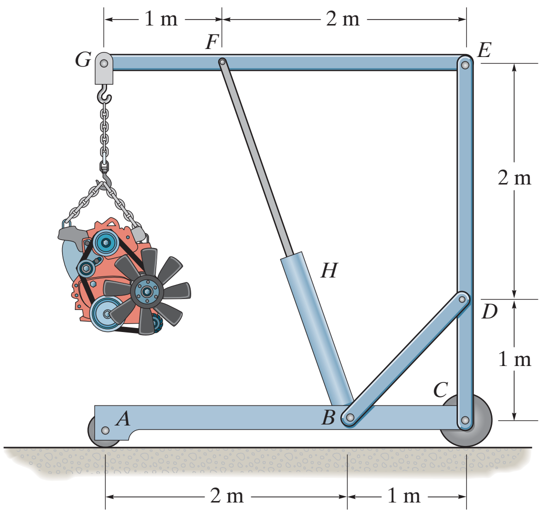



(b)




(C)

**6–87.** The hoist supports the 125-kg engine. Determine the force the load creates in member $DB$ and in member $FB$, which contains the hydraulic cylinder $H$.




***Free Body Diagram :*** The solution for this problem will be simplified if one realizes that members $FB$ and $DB$ are two-force members.

***Equations of Equilibrium :*** For FBD(a),

$$\circlearrowleft + \Sigma M_E = 0; \quad 1226.25(3) - F_{FB}\left(\frac{3}{\sqrt{10}}\right)(2) = 0$$

$$F_{FB} = 1938.87 \text{ N} = 1.94 \text{ kN} \qquad \textbf{Ans}$$

$$+\uparrow \Sigma F_y = 0; \quad 1938.87\left(\frac{3}{\sqrt{10}}\right) - 1226.25 - E_y = 0$$

$$E_y = 613.125\text{N}$$

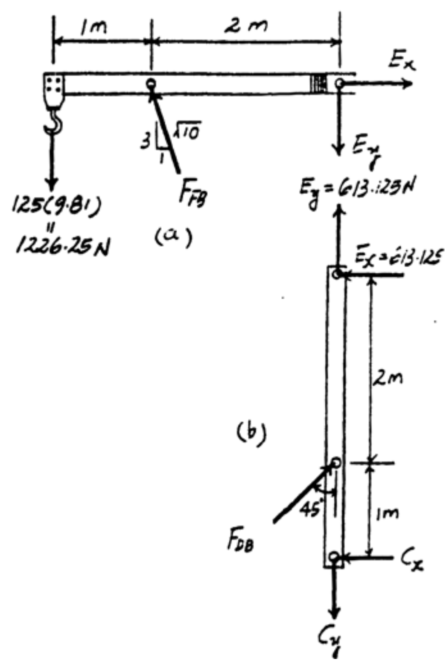
$$\xrightarrow{+} \Sigma F_x = 0; \quad E_x - 1938.87\left(\frac{1}{\sqrt{10}}\right) = 0$$

$$E_x = 613.125 \text{ N}$$

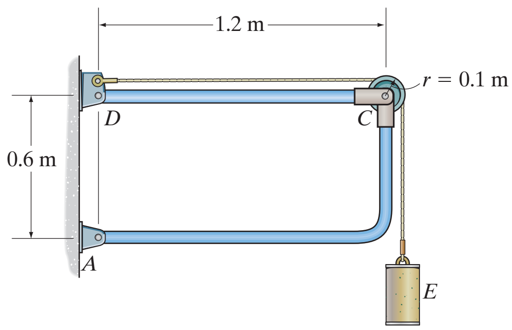
From FBD (b),

$$\circlearrowleft + \Sigma M_C = 0; \quad 613.125(3) - F_{BD}\sin 45°(1) = 0$$

$$F_{BD} = 2601.27 \text{ N} = 2.60 \text{ kN} \qquad \textbf{Ans}$$



***6–88.** The frame is used to support the 100-kg cylinder $E$. Determine the horizontal and vertical components of reaction at $A$ and $D$.




**Equations of Equilibrium:** Member $DC$ is a two-force member.

$D_y = 0$ **Ans.**

Consider the free-body diagram of member $AC$ in Fig. $a$.

$\circlearrowleft+\Sigma M_A = 0;$ $\quad D_x(0.6) - 981(1.2) + 981(0.6) = 0$

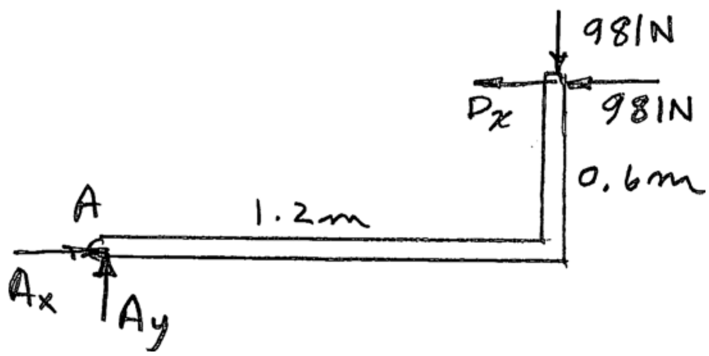
$D_x = 981 \text{ N}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad A_x - 981 - 981 = 0$

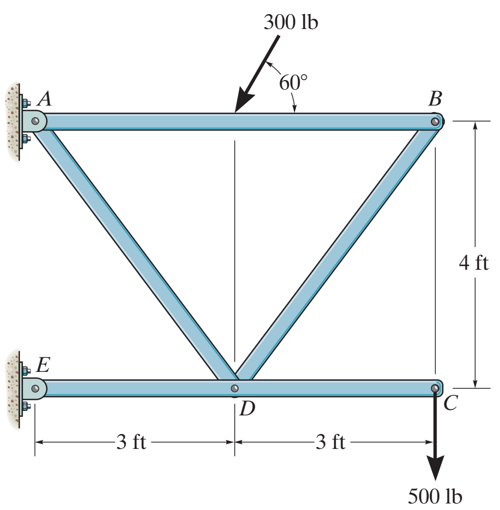
$A_x = 1962 \text{ N}$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad A_y - 981 = 0$

$A_y = 981 \text{ N}$ **Ans.**

**•6–89.** Determine the horizontal and vertical components of reaction which the pins exert on member *AB* of the frame.




**Member *AB*:**

$\curvearrowleft + \Sigma M_A = 0; \qquad -300 \sin 60° (3) + \frac{4}{5} F_{BD} (6) = 0$

$F_{BD} = 162.4 \text{ lb}$

Thus,

$B_x = \frac{3}{5}(162.4) = 97.4 \text{ lb}$ **Ans**

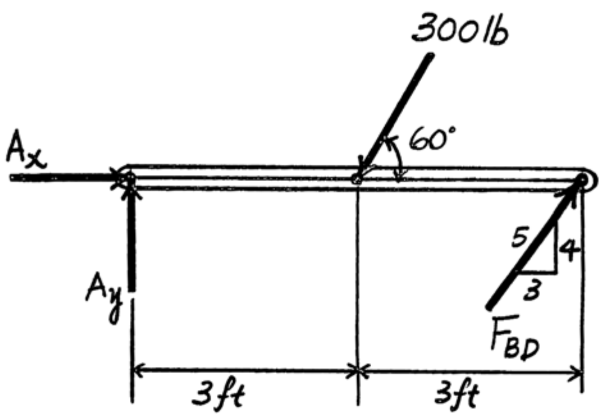
$B_y = \frac{4}{5}(162.4) = 130 \text{ lb}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \qquad -300 \cos 60° + \frac{3}{5}(162.4) + A_x = 0$

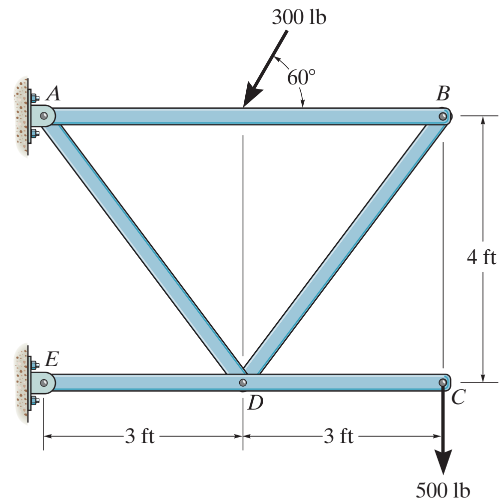
$A_x = 52.6 \text{ lb}$ **Ans**

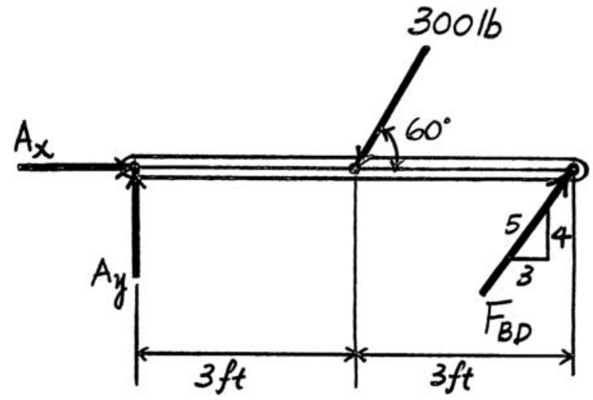
$+\uparrow \Sigma F_y = 0; \qquad A_y - 300 \sin 60° + \frac{4}{5}(162.4) = 0$

$A_y = 130 \text{ lb}$ **Ans**



**6–90.** Determine the horizontal and vertical components of reaction which the pins exert on member *EDC* of the frame.




**Member *AB*:**

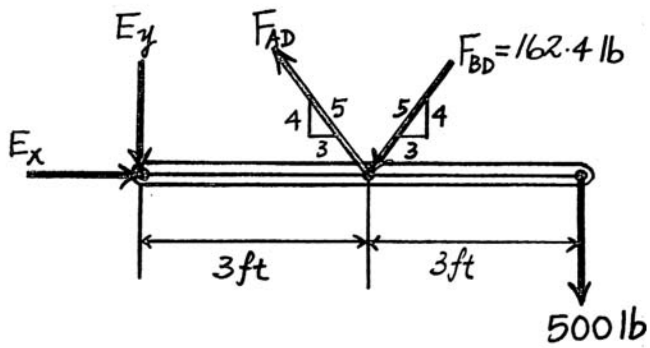
$\circlearrowleft + \Sigma M_A = 0;\quad -300 \sin 60° (3) + \frac{4}{5} F_{BD} (6) = 0$

$F_{BD} = 162.4 \text{ lb}$

**Member *EDC*:**

$\circlearrowleft + \Sigma M_E = 0;\quad -500 (6) - \frac{4}{5} (162.4) (3) + \frac{4}{5} F_{AD} (3) = 0$

$F_{AD} = 1412.4 \text{ lb}$



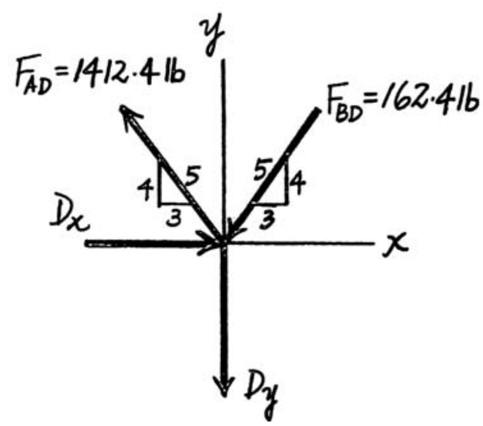

$\xrightarrow{+} \Sigma F_x = 0;\quad E_x - 162.4\left(\frac{3}{5}\right) - 1412.4\left(\frac{3}{5}\right) = 0$

$E_x = 945 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad -E_y + 1412.4\left(\frac{4}{5}\right) - 162.4\left(\frac{4}{5}\right) - 500 = 0$

$E_y = 500 \text{ lb}$ **Ans**

**Pin *D*:**



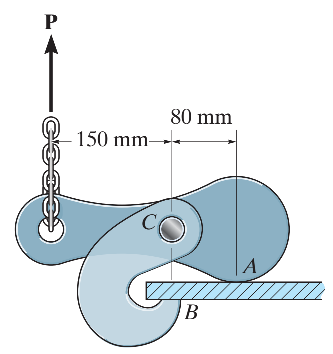

$\xrightarrow{+} \Sigma F_x = 0;\quad D_x - \frac{3}{5}(162.4) - \frac{3}{5}(1412.4) = 0$

$D_x = 945 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad -D_y - \frac{4}{5}(162.4) + \frac{4}{5}(1412.4) = 0$

$D_y = 1000 \text{ lb}$ **Ans**

**6–91.** The clamping hooks are used to lift the uniform smooth 500-kg plate. Determine the resultant compressive force that the hook exerts on the plate at *A* and *B*, and the pin reaction at *C*.




$\circlearrowleft + \Sigma M_C = 0; \quad N_A(80) - 2452.5(150) = 0$

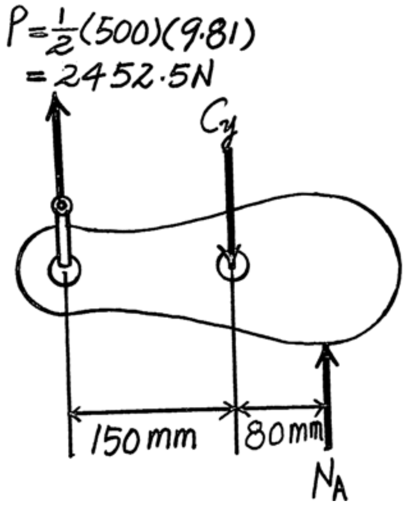
$N_A = 4598.4 \text{ N} \doteq 4.60 \text{ kN}$ **Ans**

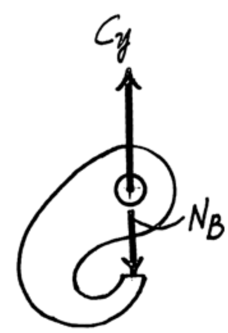
$+\uparrow \Sigma F_y = 0; \quad 2452.5 + 4598.4 - C_y = 0$

$C_y = 7050.9 \text{ N} = 7.05 \text{ kN}$ **Ans**

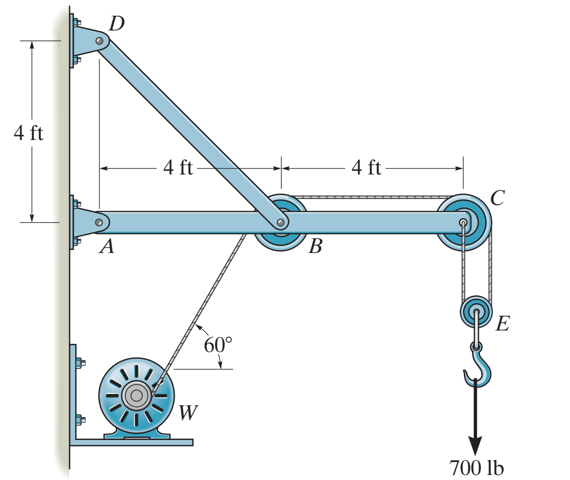
*CB* is a two-force member.

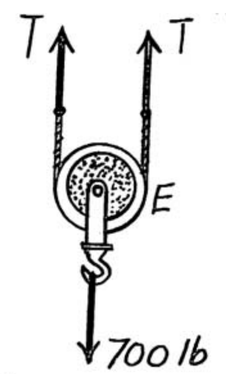
$N_B = C_y = 7.05 \text{ kN}$ **Ans**



***6–92.** The wall crane supports a load of 700 lb. Determine the horizontal and vertical components of reaction at the pins *A* and *D*. Also, what is the force in the cable at the winch *W*?




**Pulley *E*:**

$+\uparrow\Sigma F_y = 0;\quad 2T - 700 = 0$

$T = 350 \text{ lb} \quad \textbf{Ans}$

**Member *ABC*:**

$\curvearrowleft +\Sigma M_A = 0;\quad T_{BD}\sin 45^\circ(4) - 350\sin 60^\circ(4) - 700(8) = 0$

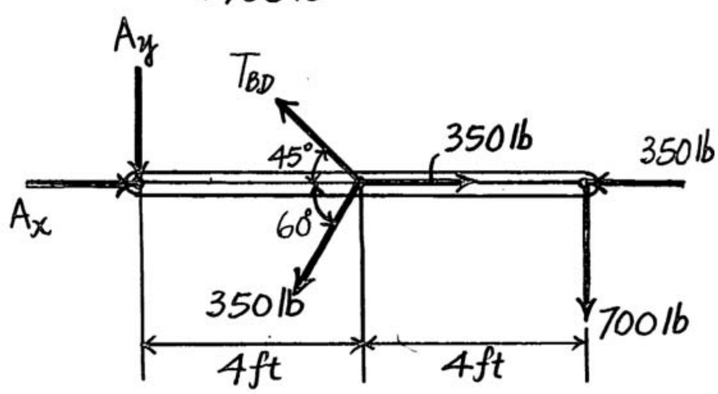
$T_{BD} = 2409 \text{ lb}$

$+\uparrow\Sigma F_y = 0;\quad -A_y + 2409\sin 45^\circ - 350\sin 60^\circ - 700 = 0$

$A_y = 700 \text{ lb} \quad \textbf{Ans}$

$\xrightarrow{+}\Sigma F_x = 0;\quad A_x - 2409\cos 45^\circ - 350\cos 60^\circ + 350 - 350 = 0$

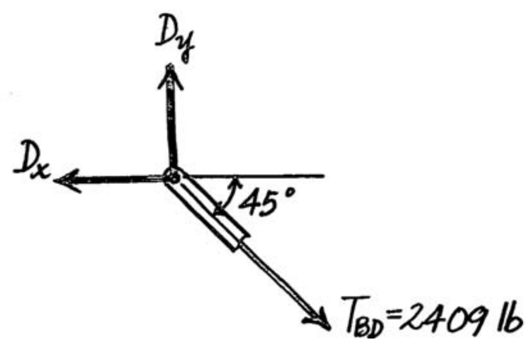
$A_x = 1.88 \text{ kip} \quad \textbf{Ans}$



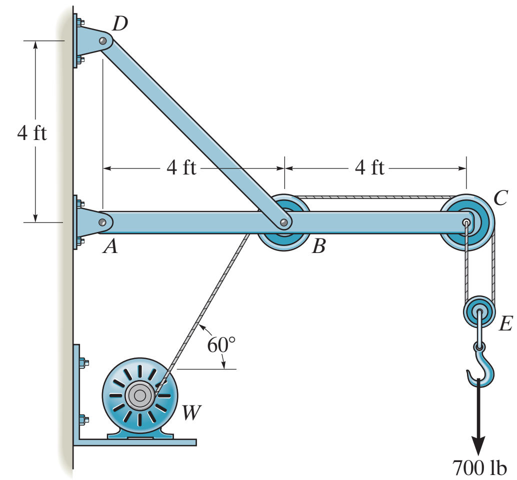

**At *D*:**

$D_x = 2409\cos 45^\circ = 1703.1 \text{ lb} = 1.70 \text{ kip} \quad \textbf{Ans}$

$D_y = 2409\sin 45^\circ = 1.70 \text{ kip} \quad \textbf{Ans}$



•**6–93.** The wall crane supports a load of 700 lb. Determine the horizontal and vertical components of reaction at the pins *A* and *D*. Also, what is the force in the cable at the winch *W*? The jib *ABC* has a weight of 100 lb and member *BD* has a weight of 40 lb. Each member is uniform and has a center of gravity at its center.





Pulley *E* :

$+\uparrow \Sigma F_y = 0;\quad 2T - 700 = 0$

$T = 350 \text{ lb}$ **Ans**

Member *ABC* :

$\curvearrowleft + \Sigma M_A = 0;\quad B_y(4) - 700(8) - 100(4) - 350 \sin 60^\circ (4) = 0$

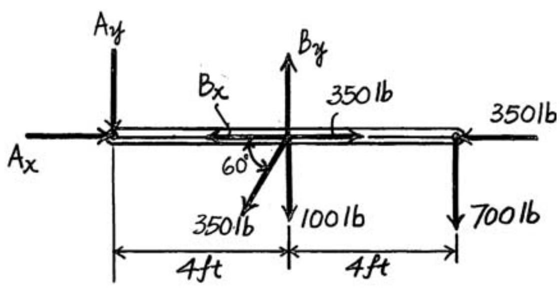
$B_y = 1803.1 \text{ lb}$

$+\uparrow \Sigma F_y = 0;\quad -A_y - 350 \sin 60^\circ - 100 - 700 + 1803.1 = 0$

$A_y = 700 \text{ lb}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad A_x - 350 \cos 60^\circ - B_x + 350 - 350 = 0$

$A_x = B_x + 175 \quad (1)$




Member *DB* :

$\curvearrowleft + \Sigma M_D = 0;\quad -40(2) - 1803.1(4) + B_x(4) = 0$

$B_x = 1823.1 \text{ lb}$

$\xrightarrow{+} \Sigma F_x = 0;\quad -D_x + 1823.1 = 0$

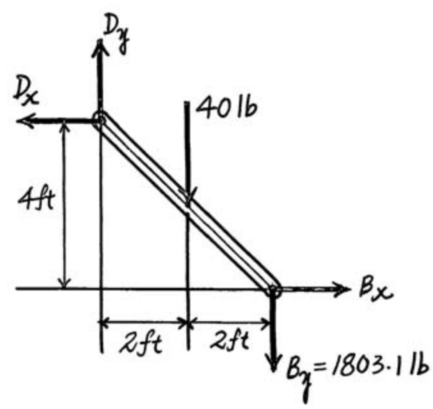
$D_x = 1.82 \text{ kip}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad D_y - 40 - 1803.1 = 0$

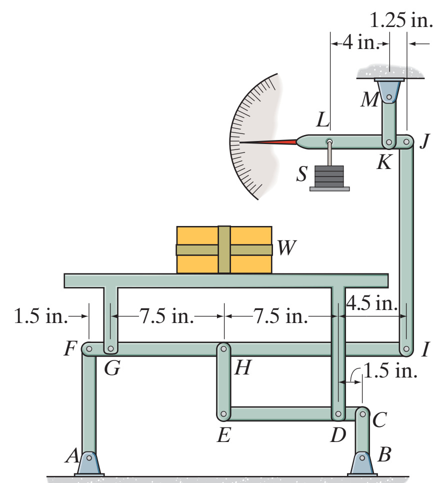
$D_y = 1843.1 = 1.84 \text{ kip}$ **Ans**

From Eq. (1)

$A_x = 2.00 \text{ kip}$ **Ans**



**6–94.** The lever-actuated scale consists of a series of compound levers. If a load of weight $W = 150$ lb is placed on the platform, determine the required weight of the counterweight $S$ to balance the load. Is it necessary to place the load symmetrically on the platform? Explain.




**Equations of Equilibrium:** First, we will consider the free-body diagram of the platform in Fig. *a*.

$\circlearrowleft +\Sigma M_D = 0;\quad 150(x) - G_y(15) = 0$

$G_y = 10x$

$+\uparrow \Sigma F_y = 0;\quad D_y + 10x - 150 = 0$

$D_y = 150 - 10x$

From the free-body diagram of member *CDE* in Fig. *b*,

$\circlearrowleft +\Sigma M_C = 0;\quad (150 - 10x)(1.5) - F_{EH}(9) = 0$

$F_{EH} = 25 - 1.6667x$

From the free-body diagram of member *FGHI* in Fig. *c*,

$\circlearrowleft +\Sigma M_F = 0;\quad F_{IJ}(21) - (25 - 1.6667x)(9) - 10x(1.5) = 0$

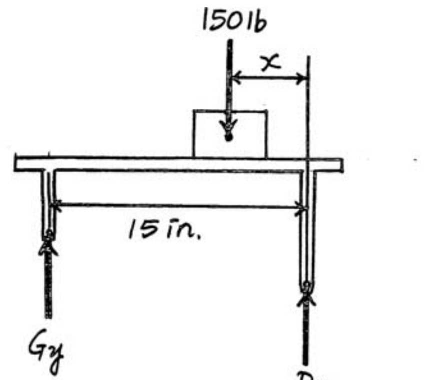
$F_{IJ} = 10.71$ lb

Finally, from the free-body diagram of member *JKL* in Fig. *d*,

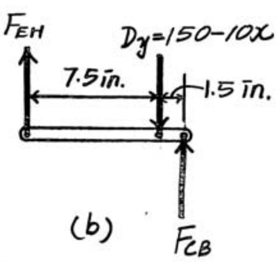
$\circlearrowleft +\Sigma M_K = 0;\quad W_s(4) - 10.71(1.25) = 0$

$W_s = 3.348 \text{ lb} = 3.35 \text{ lb}$ **Ans.**

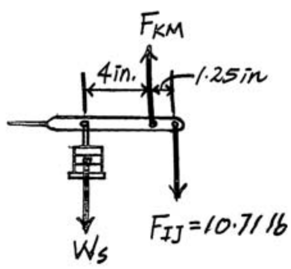
This result shows that $W_s$ is independent of the position $x$ of the load on the platform. Thus, the load can be placed at any position on the platform.



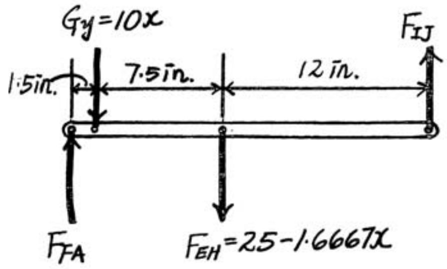

(a)




(b)

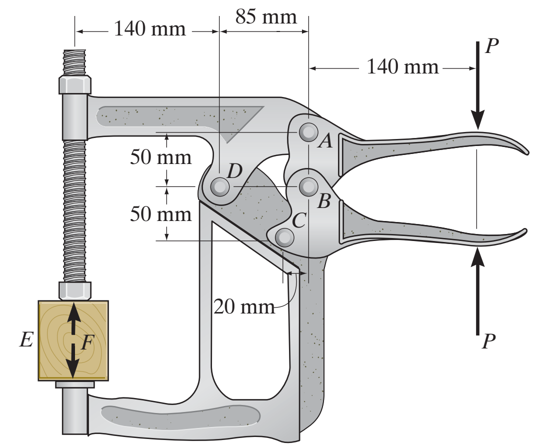



(d)




(c)

**6–95.** If $P = 75$ N, determine the force $F$ that the toggle clamp exerts on the wooden block.




**Equations of Equilibrium:** First, we will consider the free-body diagram of the upper handle in Fig. *a*.

$$\circlearrowleft +\Sigma M_A = 0; \qquad B_x(50) - 75(140) = 0$$
$$B_x = 210 \text{ N}$$

$$\xrightarrow{+} \Sigma F_x = 0; \qquad 210 - A_x = 0$$
$$A_x = 210 \text{ N}$$

$$+\uparrow \Sigma F_y = 0; \qquad B_y - A_y - 75 = 0 \qquad (1)$$

Using the result for $B_x$ and applying the moment equation of equilibrium about point $C$ on the free-body diagram of the lower handle in Fig. *b*,

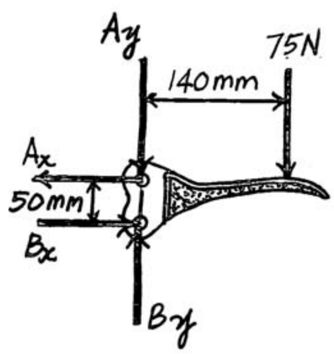
$$\circlearrowleft +\Sigma M_C = 0; \qquad 210(50) + 75(160) - B_y(20) = 0$$
$$B_y = 1125 \text{ N}$$

Substituting $B_y = 1125$ N into Eq. (1) yields

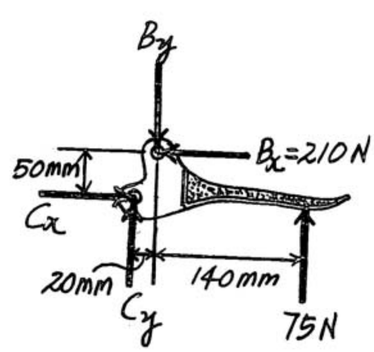
$$A_y = 1050 \text{ N}$$

Writing the moment equation of equilibrium about point $D$ on the free-body diagram of the clamp shown in Fig. *c*,

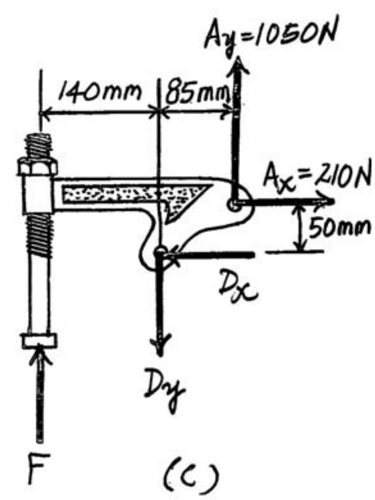
$$\circlearrowleft +\Sigma M_D = 0; \qquad 1050(85) - 210(50) - F(140) = 0$$
$$F = 562.5 \text{ N} \qquad \textbf{Ans.}$$




(a)

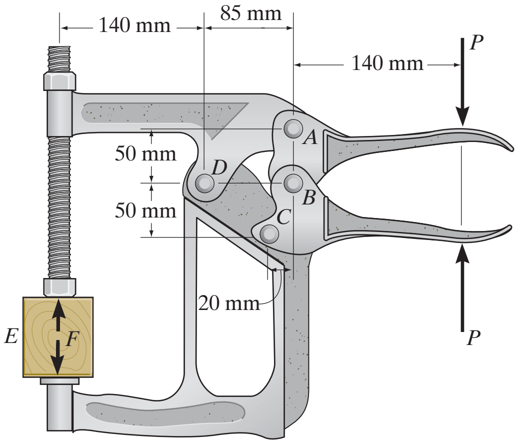



(b)




(c)

***6–96.** If the wooden block exerts a force of $F = 600$ N on the toggle clamp, determine the force $P$ applied to the handle.




**Equations of Equilibrium:** First, we will consider the free-body diagram of the upper handle in Fig. *a*.

$\circlearrowleft + \Sigma M_A = 0;$ $\quad B_x(50) - P(140) = 0$

$B_x = 2.8P$

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad 2.8P - A_x = 0$

$A_x = 2.8P$

$+\uparrow \Sigma F_y = 0;$ $\quad B_x - A_y - P = 0 \qquad (1)$

Using the result of $B_x$ and applying the moment equation of equilibrium about point $C$ on the free-body diagram of the lower handle in Fig. *b*,

$\circlearrowleft + \Sigma M_C = 0;$ $\quad P(160) + 2.8P(50) - B_y(20) = 0$

$B_y = 15P$

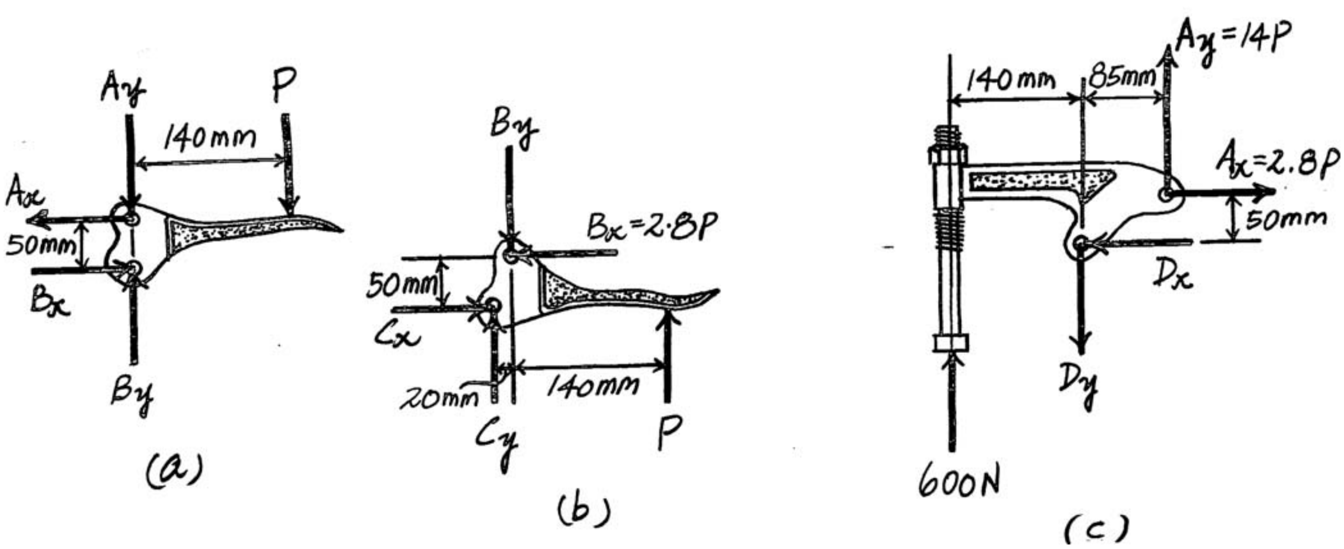
Substituting $B_y = 15P$ into Eq. (1) yields

$A_y = 14P$

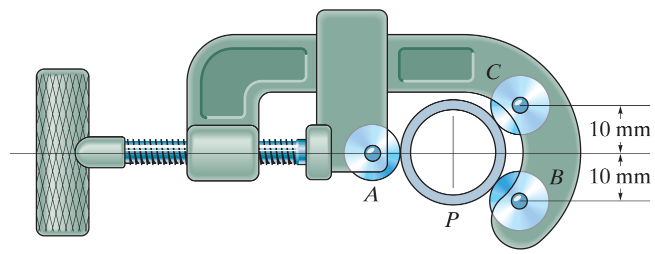
Writing the moment equation of equilibrium about point $D$ on the free-body diagram of the clamp shown in Fig. *c*,

$\circlearrowleft + \Sigma M_D = 0;$ $\quad 14P(85) - 2.8P(50) - 600(140) = 0$

$P = 80$ N **Ans.**



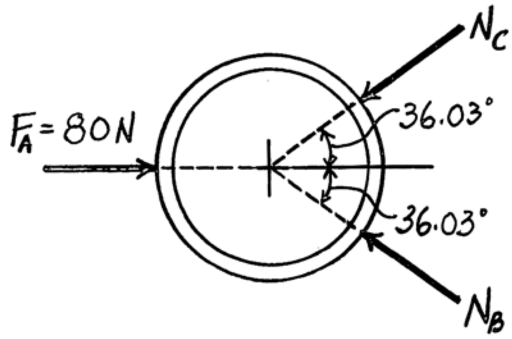
**•6–97.** The pipe cutter is clamped around the pipe $P$. If the wheel at $A$ exerts a normal force of $F_A = 80$ N on the pipe, determine the normal forces of wheels $B$ and $C$ on the pipe. The three wheels each have a radius of 7 mm and the pipe has an outer radius of 10 mm.

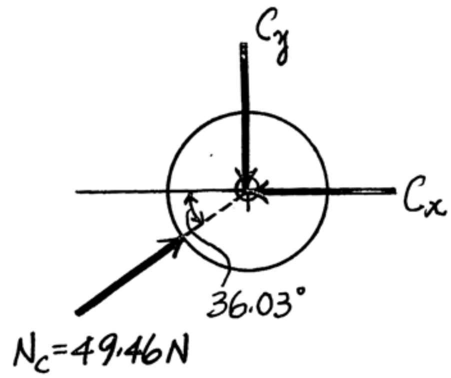



$$\theta = \sin^{-1}\left(\frac{10}{17}\right) = 36.03^\circ$$

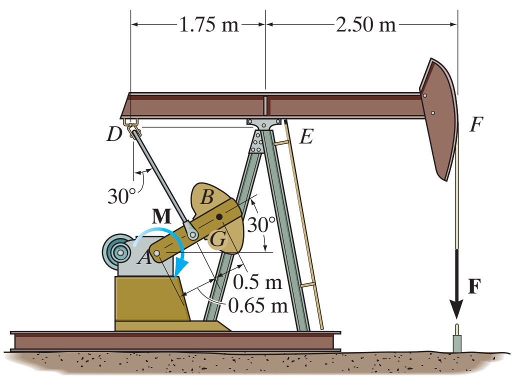
***Equations of Equilibrium:***

$$+\uparrow \Sigma F_y = 0; \quad N_B \sin 36.03^\circ - N_C \sin 36.03^\circ = 0$$
$$N_B = N_C$$
$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad 80 - N_C \cos 36.03^\circ - N_C \cos 36.03^\circ = 0$$
$$N_B = N_C = 49.5 \text{ N} \qquad \textbf{Ans}$$



**6–98.** A 300-kg counterweight, with center of mass at $G$, is mounted on the pitman crank $AB$ of the oil-pumping unit. If a force of $F = 5$ kN is to be developed in the fixed cable attached to the end of the walking beam $DEF$, determine the torque $M$ that must be supplied by the motor.

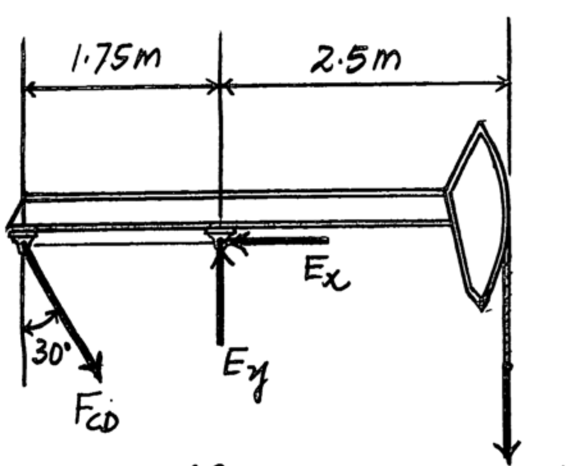



**Equations of Equilibrium:** Applying the moment equation of equilibrium about point $E$ to the free-body diagram of the walking beam in Fig. *a*,

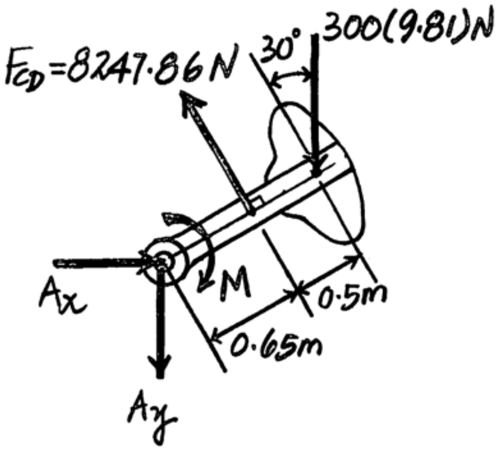
$$\circlearrowleft + \Sigma M_E = 0; \qquad F_{CD}\cos 30°(1.75) - 5000(2.5) = 0$$
$$F_{CD} = 8247.86 \text{ N}$$

Using the result of $F_{CD}$ and applying the moment equation of equilibrium about point $A$ on the free-body diagram of the pitman crank in Fig. *b*,

$$\circlearrowleft + \Sigma M_A = 0; \qquad 8247.86(0.65) - 300(9.81)\cos 30°(1.15) - M = 0$$
$$M = 2430.09 \text{ N}\cdot\text{m} = 2.43 \text{ kN}\cdot\text{m} \qquad \textbf{Ans.}$$

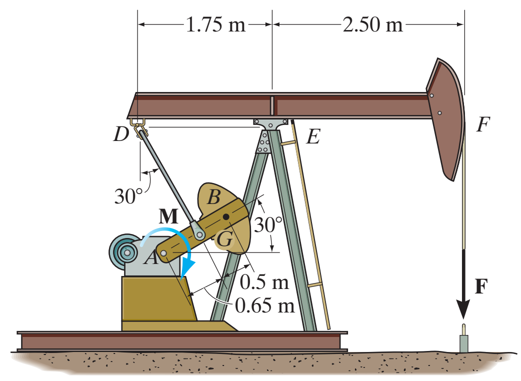



(a)




(b)

**6–99.** A 300-kg counterweight, with center of mass at $G$, is mounted on the pitman crank $AB$ of the oil-pumping unit. If the motor supplies a torque of $M = 2500\ \text{N}\cdot\text{m}$, determine the force **F** developed in the fixed cable attached to the end of the walking beam $DEF$.

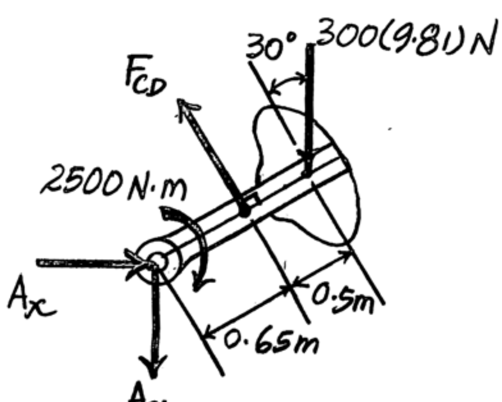



**Equations of Equilibrium:** Applying the moment equation of equilibrium about point $A$ to the free - body diagram of the pitman crank in Fig. $a$,

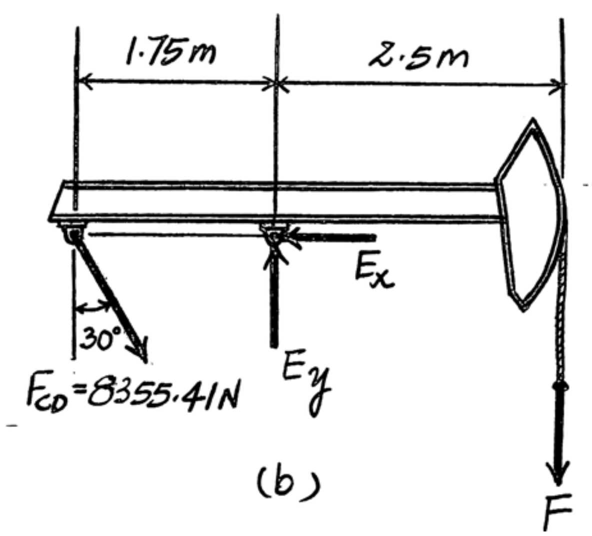
$$\circlearrowleft +\Sigma M_A = 0; \qquad F_{CD}(0.65) - 300(9.81)\cos 30°(1.15) - 2500 = 0$$
$$F_{CD} = 8355.41\ \text{N}$$

Using the result of $F_{CD}$ and applying the moment equation of equilibrium about point $E$ on the free - body diagram of the walking beam in Fig. $b$,

$$\circlearrowleft +\Sigma M_E = 0; \qquad 8355.41\cos 30°(1.75) - F(2.5) = 0$$
$$F = 5065.20\ \text{N} = 5.07\ \text{kN} \qquad \textbf{Ans.}$$

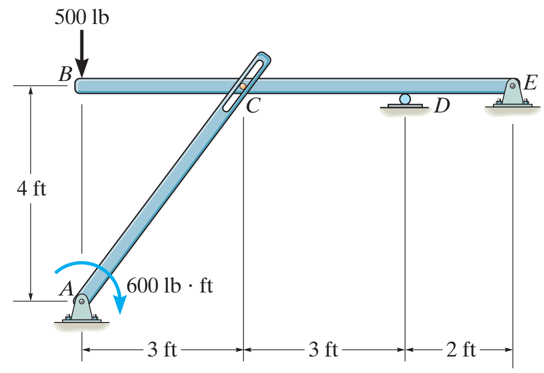



(a)




(b)

***6–100.** The two-member structure is connected at $C$ by a pin, which is fixed to $BDE$ and passes through the smooth slot in member $AC$. Determine the horizontal and vertical components of reaction at the supports.




Member $AC$:

$\curvearrowleft + \Sigma M_A = 0; \quad N_C\,(5) - 600 = 0$

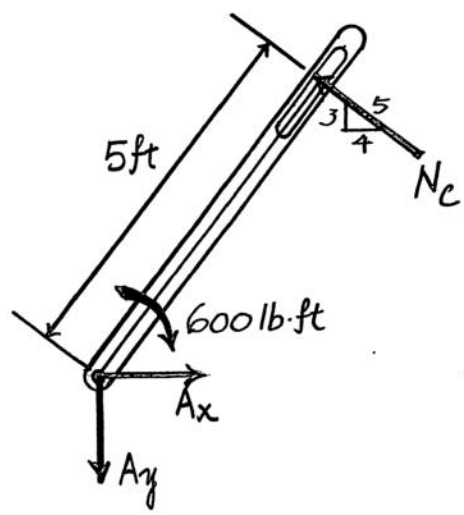
$N_C = 120 \text{ lb}$

$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - 120\left(\frac{4}{5}\right) = 0$

$A_x = 96 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad -A_y + 120\left(\frac{3}{5}\right) = 0$

$A_y = 72 \text{ lb}$ **Ans**




Member $BDE$:

$\curvearrowleft + \Sigma M_E = 0; \quad 500\,(8) + 120\left(\frac{3}{5}\right)(5) - D_y\,(2) = 0$

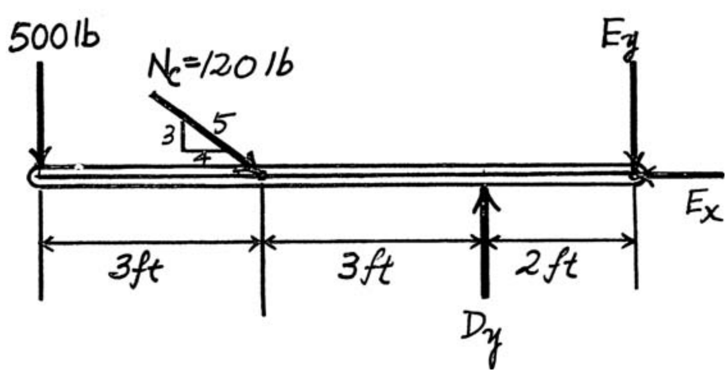
$D_y = 2180 \text{ lb} = 2.18 \text{ kip}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad -E_x + 120\left(\frac{4}{5}\right) = 0$

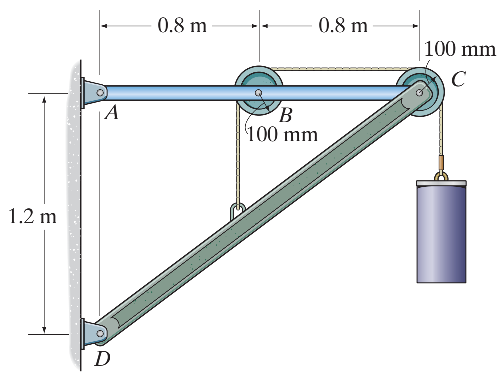
$E_x = 96 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad -500 - 120\left(\frac{3}{5}\right) + 2180 - E_y = 0$

$E_y = 1608 \text{ lb} = 1.61 \text{ kip}$ **Ans**



**•6–101.** The frame is used to support the 50-kg cylinder. Determine the horizontal and vertical components of reaction at *A* and *D*.




**Equations of Equilibrium:** First, we will consider member *ABC*.

$\circlearrowleft +\Sigma M_A = 0;\qquad C_y(1.6) - 50(9.81)(0.7) - 50(9.81)(1.7) = 0$

$C_y = 735.75\text{ N}$

$+\uparrow \Sigma F_y = 0;\qquad A_y + 735.75 - 50(9.81) - 50(9.81) = 0$

$A_y = 245.25\text{ N} = 245\text{ N}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0;\qquad C_x - A_x = 0$ (1)

Subsequently, we will consider member *CD*.

$\circlearrowleft +\Sigma M_D = 0;\qquad C_x(1.2) + 50(9.81)(0.7) - 735.75(1.6) = 0$

$C_x = 694.875\text{ N}$

$+\uparrow \Sigma F_y = 0;\qquad D_y + 50(9.81) - 735.75 = 0$

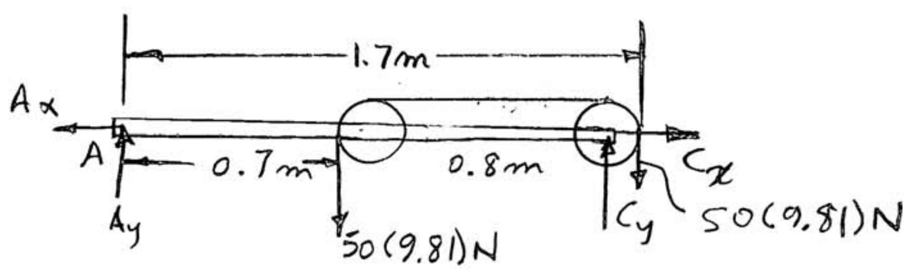
$D_y = 245.25\text{ N} = 245\text{ N}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0;\qquad D_x - 694.875 = 0$

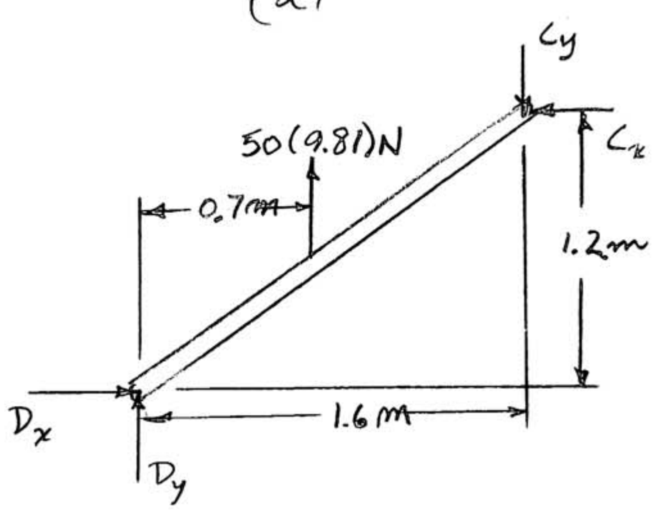
$D_x = 694.875\text{ N} = 695\text{ N}$ **Ans.**

Substituting $C_x = 694.875\text{ N}$ into Eq. (1) yields

$A_x = 694.875\text{ N} = 695\text{ N}$ **Ans.**

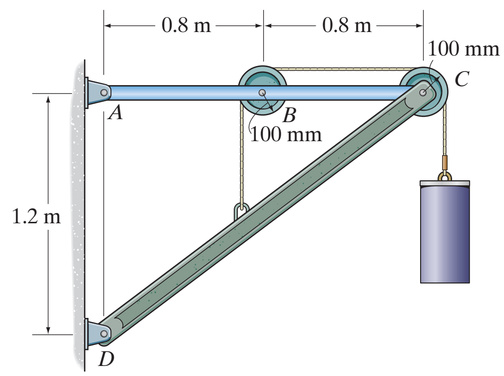



(a)




(b)

**6–102.** The frame is used to support the 50-kg cylinder. Determine the force of the pin at $C$ on member $ABC$ and on member $CD$.




**Equations of Equilibrium:** The horizontal and vertical components of force on members $CD$ and $ABD$ are denoted as $C_x$, $C_y$, $C_x'$, and $C_y'$, respectively. Writing the moment equation of equilibrium about point $A$,

$$\circlearrowleft + \Sigma M_A = 0; \qquad C_y(1.6) - 50(9.81)(0.7) - 50(9.81)(1.7) = 0$$
$$C_y = 735.75\text{ N}$$

Using this and applying the moment equation of equilibrium about point $D$ of member $CD$,

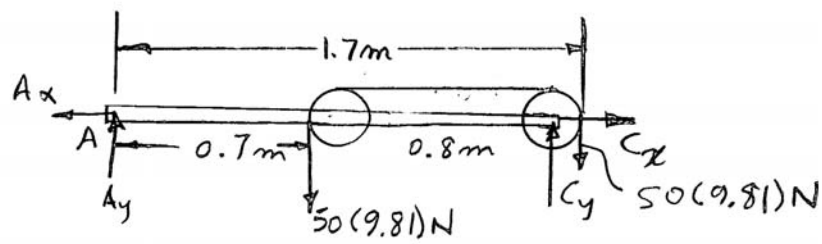
$$\circlearrowleft + \Sigma M_D = 0; \qquad C_x(1.2) + 50(9.81)(0.7) - 735.75(1.6) = 0$$
$$C_x = 694.875\text{ N}$$

Using the results of $C_x$ and $C_y$ and considering the free - body diagram of pulley $C$,

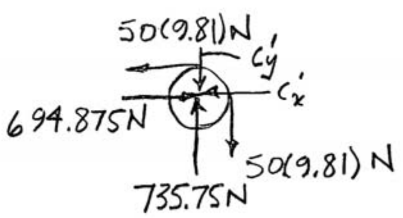
$$\overset{+}{\rightarrow}\Sigma F_x = 0; \qquad 694.875 - 50(9.81) - C_x' = 0$$
$$C_x' = 204.375\text{ N}$$
$$+\uparrow \Sigma F_y = 0; \qquad 735.75 - 50(9.81) - C_y' = 0$$
$$C_y' = 245.25\text{ N}$$

Thus, the force at pin $C$ on members $CD$ and $ABC$ are given by

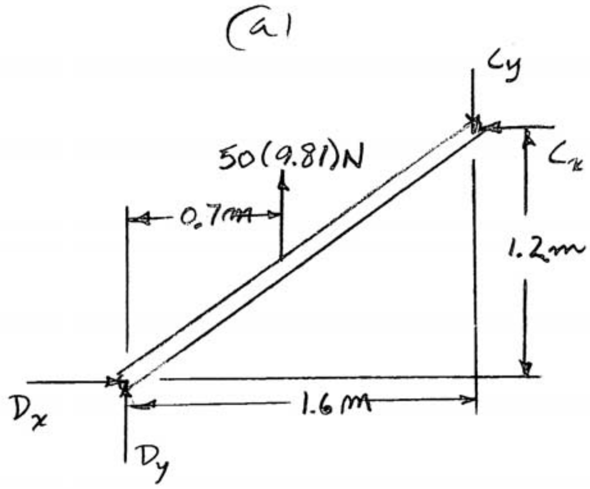
$$F_{CD} = \sqrt{C_x{}^2 + C_y{}^2} = \sqrt{694.875^2 + 735.75^2} = 1012.01\text{ N} = 1.01\text{ kN} \qquad \textbf{Ans.}$$
$$F_{ABC} = \sqrt{C_x'{}^2 + C_y'{}^2} = \sqrt{204.375^2 + 245.25^2} = 319.24\text{ N} = 319\text{ N} \qquad \textbf{Ans.}$$




(a)

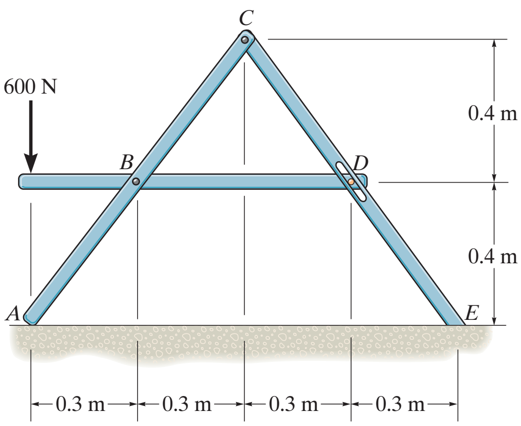


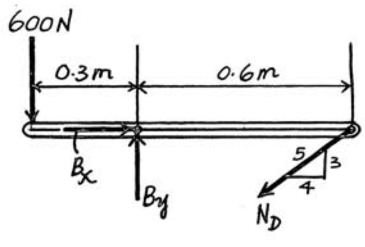

(c)




(b)

**6–103.** Determine the reactions at the fixed support $E$ and the smooth support $A$. The pin, attached to member $BD$, passes through a smooth slot at $D$.




Member $BD$:

$\curvearrowleft+\Sigma M_B = 0;\quad 600(0.3) - N_D\left(\frac{3}{5}\right)(0.6) = 0$

$N_D = 500\text{ N}$

$\xrightarrow{+}\Sigma F_x = 0;\quad B_x - \frac{4}{5}(500) = 0$

$B_x = 400\text{ N}$

$+\uparrow\Sigma F_y = 0;\quad -600 + B_y - \frac{3}{5}(500) = 0$

$B_y = 900\text{ N}$

Member $ABC$:

$\curvearrowleft+\Sigma M_C = 0;\quad 900(0.3) - 400(0.4) - A_y(0.6) = 0$

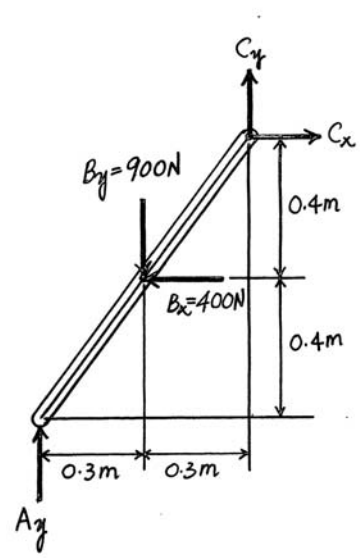
$A_y = 183.33 = 183\text{ N}$ **Ans**

$\xrightarrow{+}\Sigma F_x = 0;\quad -400 + C_x = 0$

$C_x = 400\text{ N}$

$+\uparrow\Sigma F_y = 0;\quad 183.33 - 900 + C_y = 0$

$C_y = 716.67\text{ N}$




Member $CDE$:

$\xrightarrow{+}\Sigma F_x = 0;\quad -400 + 500\left(\frac{4}{5}\right) + E_x = 0$

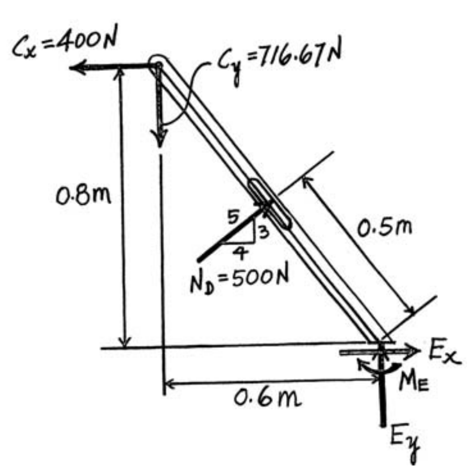
$E_x = 0$ **Ans**

$+\uparrow\Sigma F_y = 0;\quad -716.67 + 500\left(\frac{3}{5}\right) + E_y = 0$

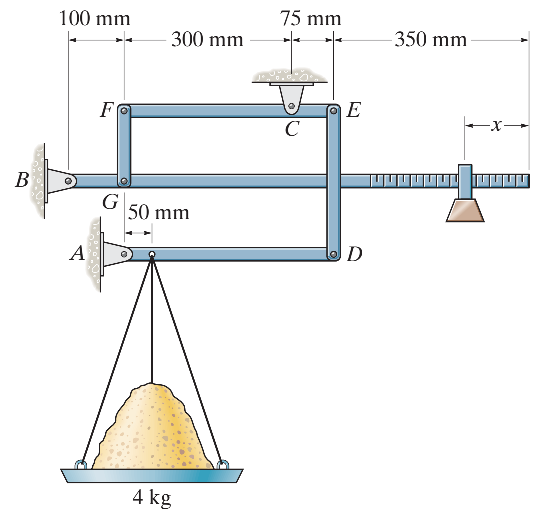
$E_y = 417\text{ N}$ **Ans**

$\curvearrowleft+\Sigma M_E = 0;\quad -M_E - 500(0.5) + 400(0.8) + 716.67(0.6) = 0$

$M_E = 500\text{ N}\cdot\text{m}$ **Ans**



***6–104.** The compound arrangement of the pan scale is shown. If the mass on the pan is 4 kg, determine the horizontal and vertical components at pins $A$, $B$, and $C$ and the distance $x$ of the 25-g mass to keep the scale in balance.




***Free Body Diagram :*** The solution for this problem will be simplified if one realizes that members $DE$ and $FG$ are two-force members.

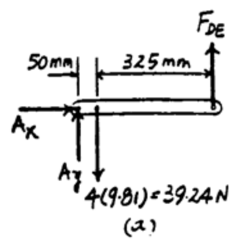
***Equations of Equilibrium :*** From FBD (a).

$\circlearrowleft + \Sigma M_A = 0; \quad F_{DE}(375) - 39.24(50) = 0 \quad F_{DE} = 5.232\text{ N}$

$+\uparrow \Sigma F_y = 0; \quad A_y + 5.232 - 39.24 = 0$

$A_y = 34.0\text{ N}$ **Ans**

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



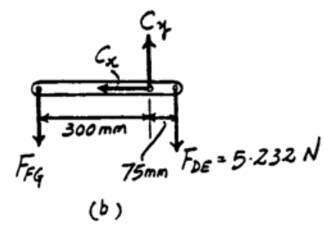

From (b).

$\circlearrowleft + \Sigma M_C = 0; \quad F_{FG}(300) - 5.232(75) = 0 \quad F_{FG} = 1.308\text{ N}$

$+\uparrow \Sigma F_y = 0; \quad C_y - 1.308 - 5.232 = 0$

$C_y = 6.54\text{ N}$ **Ans**

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




From (c).

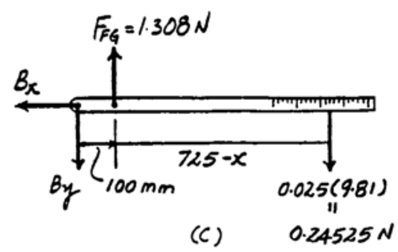
$\circlearrowleft + \Sigma M_B = 0; \quad 1.308(100) - 0.24525(825 - x) = 0$

$x = 292\text{ mm}$ **Ans**

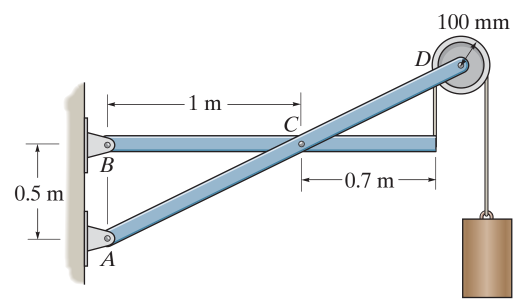
$+\uparrow \Sigma F_y = 0; \quad 1.308 - 0.24525 - B_y = 0$

$B_y = 1.06\text{ N}$ **Ans**

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



**•6–105.** Determine the horizontal and vertical components of reaction that the pins at $A$, $B$, and $C$ exert on the frame. The cylinder has a mass of 80 kg.




***Equations of Equilibrium :*** From FBD (b),

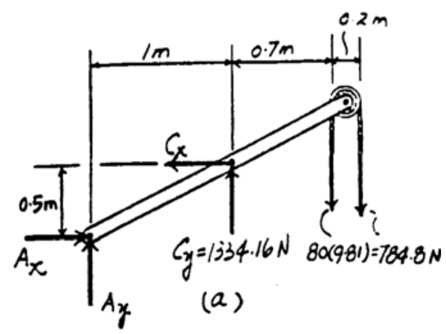
$\curvearrowleft + \Sigma M_B = 0;\quad 784.8(1.7) - C_y(1) = 0$

$C_y = 1334.16 \text{ N} = 1.33 \text{ kN}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad B_y + 784.8 - 1334.16 = 0$

$B_y = 549 \text{ N}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad C_x - B_x = 0$ [1]




From FBD (a),

$\curvearrowleft + \Sigma M_A = 0;\quad C_x(0.5) + 1334.16(1) - 784.8(1.7) - 784.8(1.9) = 0$

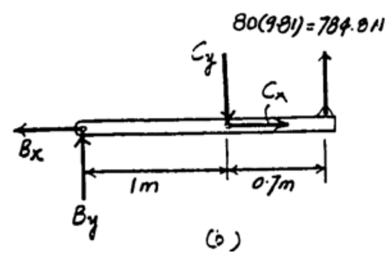
$C_x = 2982.24 \text{ N} = 2.98 \text{ kN}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad A_y + 1334.16 - 784.8 - 784.8 = 0$

$A_y = 235 \text{ N}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad A_x - 2982.24 = 0$

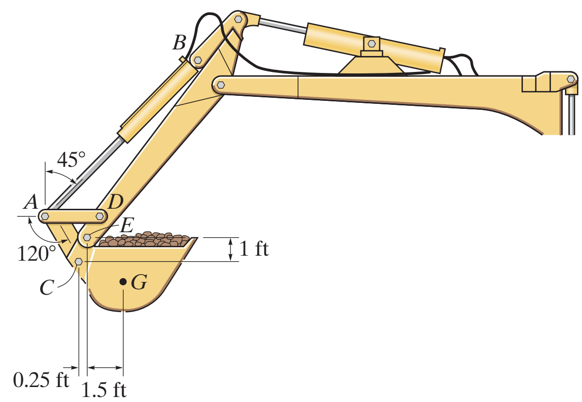
$A_x = 2982.24 \text{ N} = 2.98 \text{ kN}$ **Ans**



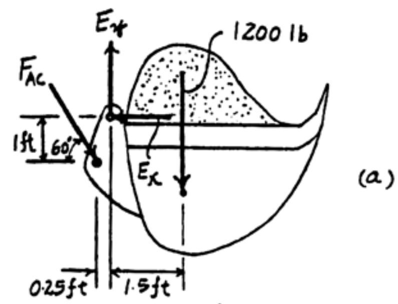

Substitute $C_x = 2982.24$ N into Eq.[1] yields,

$B_x = 2982.24 \text{ N} = 2.98 \text{ kN}$ **Ans**

**6–106.** The bucket of the backhoe and its contents have a weight of 1200 lb and a center of gravity at $G$. Determine the forces of the hydraulic cylinder $AB$ and in links $AC$ and $AD$ in order to hold the load in the position shown. The bucket is pinned at $E$.




***Free Body Diagram :*** The solution for this problem will be simplified if one realizes that the hydraulic cylinder $AB$, links $AD$ and $AC$ are two-force members.




***Equations of Equilibrium :*** From FBD (a),

$$\curvearrowleft + \Sigma M_E = 0; \quad F_{AC}\cos 60°(1) + F_{AC}\sin 60°(0.25) - 1200(1.5) = 0$$

$$F_{AC} = 2512.19 \text{ lb} = 2.51 \text{ kip} \qquad \textbf{Ans}$$

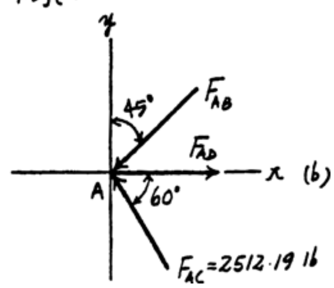
Using method of joint [FBD (b)],

$$+\uparrow \Sigma F_y = 0; \quad 2512.19\sin 60° - F_{AB}\cos 45° = 0$$

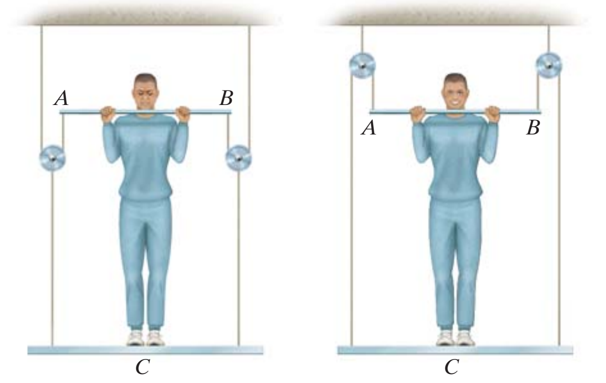
$$F_{AB} = 3076.79 \text{ lb} = 3.08 \text{ kip} \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AD} - 3076.79\sin 45° - 2512.19\cos 60° = 0$$

$$F_{AD} = 3431.72 \text{ lb} = 3.43 \text{ kip} \qquad \textbf{Ans}$$



**6–107.** A man having a weight of 175 lb attempts to hold himself using one of the two methods shown. Determine the total force he must exert on bar $AB$ in each case and the normal reaction he exerts on the platform at $C$. Neglect the weight of the platform.



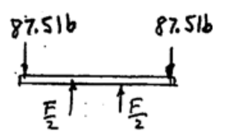

(a) (b)

**(a)**

**Bar :**

$+\uparrow \Sigma F_y = 0; \quad 2(F/2) - 2(87.5) = 0$

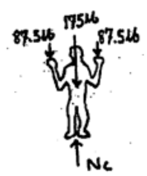
$F = 175 \text{ lb}$ **Ans**




**Man :**

$+\uparrow \Sigma F_y = 0; \quad N_C - 175 - 2(87.5) = 0$

$N_C = 350 \text{ lb}$ **Ans**

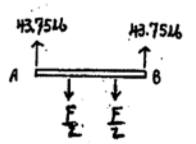



**(b)**

**Bar :**

$+\uparrow \Sigma F_y = 0; \quad 2(43.75) - 2(F/2) = 0$

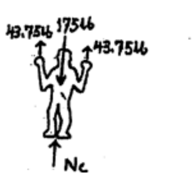
$F = 87.5 \text{ lb}$ **Ans**



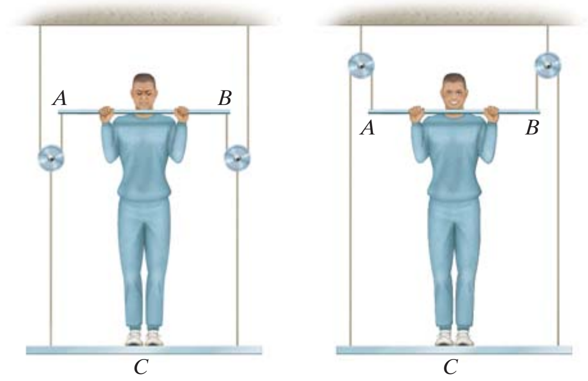

**Man :**

$+\uparrow \Sigma F_y = 0; \quad N_C - 175 + 2(43.75) = 0$

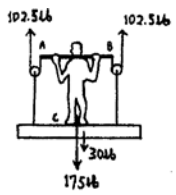
$N_C = 87.5 \text{ lb}$ **Ans**

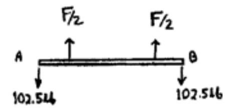


*__6–108.__ A man having a weight of 175 lb attempts to hold himself using one of the two methods shown. Determine the total force he must exert on bar $AB$ in each case and the normal reaction he exerts on the platform at $C$. The platform has a weight of 30 lb.




(a) (b)




(a)

**Bar:**

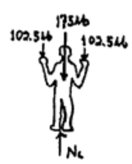
$+\uparrow \Sigma F_y = 0;\quad 2(F/2) - 102.5 - 102.5 = 0$

$F = 205 \text{ lb}$ **Ans**

**Man:**

$+\uparrow \Sigma F_y = 0;\quad N_C - 175 - 102.5 - 102.5 = 0$

$N_C = 380 \text{ lb}$ **Ans**

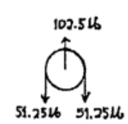



(b)

**Bar:**

$+\uparrow \Sigma F_y = 0;\quad 2(F/2) - 51.25 - 51.25 = 0$

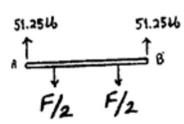
$F = 102 \text{ lb}$ **Ans**



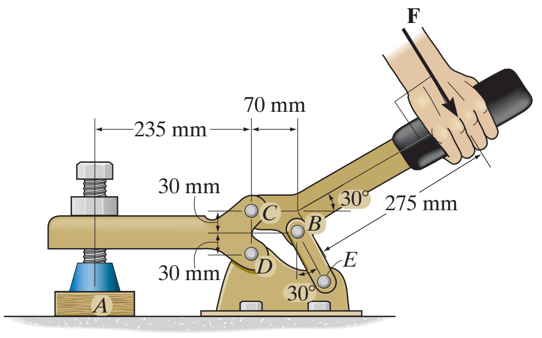

**Man:**

$+\uparrow \Sigma F_y = 0;\quad N_C - 175 + 51.25 + 51.25 = 0$

$N_C = 72.5 \text{ lb}$ **Ans**




•**6–109.** If a clamping force of 300 N is required at *A*, determine the amount of force **F** that must be applied to the handle of the toggle clamp.




**Equations of Equilibrium:** First, we will consider the free-body diagram of the clamp in Fig. *a*. Writing the moment equation of equilibrium about point *D*,

$$\circlearrowleft +\Sigma M_D = 0; \qquad C_x(60) - 300(235) = 0$$
$$C_x = 1175 \text{ N}$$

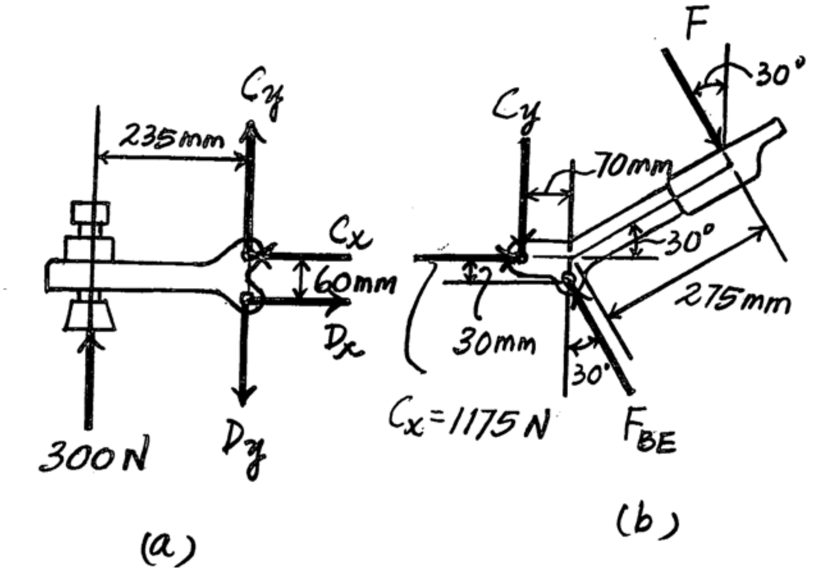
Subsequently, the free-body diagram of the handle in Fig. *b* will be considered.

$$\circlearrowleft +\Sigma M_C = 0; \qquad F_{BE}\cos 30°(70) - F_{BE}\sin 30°(30) - F\cos 30°(275\cos 30° + 70)$$
$$- F\sin 30°(275\sin 30°) = 0$$
$$45.62F_{BE} - 335.62F = 0 \qquad (1)$$

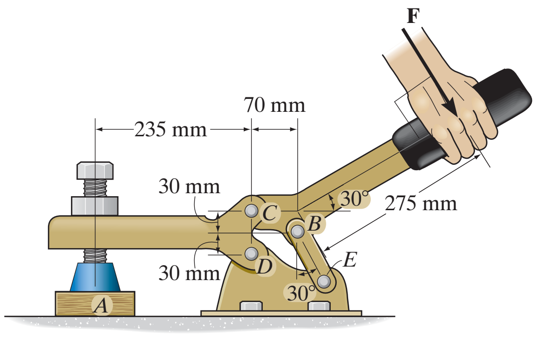
$$\xrightarrow{+} \Sigma F_x = 0; \qquad 1175 + F\sin 30° - F_{BE}\sin 30° = 0$$
$$0.5F_{BE} - 0.5F = 1175 \qquad (2)$$

Solving Eqs. (1) and (2) yields

$$F = 369.69 \text{ N} = 370 \text{ N} \qquad \textbf{Ans.}$$
$$F_{BE} = 2719.69 \text{ N}$$



**6–110.** If a force of $F = 350$ N is applied to the handle of the toggle clamp, determine the resulting clamping force at $A$.




**Equations of Equilibrium:** First, we will consider the free-body diagram of the handle in Fig. $a$.

$$\circlearrowleft + \Sigma M_C = 0; \quad F_{BE}\cos 30°(70) - F_{BE}\sin 30°(30) - 350\cos 30°(275\cos 30° + 70) - 350\sin 30°(275\sin 30°) = 0$$

$$F_{BE} = 2574.81\text{ N}$$

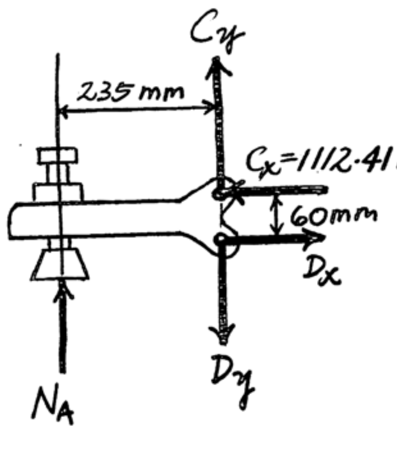
$$\overset{+}{\rightarrow}\Sigma F_x = 0; \quad C_x - 2574.81\sin 30° + 350\sin 30° = 0$$

$$C_x = 1112.41\text{ N}$$

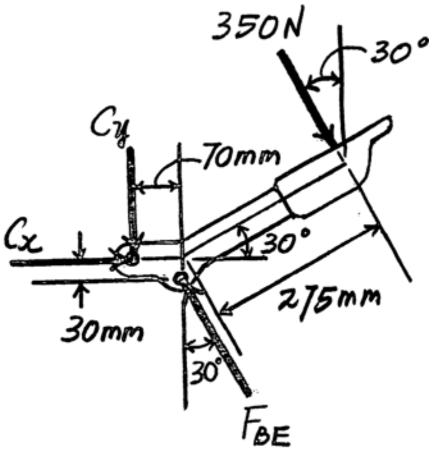
Subsequently, the free-body diagram of the clamp in Fig. $b$ will be considered. Using the result of $C_x$ and writing the moment equation of equilibrium about point $D$,

$$\circlearrowleft + \Sigma M_D = 0; \quad 1112.41(60) - N_A(235) = 0$$

$$N_A = 284.01\text{ N} = 284\text{ N} \qquad \textbf{Ans.}$$

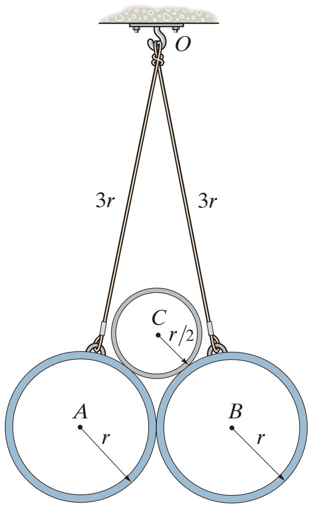



(b)

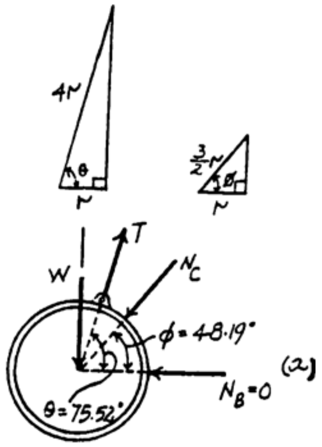



(a)

**6–111.** Two smooth tubes $A$ and $B$, each having the same weight, $W$, are suspended from a common point $O$ by means of equal-length cords. A third tube, $C$, is placed between $A$ and $B$. Determine the greatest weight of $C$ without upsetting equilibrium.




***Free Body Diagram :*** When the equilibrium is about to be upset, the reaction at $B$ must be zero ($N_B = 0$). From the geometry, $\phi = \cos^{-1}\left(\frac{r}{\frac{3}{2}r}\right) = 48.19°$ and $\theta = \cos^{-1}\left(\frac{r}{4r}\right) = 75.52°$.




***Equations of Equilibrium :*** From FBD (a),

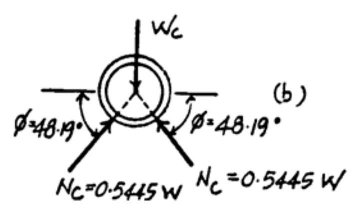
$$\xrightarrow{+} \Sigma F_x = 0; \qquad T\cos 75.52° - N_C \cos 48.19° = 0 \qquad [1]$$

$$+\uparrow \Sigma F_y = 0; \qquad T\sin 75.52° - N_C \sin 48.19° - W = 0 \qquad [2]$$

Solving Eq. [1] and [2] yields,

$$T = 1.452W \qquad N_C = 0.5445W$$

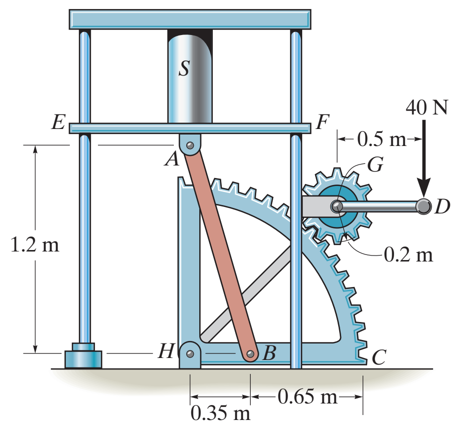
From FBD (b),




$$+\uparrow \Sigma F_y = 0; \qquad 2(0.5445W \sin 48.19°) - W_C = 0$$

$$W_C = 0.812W \qquad \textbf{Ans}$$

*6–112. The handle of the sector press is fixed to gear $G$, which in turn is in mesh with the sector gear $C$. Note that $AB$ is pinned at its ends to gear $C$ and the underside of the table $EF$, which is allowed to move vertically due to the smooth guides at $E$ and $F$. If the gears only exert tangential forces between them, determine the compressive force developed on the cylinder $S$ when a vertical force of 40 N is applied to the handle of the press.




**Member GD:**

$\circlearrowleft + \Sigma M_G = 0; \quad -40(0.5) + F_{CG}(0.2) = 0$

$F_{CG} = 100 \text{ N}$

**Sector gear:**

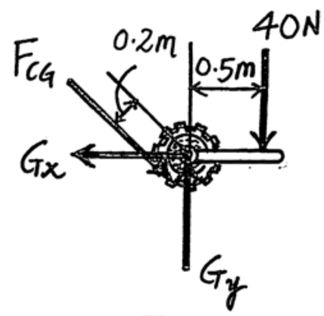
$\circlearrowleft + \Sigma M_H = 0; \quad 100(1) - F_{AB}\left(\frac{1.2}{1.25}\right)(0.35) = 0$

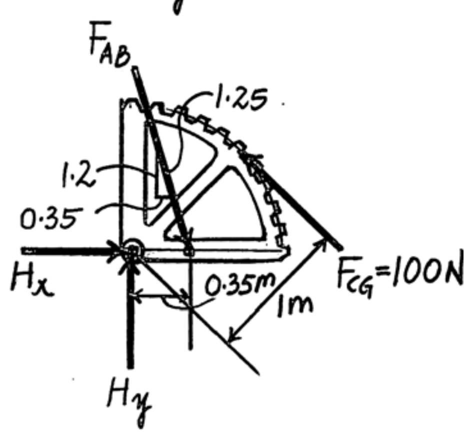
$F_{AB} = 297.62 \text{ N}$

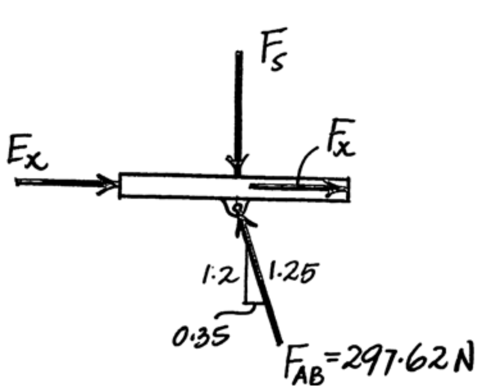
**Table:**

$+\uparrow \Sigma F_y = 0; \quad 297.62\left(\frac{1.2}{1.25}\right) - F_S = 0$

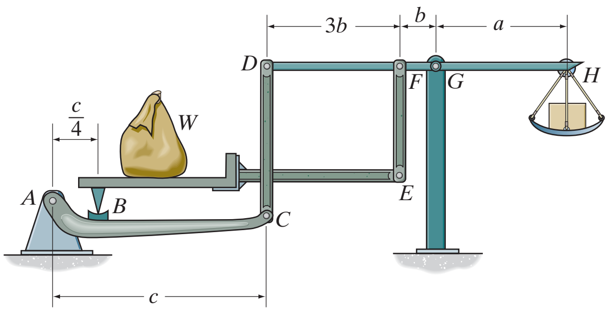
$F_S = 286 \text{ N}$ **Ans**



**•6–113.** Show that the weight $W_1$ of the counterweight at $H$ required for equilibrium is $W_1 = (b/a)W$, and so it is independent of the placement of the load $W$ on the platform.




**Equations of Equilibrium:** First, we will consider member $BE$.

$$\circlearrowleft + \Sigma M_E = 0; \qquad W(x) - N_B\left(3b + \frac{3}{4}c\right) = 0$$

$$N_B = \frac{Wx}{\left(3b + \frac{3}{4}c\right)}$$

$$+\uparrow \Sigma F_y = 0; \qquad F_{EF} + \frac{W_1 x}{\left(3b + \frac{3}{4}c\right)} - W = 0$$

$$F_{EF} = W\left(1 - \frac{x}{3b + \frac{3}{4}c}\right)$$

Using the result for $N_B$ and applying the moment equation of equilibrium about point $A$,

$$\circlearrowleft + \Sigma M_A = 0; \qquad F_{CD}(c) - \frac{Wx}{\left(3b + \frac{3}{4}c\right)}\left(\frac{1}{4}c\right) = 0$$

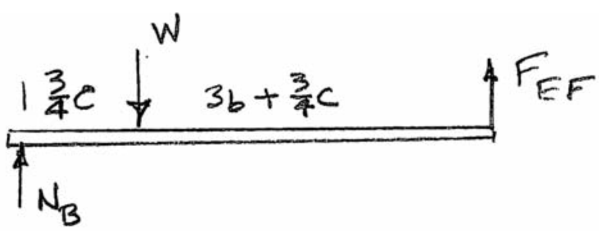
$$F_{CD} = \frac{Wx}{12b + 3c}$$

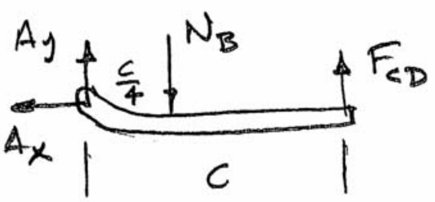
Writing the moment equation of equilibrium about point $G$,

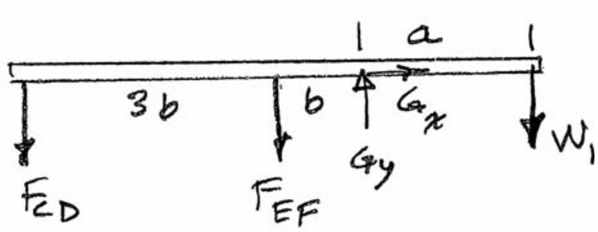
$$\circlearrowleft + \Sigma M_G = 0; \qquad \frac{Wx}{12b + 3c}(4b) + W\left(1 - \frac{x}{3b + \frac{3}{4}c}\right)(b) - W_1(a) = 0$$

$$W_1 = \frac{b}{a}W \qquad \textbf{Ans.}$$

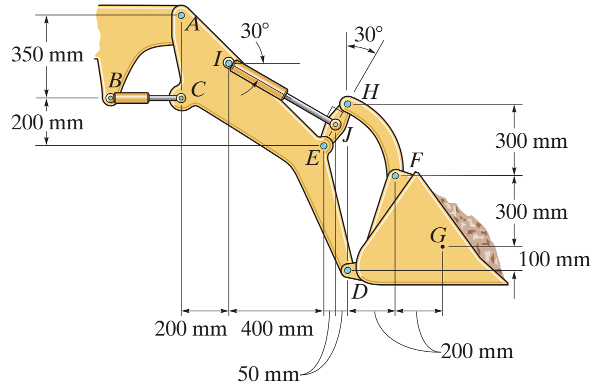
This result shows that the required weight $W_1$ of the counterweight is independent of the position $x$ of the load on the platform.

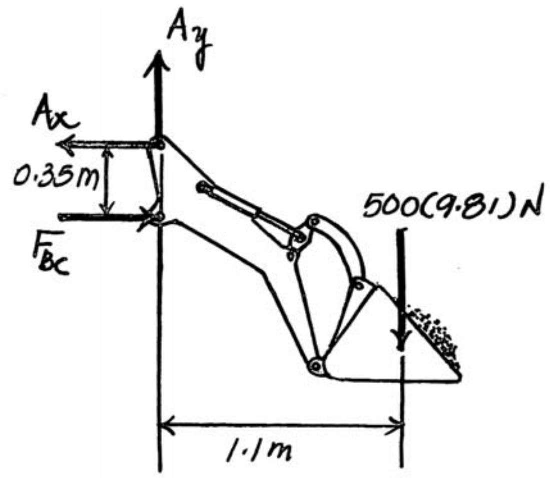


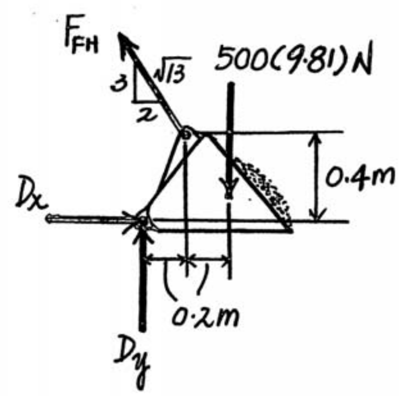



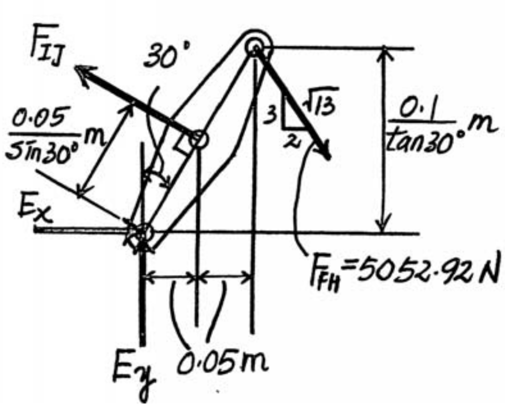



**6–114.** The tractor shovel carries a 500-kg load of soil, having a center of mass at $G$. Compute the forces developed in the hydraulic cylinders $IJ$ and $BC$ due to this loading.




**Shovel :**

$$+\Sigma M_D = 0; \quad -500(9.81)(0.4) + F_{FH}\left(\frac{2}{\sqrt{13}}\right)(0.4) + F_{FH}\left(\frac{3}{\sqrt{13}}\right)(0.2) = 0$$

$$F_{FH} = 5052.92 \text{ N}$$

**Member $EH$ :**

$$+\Sigma M_E = 0; \quad F_{IJ}\left(\frac{0.05}{\sin 30^\circ}\right) - 5052.92\left(\frac{3}{\sqrt{13}}\right)(0.1)$$

$$- 5052.92\left(\frac{2}{\sqrt{13}}\right)\left(\frac{0.1}{\tan 30^\circ}\right) = 0$$

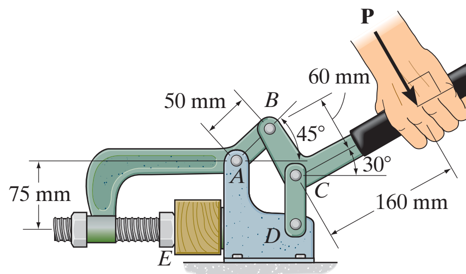
$$F_{IJ} = 9059 \text{ N} = 9.06 \text{ kN (T)} \qquad \textbf{Ans}$$

**Assembly :**

$$+\Sigma M_A = 0; \quad -500(9.81)(1.1) + F_{BC}(0.35) = 0$$

$$F_{BC} = 15\,415.7 \text{ N} = 15.4 \text{ kN (C)} \qquad \textbf{Ans}$$

**6–115.** If a force of $P = 100$ N is applied to the handle of the toggle clamp, determine the horizontal clamping force $N_E$ that the clamp exerts on the smooth wooden block at $E$.




**Equations of Equilibrium:** First, we will consider the free-body diagram of the handle in Fig. *a*.

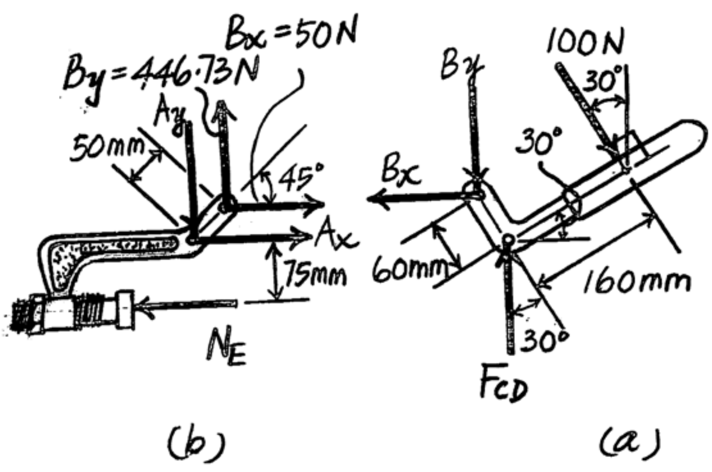
$$\circlearrowleft +\Sigma M_B = 0; \qquad F_{CD}\sin 30°(60) - 100(160) = 0$$
$$F_{CD} = 533.33\text{ N}$$

$$\xrightarrow{+} \Sigma F_x = 0; \qquad 100\sin 30° - B_x = 0$$
$$B_x = 50\text{ N}$$

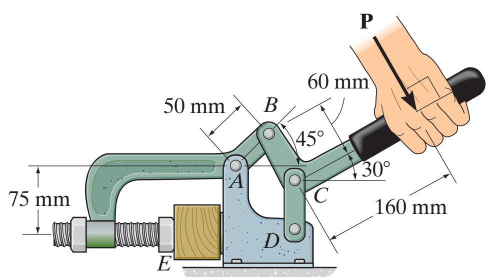
$$+\uparrow \Sigma F_y = 0; \qquad 533.33 - 100\cos 30° - B_y = 0$$
$$B_y = 446.73\text{ N}$$

Using the results of $B_x$ and $B_y$ obtained above and applying the moment equation of equilibrium about point $A$ on the free-body diagram of the clamp in Fig. *b*,

$$\circlearrowleft +\Sigma M_A = 0; \qquad 446.73(50\cos 45°) - 50(50\sin 45°) - N_E(75) = 0$$
$$N_E = 187.02\text{ N} = 187\text{ N} \qquad \textbf{Ans.}$$



***6–116.** If the horizontal clamping force that the toggle clamp exerts on the smooth wooden block at $E$ is $N_E = 200$ N, determine the force **P** applied to the handle of the clamp.




**Equations of Equilibrium:** First, we will consider the free-body diagram of the handle in Fig. *a*.

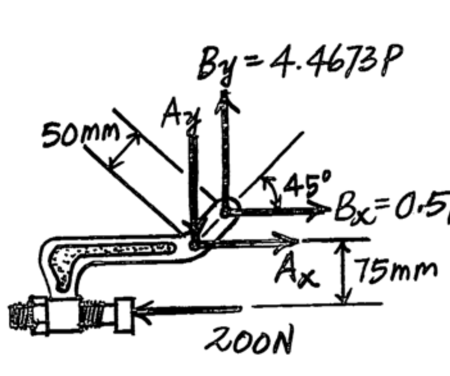
$$\circlearrowleft + \Sigma M_B = 0; \qquad F_{CD} \sin 30°(60) - P(160) = 0$$
$$F_{CD} = 5.333P$$

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad P \sin 30° - B_x = 0$$
$$B_x = 0.5P$$

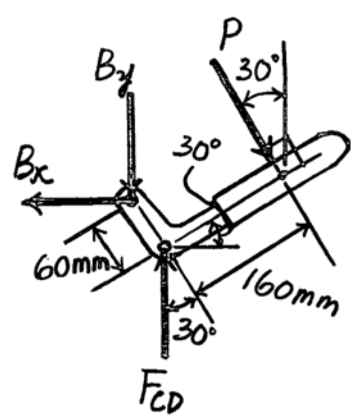
$$+\uparrow \Sigma F_y = 0; \qquad 5.333P - P\cos 30° - B_y = 0$$
$$B_y = 4.4673P$$

Using the results of $B_x$ and $B_y$ obtained above and applying the moment equation of equilibrium about point $A$ on the free-body diagram of the clamp in Fig. *b*,

$$\circlearrowleft + \Sigma M_A = 0; \qquad 4.4673P(50\cos 45°) - 0.5P(50 \sin 45°) - 200(75) = 0$$
$$P = 106.94 \text{ N} = 107 \text{ N}$$ **Ans.**

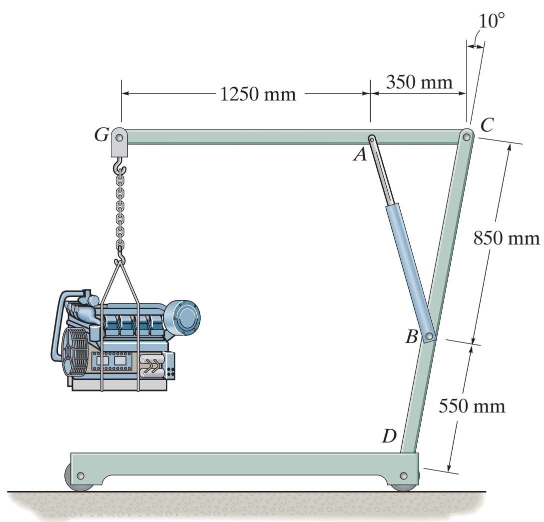



(b)




(a)

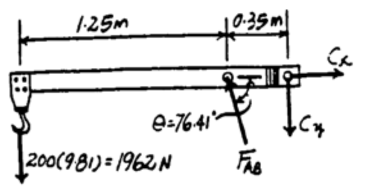
**•6–117.** The engine hoist is used to support the 200-kg engine. Determine the force acting in the hydraulic cylinder $AB$, the horizontal and vertical components of force at the pin $C$, and the reactions at the fixed support $D$.

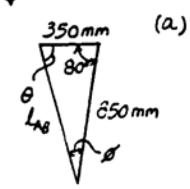



***Free Body Diagram :*** The solution for this problem will be simplified if one realizes that member $AB$ is a two force member. From the geometry,

$$l_{AB} = \sqrt{350^2 + 850^2 - 2(350)(850)\cos 80^\circ} = 861.21 \text{ mm}$$

$$\frac{\sin\theta}{850} = \frac{\sin 80^\circ}{861.21} \qquad \theta = 76.41^\circ$$




***Equations of Equilibrium :*** From FBD (a),

$$\curvearrowleft + \Sigma M_C = 0; \qquad 1962(1.60) - F_{AB}\sin 76.41^\circ(0.35) = 0$$
$$F_{AB} = 9227.60 \text{ N} = 9.23 \text{ kN} \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \qquad C_x - 9227.60\cos 76.41^\circ = 0$$
$$C_x = 2168.65 \text{ N} = 2.17 \text{ kN} \qquad \textbf{Ans}$$

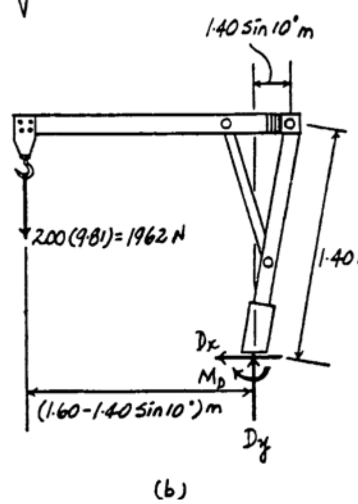
$$+\uparrow \Sigma F_y = 0; \qquad 9227.60\sin 76.41^\circ - 1962 - C_y = 0$$
$$C_y = 7007.14 \text{ N} = 7.01 \text{ kN} \qquad \textbf{Ans}$$

From FBD (b),

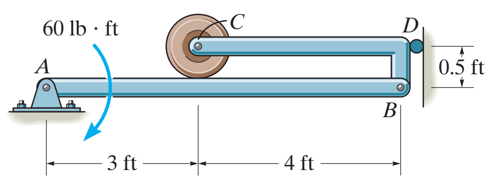
$$\xrightarrow{+} \Sigma F_x = 0; \qquad D_x = 0 \qquad \textbf{Ans}$$

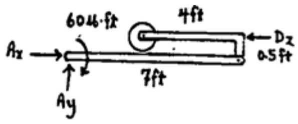
$$+\uparrow \Sigma F_y = 0; \qquad D_y - 1962 = 0$$
$$D_y = 1962 \text{ N} = 1.96 \text{ kN} \qquad \textbf{Ans}$$

$$\curvearrowleft + \Sigma M_D = 0; \qquad 1962(1.60 - 1.40\sin 10^\circ) - M_D = 0$$
$$M_D = 2662.22 \text{ N}\cdot\text{m} = 2.66 \text{ kN}\cdot\text{m} \qquad \textbf{Ans}$$



**6–118.** Determine the force that the smooth roller $C$ exerts on member $AB$. Also, what are the horizontal and vertical components of reaction at pin $A$? Neglect the weight of the frame and roller.



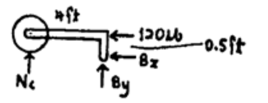




$\circlearrowleft + \Sigma M_A = 0; \quad -60 + D_x(0.5) = 0$

$D_x = 120 \text{ lb}$

$\xrightarrow{+} \Sigma F_x = 0; \quad A_x = 120 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad A_y = 0$ **Ans**




$\circlearrowleft + \Sigma M_B = 0; \quad -N_C(4) + 120(0.5) = 0$

$N_C = 15.0 \text{ lb}$ **Ans**

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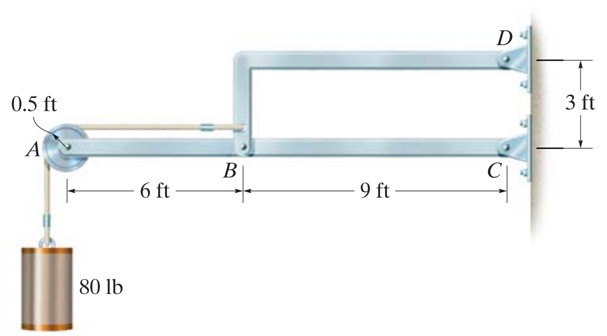
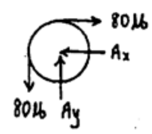
**6–119.** Determine the horizontal and vertical components of reaction which the pins exert on member $ABC$.



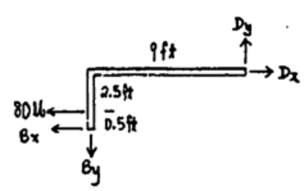




$\xrightarrow{+} \Sigma F_x = 0; \quad A_x = 80 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad A_y = 80 \text{ lb}$ **Ans**

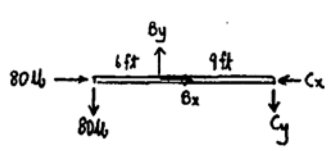
$\circlearrowleft + \Sigma M_C = 0; \quad 80(15) - B_y(9) = 0$

$B_y = 133.3 = 133 \text{ lb}$ **Ans**




$\circlearrowleft + \Sigma M_D = 0; \quad -80(2.5) + 133.3(9) - B_x(3) = 0$

$B_x = 333 \text{ lb}$ **Ans**



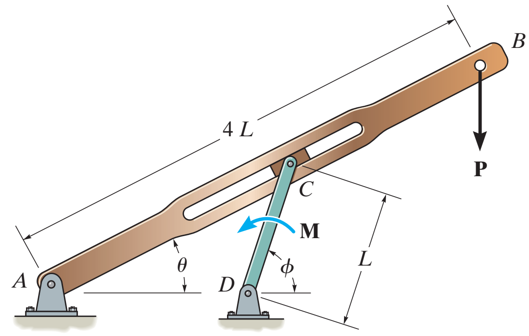

$\xrightarrow{+} \Sigma F_x = 0; \quad 80 + 333 - C_x = 0$

$C_x = 413 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad -80 + 133.3 - C_y = 0$

$C_y = 53.3 \text{ lb}$ **Ans**

***6–120.** Determine the couple moment **M** that must be applied to member *DC* for equilibrium of the quick-return mechanism. Express the result in terms of the angles $\phi$ and $\theta$, dimension $L$, and the applied *vertical force* **P**. The block at *C* is confined to slide within the slot of member *AB*.




$$\frac{x}{4L} = \frac{L\sin\phi}{4L\sin\theta} \qquad x = \frac{L\sin\phi}{\sin\theta}$$

From FBD (a)

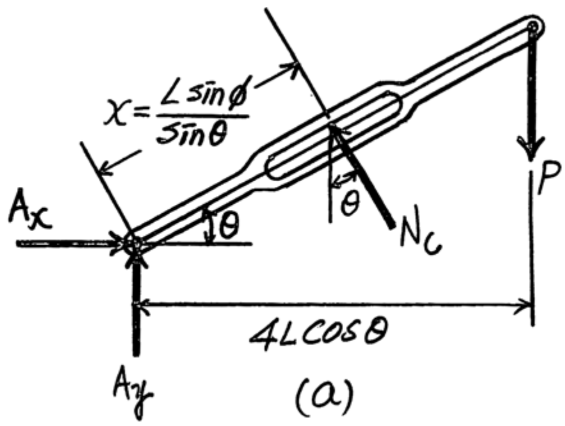
$$\circlearrowleft + \Sigma M_A = 0; \quad N_C\left(\frac{L\sin\phi}{\sin\theta}\right) - P(4L\cos\theta) = 0 \qquad N_C = \frac{4P\cos\theta\sin\theta}{\sin\phi}$$

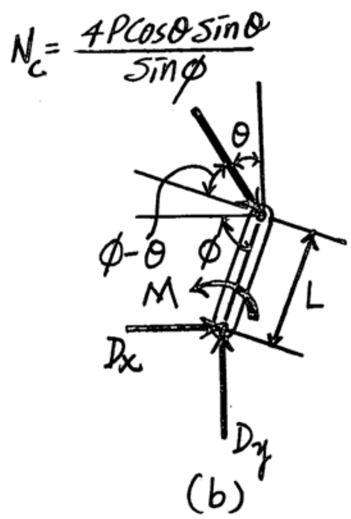
From FBD (b)

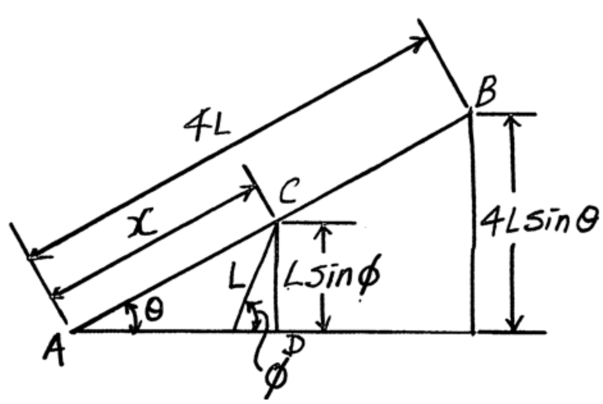
$$\circlearrowleft + \Sigma M_D = 0; \quad M - \frac{4P\cos\theta\sin\theta}{\sin\phi}[\cos(\phi - \theta)]L = 0$$

$$M = \frac{4PL\cos\theta\sin\theta}{\sin\phi}[\cos(\phi - \theta)]$$

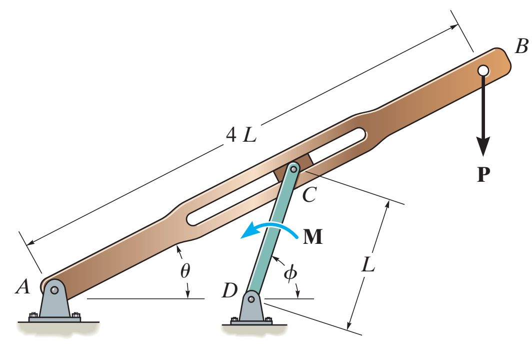
$$= \frac{2PL\sin 2\theta}{\sin\phi}[\cos(\phi - \theta)] \qquad \textbf{Ans}$$



**•6–121.** Determine the couple moment **M** that must be applied to member $DC$ for equilibrium of the quick-return mechanism. Express the result in terms of the angles $\phi$ and $\theta$, dimension $L$, and the applied force **P**, which should be changed in the figure and instead directed horizontally to the right. The block at $C$ is confined to slide within the slot of member $AB$.




$$\frac{x}{4L} = \frac{L\sin\phi}{4L\sin\theta} \qquad x = \frac{L\sin\phi}{\sin\theta}$$

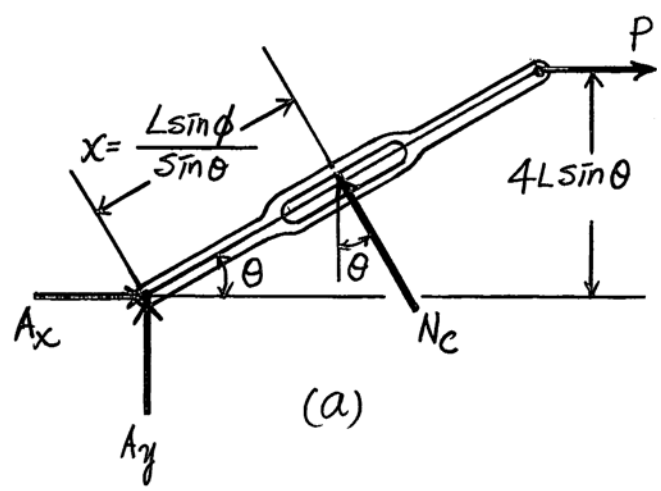
From FBD (a)

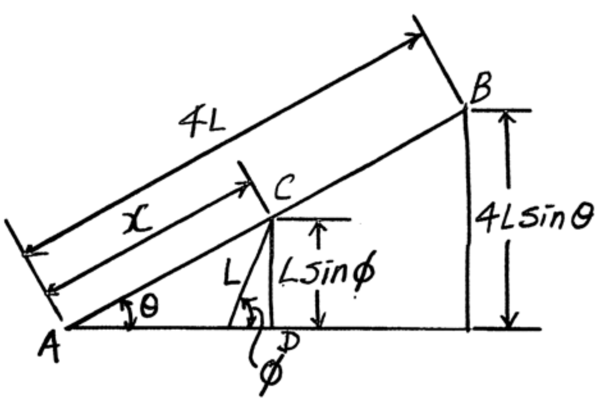
$$\curvearrowleft +\Sigma M_A = 0; \quad N_C\left(\frac{L\sin\phi}{\sin\theta}\right) - P(4L\sin\theta) = 0 \qquad N_C = \frac{4P\sin^2\theta}{\sin\phi}$$

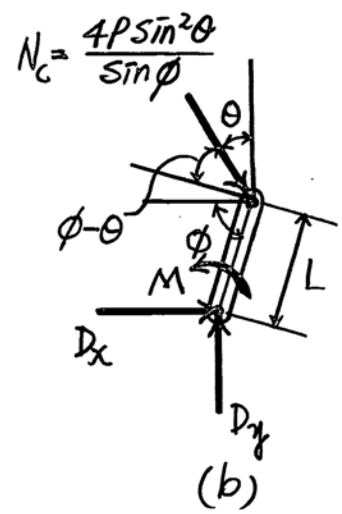
From FBD (b)

$$\curvearrowleft +\Sigma M_D = 0; \quad M - \frac{4P\sin^2\theta}{\sin\phi}[\cos(\phi-\theta)]L = 0$$

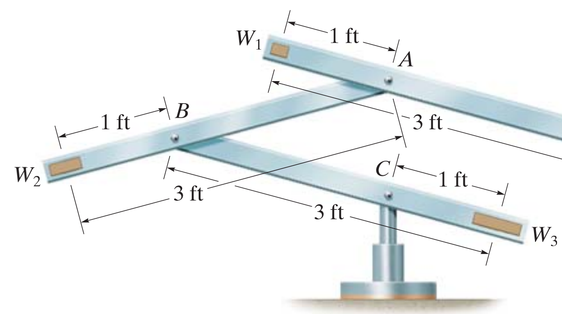
$$M = \frac{4PL\sin^2\theta}{\sin\phi}[\cos(\phi-\theta)] \qquad \textbf{Ans}$$



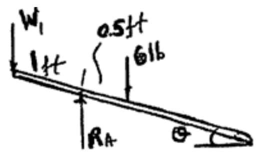



**6–122.** The kinetic sculpture requires that each of the three pinned beams be in perfect balance at all times during its slow motion. If each member has a uniform weight of 2 lb/ft and length of 3 ft, determine the necessary counterweights $W_1$, $W_2$, and $W_3$ which must be added to the ends of each member to keep the system in balance for any position. Neglect the size of the counterweights.




$\circlearrowleft + \Sigma M_A = 0;\quad W_1(1\cos\theta) - 6(0.5\cos\theta) = 0$

$W_1 = 3$ lb **Ans**

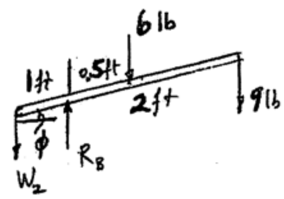



$+\uparrow \Sigma F_y = 0;\quad R_A - 3 - 6 = 0$

$R_A = 9$ lb

$\circlearrowleft + \Sigma M_B = 0;\quad W_2(1\cos\phi) - 6(0.5\cos\phi) - 9(2\cos\phi) = 0$

$W_2 = 21$ lb **Ans**

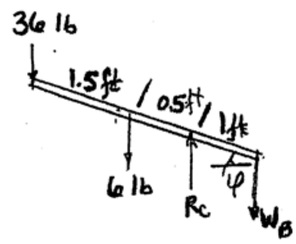



$+\uparrow \Sigma F_y = 0;\quad R_B - 21 - 6 - 9 = 0$

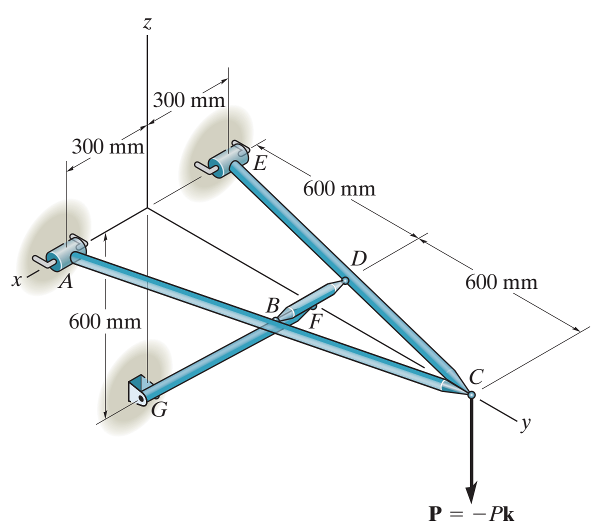
$R_B = 36$ lb

$\circlearrowleft + \Sigma M_C = 0;\quad 36(2\cos\varphi) + 6(0.5\cos\varphi) - W_3(1\cos\varphi) = 0$

$W_3 = 75$ lb **Ans**



**6–123.** The four-member "A" frame is supported at $A$ and $E$ by smooth collars and at $G$ by a pin. All the other joints are ball-and-sockets. If the pin at $G$ will fail when the resultant force there is 800 N, determine the largest vertical force $P$ that can be supported by the frame. Also, what are the $x$, $y$, $z$ force components which member $BD$ exerts on members $EDC$ and $ABC$? The collars at $A$ and $E$ and the pin at $G$ only exert force components on the frame.




*GF* is a two - force member, so the 800 - N force acts along the axis of *GF*. Using FBD (a),

$\Sigma M_x = 0;$ $\quad -P(1.2) + 800\sin 45°(0.6) = 0$

$P = 283\text{ N}$ **Ans.**

$\Sigma M_z = 0;$ $\quad -A_y(0.3) + E_y(0.3) = 0$

$\Sigma F_y = 0;$ $\quad -A_y - E_y + 800\sin 45° = 0$

$A_y = E_y = 283\text{ N}$

$\Sigma M_x = 0;$ $\quad A_z(0.6) + E_z(0.6) - 283((0.6) = 0$

$\Sigma M_y = 0;$ $\quad A_z(0.3) - E_z(0.3) = 0$

$A_z = E_z = 118\text{N}$

Using FBD (b),

$\Sigma F_y = 0;$ $\quad -B_y - D_y + 800\sin 45° = 0$

$\Sigma M_z = 0;$ $\quad D_y(0.3) - B_y(0.3) = 0$

$B_y = D_y = 283\text{ N}$ **Ans.**

$\Sigma F_z = 0;$ $\quad -B_z - D_z + 800\cos 45° = 0$

$\Sigma M_y = 0;$ $\quad -D_z(0.3) + B_z(0.3) = 0$

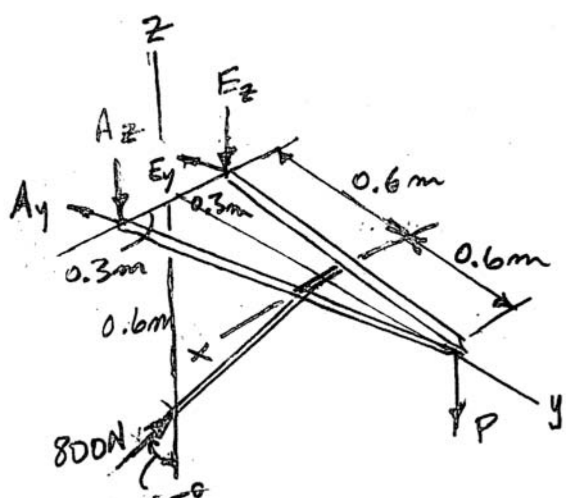
$B_z = D_z = 283\text{ N}$ **Ans.**

$\Sigma F_x = 0;$ $\quad -B_x + D_x = 0$

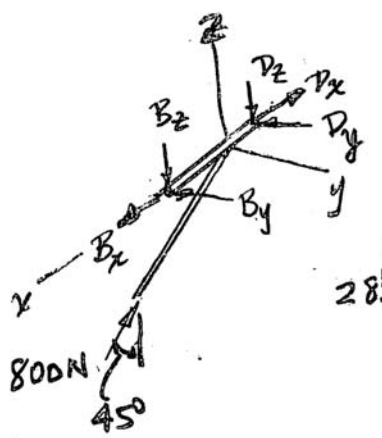
Using FBD (c),

$\Sigma M_z = 0;$ $\quad -B_y(0.6) + 283(0.15) - 283(0.3) = 0$

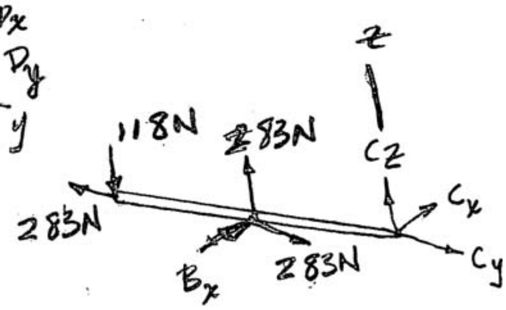
$B_x = D_x = 42.5\text{ N}$ **Ans.**




(a)

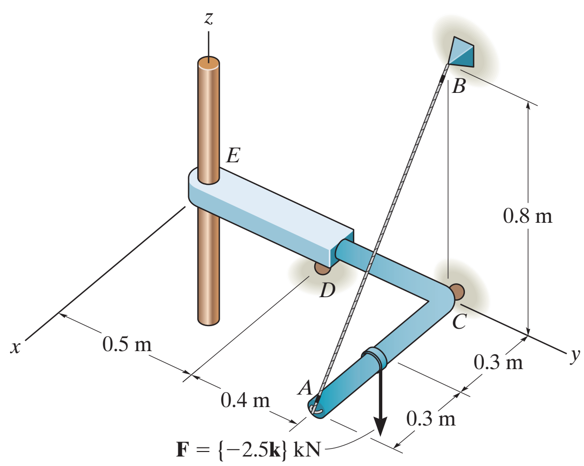



(b)




(c)

***6–124.** The structure is subjected to the loading shown. Member $AD$ is supported by a cable $AB$ and roller at $C$ and fits through a smooth circular hole at $D$. Member $ED$ is supported by a roller at $D$ and a pole that fits in a smooth snug circular hole at $E$. Determine the $x$, $y$, $z$ components of reaction at $E$ and the tension in cable $AB$.

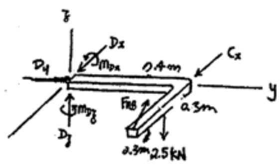



$\Sigma M_y = 0;\quad -\frac{4}{5}F_{AB}(0.6) + 2.5(0.3) = 0$

$F_{AB} = 1.563 = 1.56$ kN  **Ans**

$\Sigma F_z = 0;\quad \frac{4}{5}(1.563) - 2.5 + D_z = 0$

$D_z = 1.25$ kN




$\Sigma F_y = 0;\quad D_y = 0$

$\Sigma F_x = 0;\quad D_x + C_x - \frac{3}{5}(1.563) = 0 \quad (1)$

$\Sigma M_x = 0;\quad M_{Dx} + \frac{4}{5}(1.563)(0.4) - 2.5(0.4) = 0$

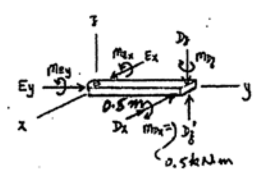
$M_{Dx} = 0.5$ kN·m

$\Sigma M_z = 0;\quad M_{Dz} + \frac{3}{5}(1.563)(0.4) - C_x(0.4) = 0 \quad (2)$

$\Sigma F_z = 0;\quad D_z' = 1.25$ kN

$\Sigma M_x = 0;\quad M_{Ex} = 0.5$ kN·m  **Ans**

$\Sigma M_y = 0;\quad M_{Ey} = 0$  **Ans**




$\Sigma F_y = 0;\quad E_y = 0$  **Ans**

$\Sigma M_z = 0;\quad D_x(0.5) - M_{Dz} = 0 \quad (3)$

Solving Eqs. (1), (2) and (3):

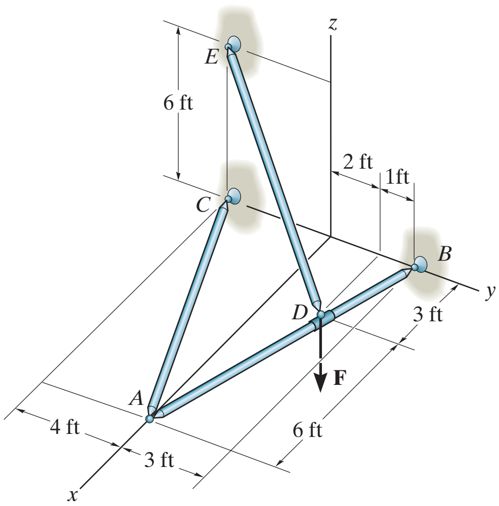
$C_x = 0.938$ kN

$M_{Dz} = 0$

$D_x = 0$

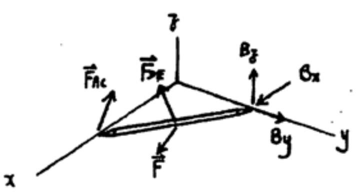
$\Sigma F_x = 0;\quad E_x = 0$  **Ans**

•**6–125.** The three-member frame is connected at its ends using ball-and-socket joints. Determine the $x$, $y$, $z$ components of reaction at $B$ and the tension in member $ED$. The force acting at $D$ is $\mathbf{F} = \{135\mathbf{i} + 200\mathbf{j} - 180\mathbf{k}\}$ lb.




***AC*** **is a two-force member.**

$$\mathbf{F} = \{135\mathbf{i} + 200\mathbf{j} - 180\mathbf{k}\}\ \text{lb}$$




$\Sigma M_y = 0;\qquad -\frac{6}{9}F_{DE}(3) + 180(3) = 0$

$F_{DE} = 270\ \text{lb}$ **Ans**

$\Sigma F_z = 0;\qquad B_z + \frac{6}{9}(270) - 180 = 0$

$B_z = 0$ **Ans**

$\Sigma(M_B)_z = 0;\qquad -\frac{9}{\sqrt{97}}F_{AC}(3) - \frac{4}{\sqrt{97}}F_{AC}(9) + 135(1) + 200(3) - \frac{6}{9}(270)(3) - \frac{3}{9}(270)(1) = 0$

$F_{AC} = 16.41\ \text{lb}$

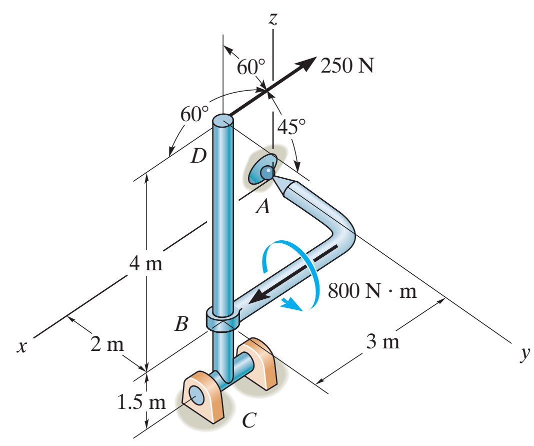
$\Sigma F_x = 0;\qquad 135 - \frac{3}{9}(270) + B_x - \frac{9}{\sqrt{97}}(16.41) = 0$

$B_x = -30\ \text{lb}$ **Ans**

$\Sigma F_y = 0;\qquad B_y - \frac{4}{\sqrt{97}}(16.41) + 200 - \frac{6}{9}(270) = 0$

$B_y = -13.3\ \text{lb}$ **Ans**

**6–126.** The structure is subjected to the loadings shown. Member $AB$ is supported by a ball-and-socket at $A$ and smooth collar at $B$. Member $CD$ is supported by a pin at $C$. Determine the $x$, $y$, $z$ components of reaction at $A$ and $C$.




From FBD (a)

$\Sigma M_y = 0;\qquad M_{By} = 0$

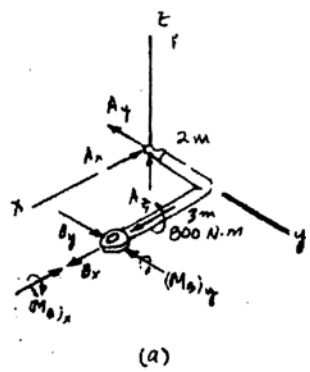
$\Sigma M_x = 0;\qquad -M_{Bx} + 800 = 0 \qquad M_{Bx} = 800\ \text{N}\cdot\text{m}$

$\Sigma M_z = 0;\qquad B_y(3) - B_x(2) = 0 \qquad (1)$

$\Sigma F_z = 0;\qquad A_z = 0 \qquad$ **Ans**

$\Sigma F_x = 0;\qquad -A_x + B_x = 0 \qquad (2)$

$\Sigma F_y = 0;\qquad -A_y + B_y = 0 \qquad (3)$




From FBD (b)

$\Sigma M_x = 0;\qquad B_y(1.5) + 800 - 250\cos 45°(5.5) = 0 \qquad B_y = 114.85\ \text{N}$

From Eq. (1) $\qquad 114.85(3) - B_x(2) = 0 \qquad B_x = 172.27\ \text{N}$

From Eq. (2) $\qquad A_x = 172\ \text{N}$ **Ans**

From Eq. (3) $\qquad A_y = 115\ \text{N}$ **Ans**

$\Sigma F_x = 0;\qquad C_x + 250\cos 60° - 172.27 = 0 \qquad C_x = 47.3\ \text{N}$ **Ans**

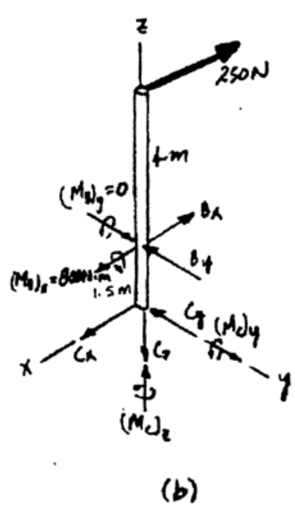
$\Sigma F_y = 0;\qquad 250\cos 45° - 114.85 - C_y = 0 \qquad C_y = 61.9\ \text{N}$ **Ans**

$\Sigma F_z = 0;\qquad 250\cos 60° - C_z = 0 \qquad C_z = 125\ \text{N}$ **Ans**

$\Sigma M_y = 0;\qquad M_{Cy} - 172.27(1.5) + 250\cos 60°(5.5) = 0$

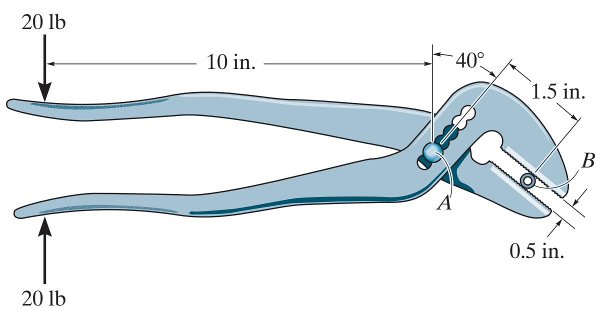
$M_{Cy} = -429\ \text{N}\cdot\text{m}$ **Ans**

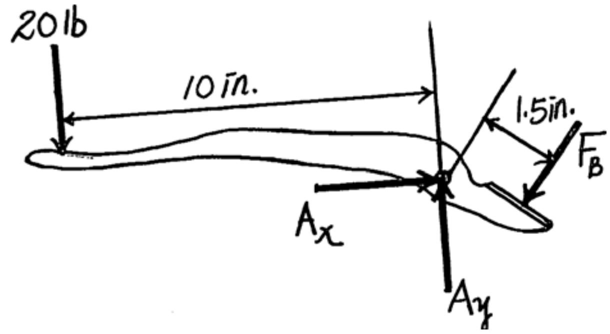
$\Sigma M_z = 0;\qquad M_{Cz} = 0$ **Ans**




Negative sign indicates that $M_{Cy}$ acts in the opposite sense to that shown on FBD.

**6–127.** Determine the clamping force exerted on the smooth pipe at $B$ if a force of 20 lb is applied to the handles of the pliers. The pliers are pinned together at $A$.

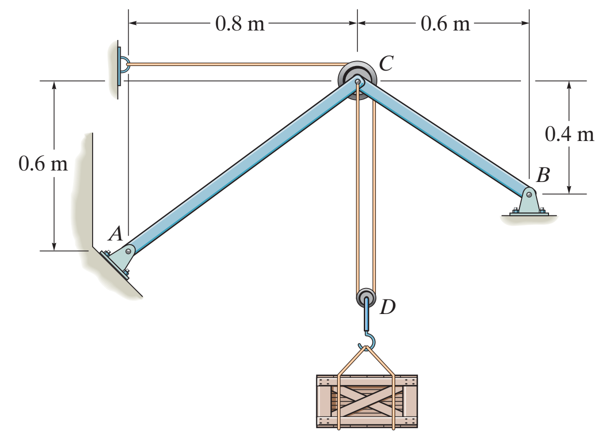



$\circlearrowleft+\Sigma M_A = 0;\qquad 20(10) - 1.5(F_B) = 0$

$F_B = 133\text{ lb}$ **Ans**

*6–128. Determine the forces which the pins at $A$ and $B$ exert on the two-member frame which supports the 100-kg crate.




**$AC$ and $BC$ are two-force members.**

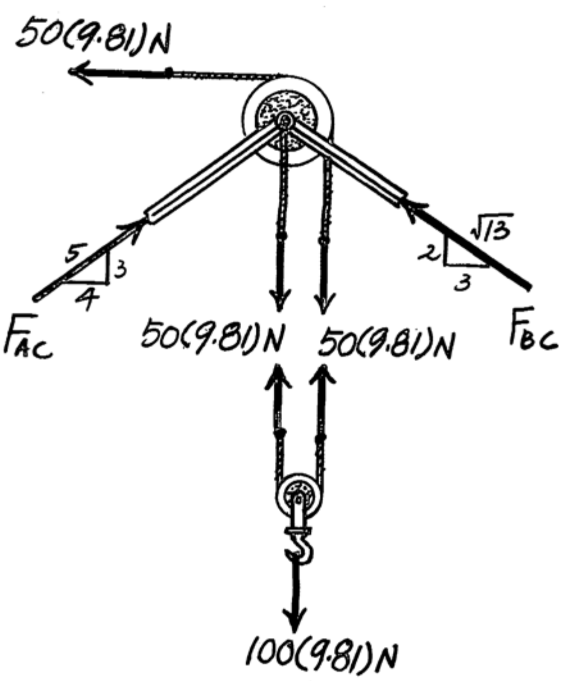
**Pin $C$:**

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AC}\left(\frac{4}{5}\right) - F_{BC}\left(\frac{3}{\sqrt{13}}\right) - 50(9.81) = 0$$

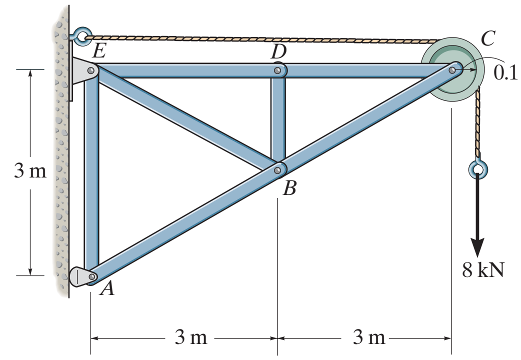
$$+\uparrow \Sigma F_y = 0; \quad F_{AC}\left(\frac{3}{5}\right) + F_{BC}\left(\frac{2}{\sqrt{13}}\right) - 100(9.81) = 0$$

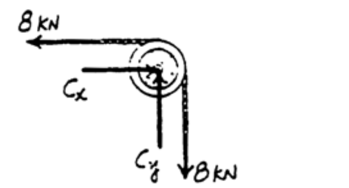
$$F_{AC} = 1154 \text{ N} = 1.15 \text{ kN} \quad \textbf{Ans}$$

$$F_{BC} = 520 \text{ N} \quad \textbf{Ans}$$



**•6–129.** Determine the force in each member of the truss and state if the members are in tension or compression.

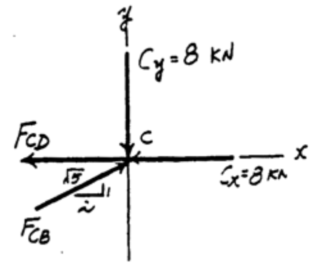



***Method of Joint :*** In this case, support reactions are not required for determining the member forces. By inspection, members *DB* and *BE* are zero force members. Hence

$$F_{DB} = F_{BE} = 0 \qquad \textbf{Ans}$$

**Joint *C***



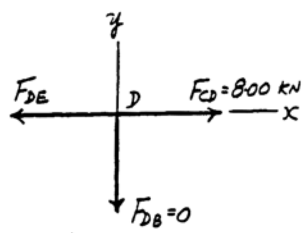

$$+\uparrow \Sigma F_y = 0; \qquad F_{CB}\left(\frac{1}{\sqrt{5}}\right) - 8 = 0$$

$$F_{CB} = 17.89 \text{ kN (C)} = 17.9 \text{ kN (C)} \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \qquad 17.89\left(\frac{2}{\sqrt{5}}\right) - 8 - F_{CD} = 0$$

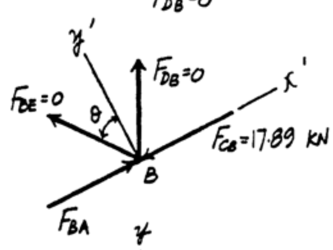
$$F_{CD} = 8.00 \text{ kN (T)} \qquad \textbf{Ans}$$

**Joint *D***




$$\xrightarrow{+} \Sigma F_x = 0; \qquad 8.00 - F_{DE} = 0 \qquad F_{DE} = 8.00 \text{ kN (T)} \qquad \textbf{Ans}$$

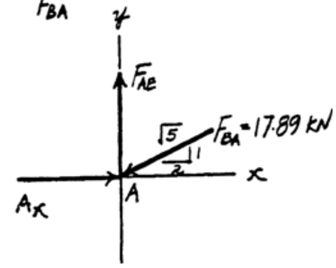
**Joint *B***




$$+ \Sigma F_{x'} = 0; \qquad F_{BA} - 17.89 = 0$$

$$F_{BA} = 17.89 \text{ kN (C)} = 17.9 \text{ kN (C)} \qquad \textbf{Ans}$$

**Joint *A***



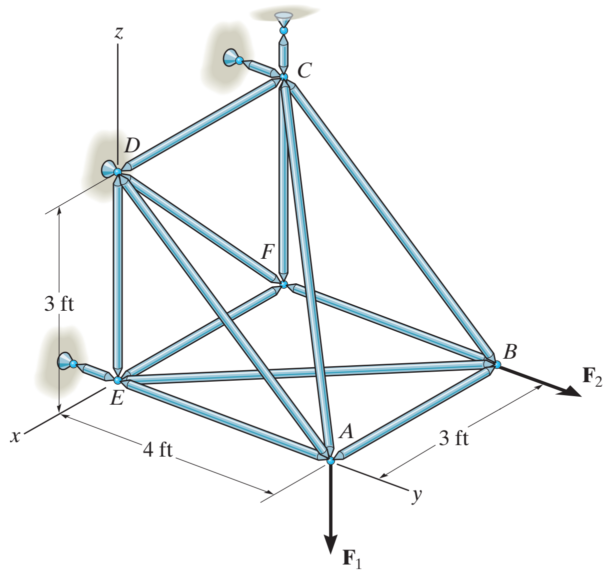

$$+\uparrow \Sigma F_y = 0; \qquad F_{AE} - 17.89\left(\frac{1}{\sqrt{5}}\right) = 0$$

$$F_{AE} = 8.00 \text{ kN (T)} \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \qquad A_x - 17.89\left(\frac{2}{\sqrt{5}}\right) = 0 \qquad A_x = 16.0 \text{ kN}$$

**Note :** The support reactions $E_x$ and $E_y$ can be determined by analyzing Joint *E* using the results obtained above.

**6–130.** The space truss is supported by a ball-and-socket joint at $D$ and short links at $C$ and $E$. Determine the force in each member and state if the members are in tension or compression. Take $\mathbf{F}_1 = \{-500\mathbf{k}\}$ lb and $\mathbf{F}_2 = \{400\mathbf{j}\}$ lb.




$\Sigma M_x = 0;\quad -C_y(3) - 400(3) = 0$

$C_y = -400$ lb

$\Sigma F_x = 0;\quad D_x = 0$

$\Sigma M_y = 0;\quad C_x = 0$

**Joint $F$:** $\Sigma F_y = 0;\quad F_{BF} = 0$ Ans

**Joint $B$:**

$\Sigma F_z = 0;\quad F_{BC} = 0$ Ans

$\Sigma F_y = 0;\quad 400 - \frac{4}{5}F_{BE} = 0$

$F_{BE} = 500$ lb (T) Ans

$\Sigma F_x = 0;\quad F_{AB} - \frac{3}{5}(500) = 0$

$F_{AB} = 300$ lb (C) Ans

**Joint $A$:**

$\Sigma F_x = 0;\quad 300 - \frac{3}{\sqrt{34}}F_{AC} = 0$

$F_{AC} = 583.1 = 583$ lb (T) Ans

$\Sigma F_z = 0;\quad \frac{3}{\sqrt{34}}(583.1) - 500 + \frac{3}{5}F_{AD} = 0$

$F_{AD} = 333$ lb (T) Ans

$\Sigma F_y = 0;\quad F_{AE} - \frac{4}{5}(333.3) - \frac{4}{\sqrt{34}}(583.1) = 0$

$F_{AE} = 667$ lb (C) Ans

**Joint $E$:**

$\Sigma F_z = 0;\quad F_{DE} = 0$ Ans

$\Sigma F_x = 0;\quad F_{EF} - \frac{3}{5}(500) = 0$

$F_{EF} = 300$ lb (C) Ans

**Joint $C$:**

$\Sigma F_x = 0;\quad \frac{3}{\sqrt{34}}(583.1) - F_{CD} = 0$

$F_{CD} = 300$ lb (C) Ans

$\Sigma F_z = 0;\quad F_{CF} - \frac{3}{\sqrt{34}}(583.1) = 0$

$F_{CF} = 300$ lb (C) Ans

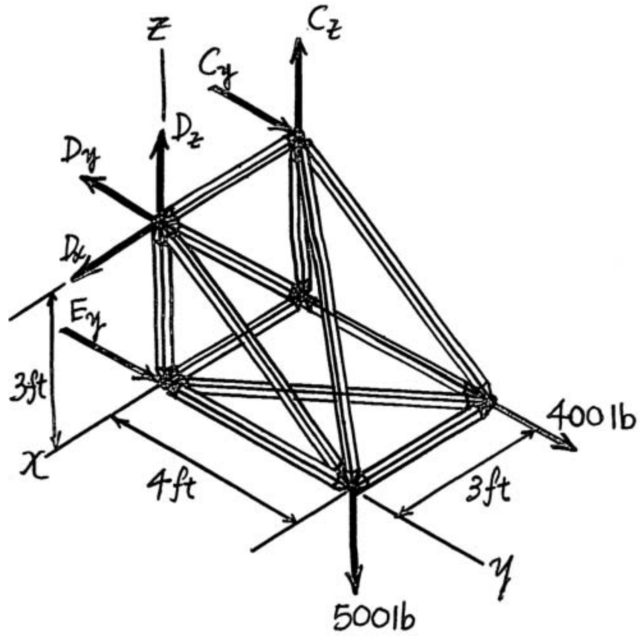
$\Sigma F_y = 0;\quad \frac{4}{\sqrt{34}}(583.1) - 400 = 0$ Check!

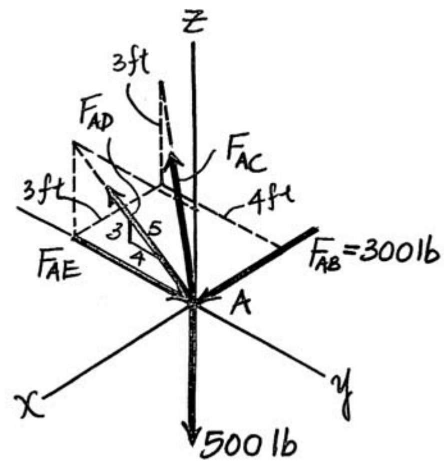
**Joint $F$:**

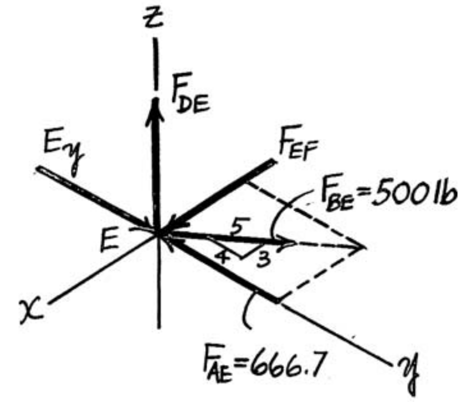
$\Sigma F_x = 0;\quad \frac{3}{\sqrt{18}}F_{DF} - 300 = 0$

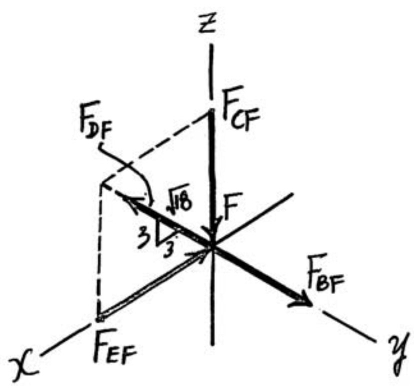
$F_{DF} = 424$ lb (T) Ans

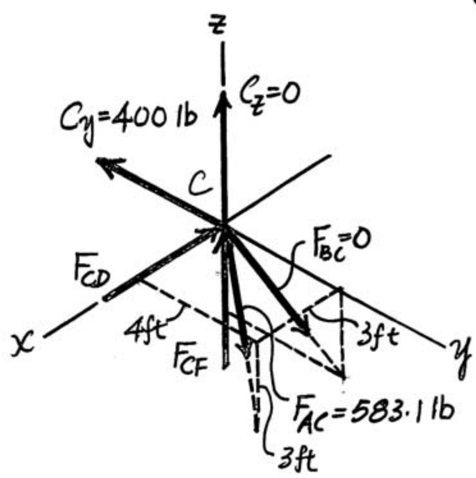
$\Sigma F_z = 0;\quad \frac{3}{\sqrt{18}}(424.3) - 300 = 0$ Check!

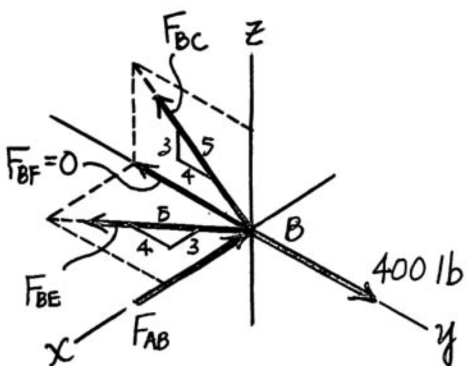

z
Cz
Cy
Dz
Dy
Dx
Ey
3ft
x
4ft
3ft
400 lb
y
500 lb


z
3ft
FAD
FAC
3ft
4ft
3
5
4
FAE
FAB=300 lb
A
x
y
500 lb

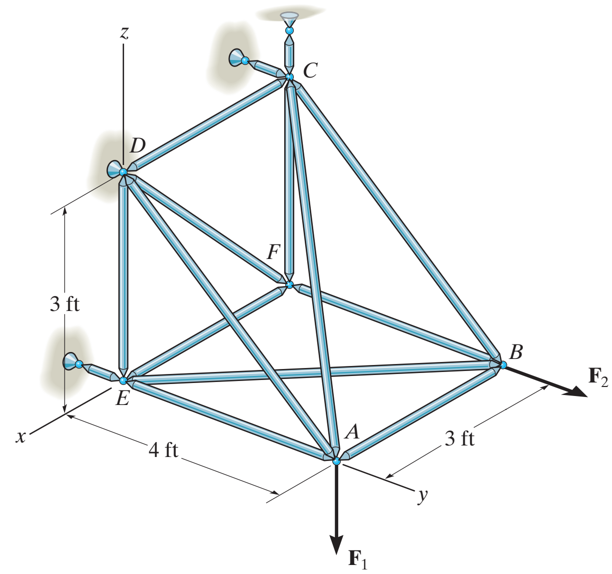

z
FDE
Ey
FEF
FBE=500 lb
5
E
4
3
x
FAE=666.7
y

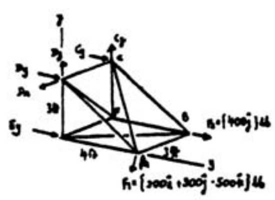

z
FCF
FDF
√18
F
3
3
FBF
x
FEF
y

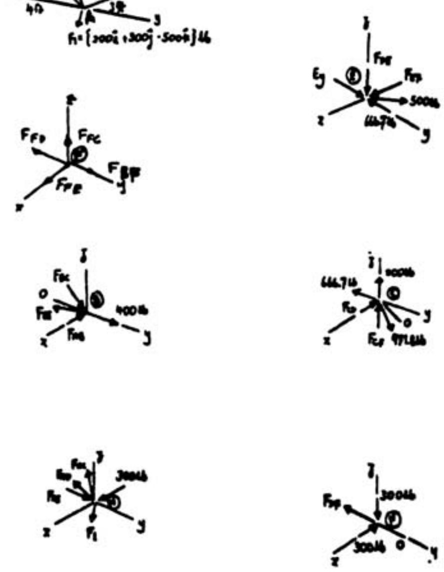

z
Cy=400 lb
Cz=0
C
FBC=0
FCD
x
4ft
FCF
3ft
y
FAC=583.1 lb
3ft


FBC
z
FBF=0
3
5
4
5
4
3
B
400 lb
FBE
x
FAB
y

**6–131.** The space truss is supported by a ball-and-socket joint at $D$ and short links at $C$ and $E$. Determine the force in each member and state if the members are in tension or compression. Take $\mathbf{F}_1 = \{200\mathbf{i} + 300\mathbf{j} - 500\mathbf{k}\}$ lb and $\mathbf{F}_2 = \{400\mathbf{j}\}$ lb.





$\Sigma F_x = 0;\quad D_x + 200 = 0$

$D_x = -200$ lb

$\Sigma M_x = 0;\quad -C_y(3) - 400(3) - 200(4) = 0$

$C_y = -666.7$ lb

$\Sigma M_y = 0;\quad C_z(3) - 200(3) = 0$

$C_z = 200$ lb

**Joint $F$:**

$\Sigma F_y = 0;\quad F_{BF} = 0$ **Ans**

**Joint $B$:**

$\Sigma F_z = 0;\quad F_{BC} = 0$ **Ans**

$\Sigma F_y = 0;\quad 400 - \frac{4}{5}F_{BE} = 0$

$F_{BE} = 500$ lb (T) **Ans**

$\Sigma F_x = 0;\quad F_{AB} - \frac{3}{5}(500) = 0$

$F_{AB} = 300$ lb (C) **Ans**

**Joint $A$:**

$\Sigma F_x = 0;\quad 300 + 200 - \frac{3}{\sqrt{34}}F_{AC} = 0$

$F_{AC} = 971.8 = 972$ lb (T) **Ans**

$\Sigma F_z = 0;\quad \frac{3}{\sqrt{34}}(971.8) - 500 + \frac{3}{5}F_{AD} = 0$

$F_{AD} = 0$ **Ans**

$\Sigma F_y = 0;\quad F_{AE} + 300 - \frac{4}{\sqrt{34}}(971.8) = 0$

$F_{AE} = 367$ lb (C) **Ans**

**Joint $E$:**

$\Sigma F_z = 0;\quad F_{DE} = 0$ **Ans**

$\Sigma F_x = 0;\quad F_{EF} - \frac{3}{5}(500) = 0$

$F_{EF} = 300$ lb (C) **Ans**

**Joint $C$:**

$\Sigma F_x = 0;\quad \frac{3}{\sqrt{34}}(971.8) - F_{CD} = 0$

$F_{CD} = 500$ lb (C) **Ans**

$\Sigma F_z = 0;\quad F_{CF} - \frac{3}{\sqrt{34}}(971.8) + 200 = 0$

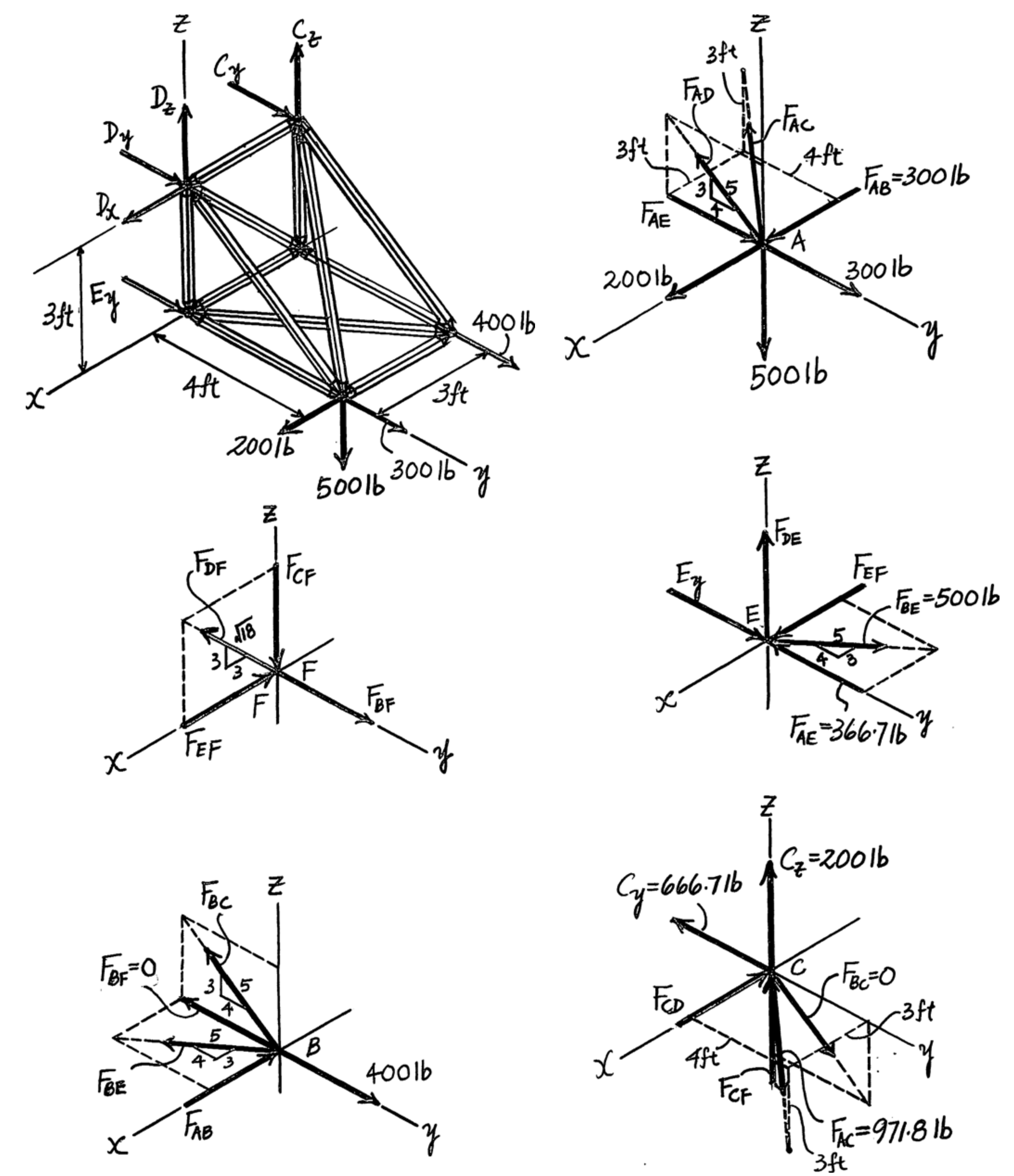
$F_{CF} = 300$ lb (C) **Ans**

$\Sigma F_y = 0;\quad \frac{4}{\sqrt{34}}(971.8) - 666.7 = 0$ **Check!**

**Joint $F$:**

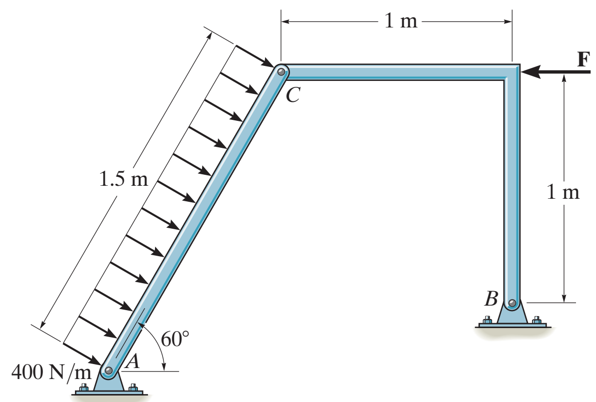
$\Sigma F_x = 0;\quad \frac{3}{\sqrt{18}}F_{DF} - 300 = 0$

$F_{DF} = 424$ lb (T) **Ans**



z
Cz
Cy
Dz
Dy
Dx
3ft
Ey
400 lb
x
4ft
3ft
200 lb
500 lb
300 lb
y
3ft
FAD
FAC
3ft
4ft
FAB=300 lb
3
5
4
FAE
A
200 lb
300 lb
500 lb
FDF
FCF
√18
3
3
F
F
FBF
FEF
FDE
Ey
FEF
FBE=500 lb
E
5
4
3
FAE=366.7 lb
Cz=200 lb
Cy=666.7 lb
FBC
FBF=0
3
5
4
5
4
3
B
400 lb
FBE
FAB
C
FBC=0
FCD
3ft
4ft
FCF
FAC=971.8 lb
3ft

***6–132.** Determine the horizontal and vertical components of reaction that the pins $A$ and $B$ exert on the two-member frame. Set $F = 0$.




$CB$ is a two-force member.

Member $AC$:

$\circlearrowleft + \Sigma M_A = 0; \quad -600(0.75) + 1.5(F_{CB} \sin 75°) = 0$

$F_{CB} = 310.6$

Thus,

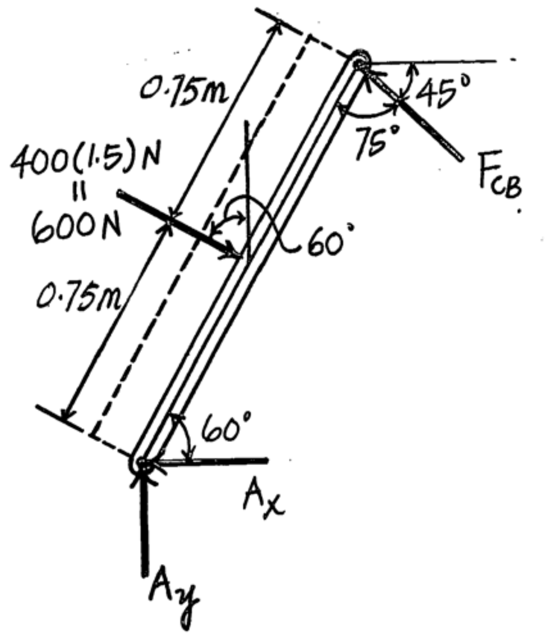
$$B_x = B_y = 310.6\left(\frac{1}{\sqrt{2}}\right) = 220 \text{ N} \quad \textbf{Ans}$$

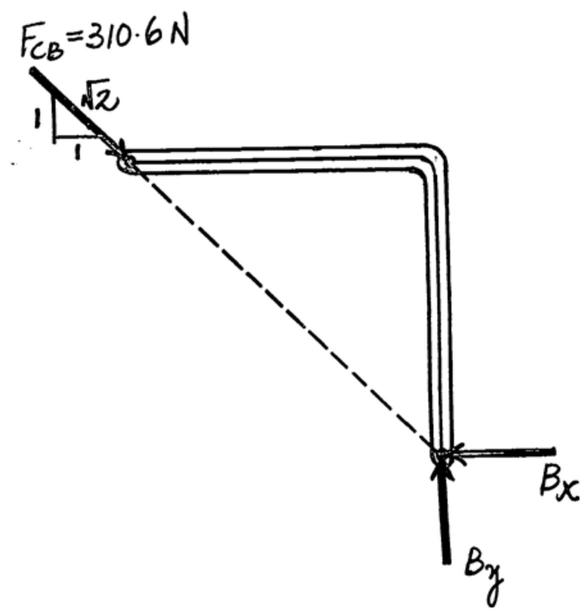
$\xrightarrow{+} \Sigma F_x = 0; \quad -A_x + 600 \sin 60° - 310.6 \cos 45° = 0$

$A_x = 300 \text{ N} \quad \textbf{Ans}$

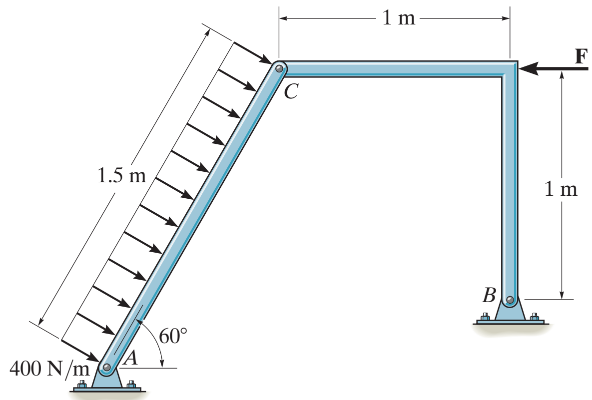
$+\uparrow \Sigma F_y = 0; \quad A_y - 600 \cos 60° + 310.6 \sin 45° = 0$

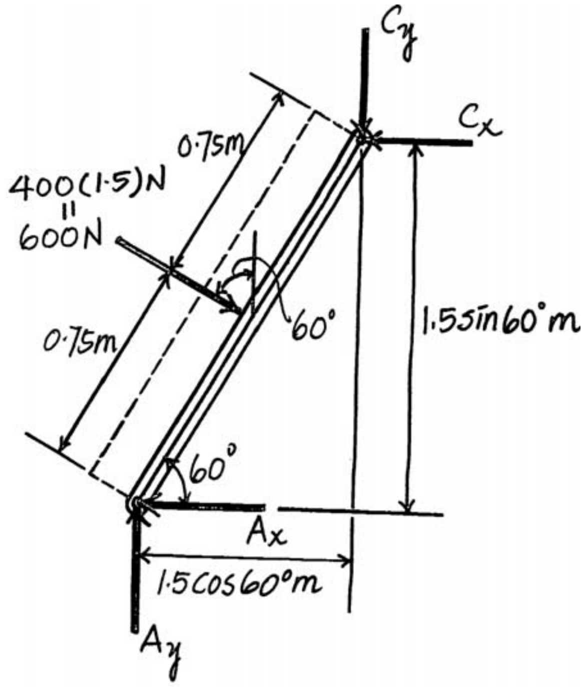
$A_y = 80.4 \text{ N} \quad \textbf{Ans}$



**•6–133.** Determine the horizontal and vertical components of reaction that pins $A$ and $B$ exert on the two-member frame. Set $F = 500$ N.




**Member AC:**

$\curvearrowleft+\Sigma M_A = 0;\quad -600\,(0.75) - C_y\,(1.5\cos 60^\circ) + C_x\,(1.5\sin 60^\circ) = 0$

**Member CB:**

$\curvearrowleft+\Sigma M_B = 0;\quad -C_x\,(1) - C_y\,(1) + 500\,(1) = 0$

Solving,

$C_x = 402.6\text{ N}$

$C_y = 97.4\text{ N}$

**Member AC:**

$\xrightarrow{+}\Sigma F_x = 0;\quad -A_x + 600\sin 60^\circ - 402.6 = 0$

$A_x = 117\text{ N}$ **Ans**

$+\uparrow\Sigma F_y = 0;\quad A_y - 600\cos 60^\circ - 97.4 = 0$

$A_y = 397\text{ N}$ **Ans**

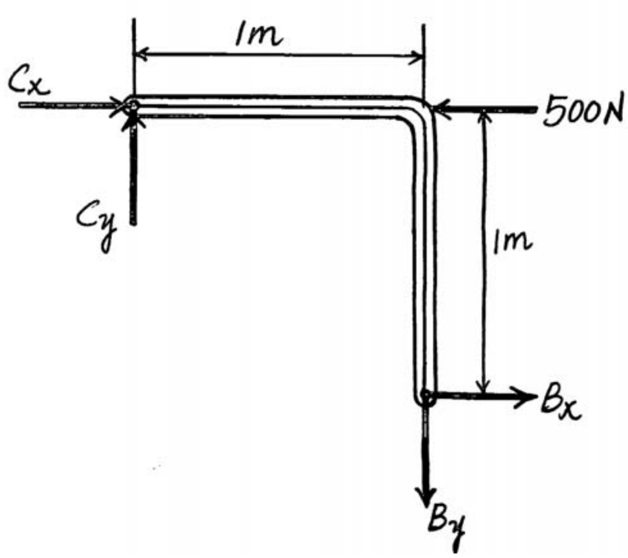
**Member CB:**

$\xrightarrow{+}\Sigma F_x = 0;\quad 402.6 - 500 + B_x = 0$

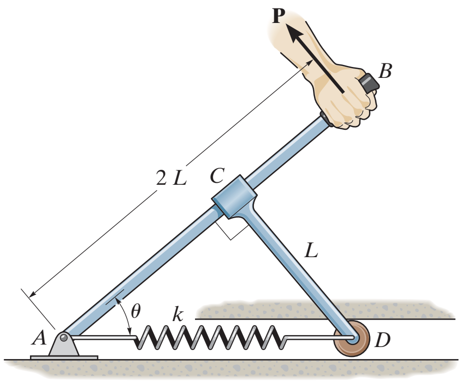
$B_x = 97.4\text{ N}$ **Ans**

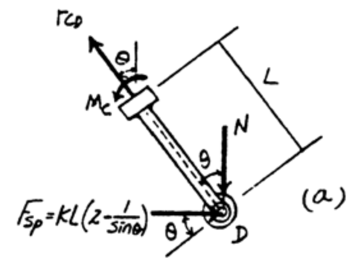
$+\uparrow\Sigma F_y = 0;\quad -B_y + 97.4 = 0$

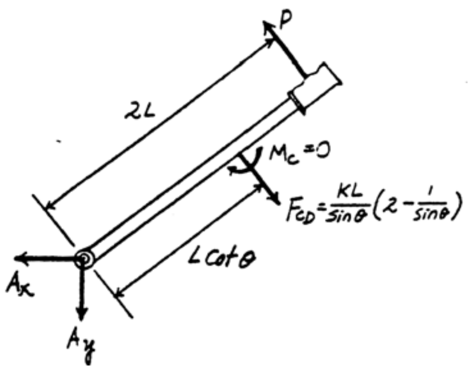
$B_y = 97.4\text{ N}$ **Ans**



**6–134.** The two-bar mechanism consists of a lever arm $AB$ and smooth link $CD$, which has a fixed smooth collar at its end $C$ and a roller at the other end $D$. Determine the force **P** needed to hold the lever in the position $\theta$. The spring has a stiffness $k$ and unstretched length $2L$. The roller contacts either the top or bottom portion of the horizontal guide.




***Free Body Diagram :*** The spring compresses $x = 2L - \dfrac{L}{\sin\theta}$. Then, the spring force developed is $F_{sp} = kx = kL\left(2 - \dfrac{1}{\sin\theta}\right)$.

***Equations of Equilibrium :*** From FBD (a),

$$\xrightarrow{+} \Sigma F_x = 0; \quad kL\left(2 - \frac{1}{\sin\theta}\right) - F_{CD}\sin\theta = 0$$

$$F_{CD} = \frac{kL}{\sin\theta}\left(2 - \frac{1}{\sin\theta}\right)$$

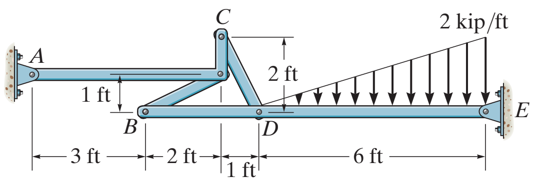
$$\circlearrowleft + \Sigma M_D = 0; \qquad M_C = 0$$

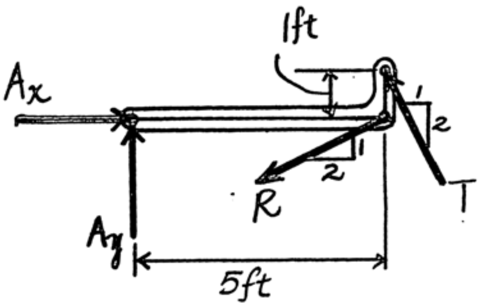
From FBD (b),

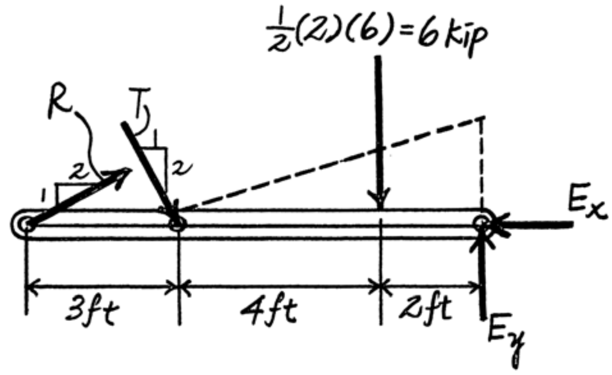
$$\circlearrowleft + \Sigma M_A = 0; \quad P(2L) - \frac{kL}{\sin\theta}\left(2 - \frac{1}{\sin\theta}\right)(L\cot\theta) = 0$$

$$P = \frac{kL}{2\tan\theta\sin\theta}(2 - \csc\theta) \qquad \textbf{Ans}$$

**6–135.** Determine the horizontal and vertical components of reaction at the pin supports $A$ and $E$ of the compound beam assembly.




Member $BDE$ :

$$\curvearrowleft+\Sigma M_E = 0; \quad 6\,(2) + T\left(\frac{2}{\sqrt{5}}\right)(6) - R\left(\frac{1}{\sqrt{5}}\right)(9) = 0$$

Member $AC$ :

$$\curvearrowleft+\Sigma M_A = 0; \quad T\left(\frac{1}{\sqrt{5}}\right)(1) + T\left(\frac{2}{\sqrt{5}}\right)(5) - R\left(\frac{1}{\sqrt{5}}\right)(5) = 0$$

Solving,

$$T = 3.440 \text{ kip}, \quad R = 7.568 \text{ kip}$$

Member $AC$ :

$$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - 7.568\left(\frac{2}{\sqrt{5}}\right) - 3.440\left(\frac{1}{\sqrt{5}}\right) = 0$$

$$A_x = 8.31 \text{ kip} \quad \textbf{Ans}$$

$$+\uparrow \Sigma F_y = 0; \quad A_y - 7.568\left(\frac{1}{\sqrt{5}}\right) + 3.440\left(\frac{2}{\sqrt{5}}\right) = 0$$

$$A_y = 0.308 \text{ kip} \quad \textbf{Ans}$$

Member $BDE$ :

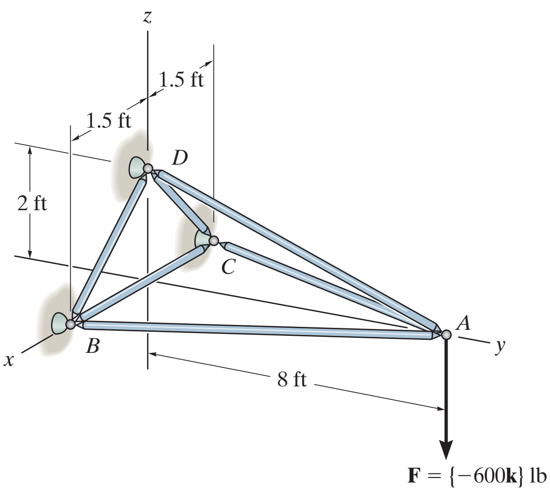
$$\xrightarrow{+} \Sigma F_x = 0; \quad 7.568\left(\frac{2}{\sqrt{5}}\right) + 3.440\left(\frac{1}{\sqrt{5}}\right) - E_x = 0$$

$$E_x = 8.31 \text{ kip} \quad \textbf{Ans}$$

$$+\uparrow \Sigma F_y = 0; \quad 7.568\left(\frac{1}{\sqrt{5}}\right) - 3.440\left(\frac{2}{\sqrt{5}}\right) - 6 + E_y = 0$$

$$E_y = 5.69 \text{ kip} \quad \textbf{Ans}$$

***6–136.** Determine the force in members $AB$, $AD$, and $AC$ of the space truss and state if the members are in tension or compression.




***Method of Joints :*** In this case the support reactions are not required for determining the member forces.

**Joint A**

$$\Sigma F_z = 0; \quad F_{AD}\left(\frac{2}{\sqrt{68}}\right) - 600 = 0$$

$$F_{AD} = 2473.86 \text{ lb (T)} = 2.47 \text{ kip (T)} \qquad \textbf{Ans}$$

$$\Sigma F_x = 0; \quad F_{AC}\left(\frac{1.5}{\sqrt{66.25}}\right) - F_{AB}\left(\frac{1.5}{\sqrt{66.25}}\right) = 0$$

$$F_{AC} = F_{AB} \qquad [1]$$

$$\Sigma F_y = 0; \quad F_{AC}\left(\frac{8}{\sqrt{66.25}}\right) + F_{AB}\left(\frac{8}{\sqrt{66.25}}\right) - 2473.86\left(\frac{8}{\sqrt{68}}\right) = 0$$

$$0.9829F_{AC} + 0.9829F_{AB} = 2400 \qquad [2]$$

Solving Eqs. [1] and [2] yields

$$F_{AC} = F_{AB} = 1220.91 \text{ lb (C)} = 1.22 \text{ kip (C)} \qquad \textbf{Ans}$$