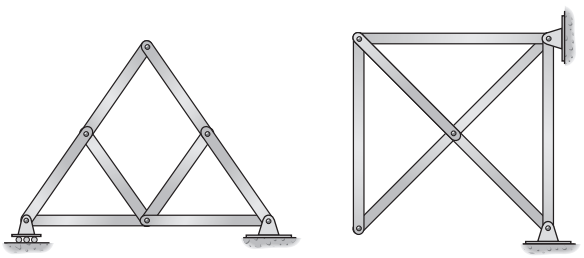
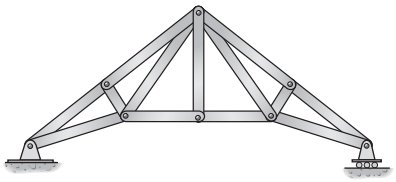
3–1. Classify each of the following trusses as statically determinate, statically indeterminate, or unstable. If indeterminate, state its degree.



(a) (b)

a) $b = 8,\ r = 3,\ j = 6$
$b + r = 2j$
$11 < 12$
Unstable. **Ans.**

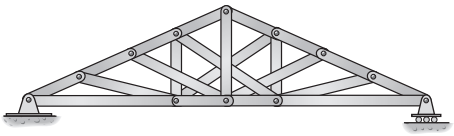
b) $b = 7,\ r = 4,\ j = 5$
$b + r = 2j$
$11 > 10$
Statically indeterminate to 1°. **Ans.**



(c)

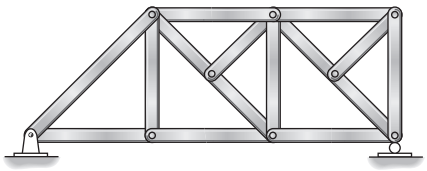
c) $b = 13,\ r = 3,\ j = 8$
$b + r = 2j$
$16 = 16$
Statically determinate. **Ans.**

d) $b = 21,\ r = 3,\ j = 12$
$b + r = 2j$
$24 = 24$
Statically determinate. **Ans.**



(d)

3–2. Classify each of the following trusses as stable, unstable, statically determinate, or statically indeterminate. If indeterminate, state its degree.

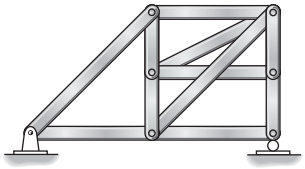


(a)

(a) $r = 3$
$b = 15$
$j = 9$

$3 + 15 = 9(2)$

Statically determinate. **Ans.**

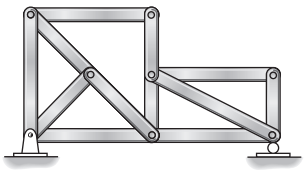


(b)

(b) $r = 3$
$b = 11$
$j = 7$

$3 + 11 = 7(2)$

Statically determinate. **Ans.**



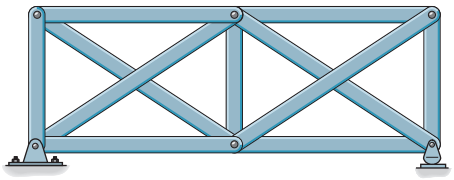
(c)

(c) $r = 3$
$b = 12$
$j = 8$

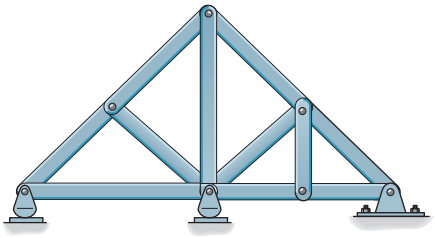
$3 + 12 < 8(2)$
$15 < 16$

Unstable. **Ans.**

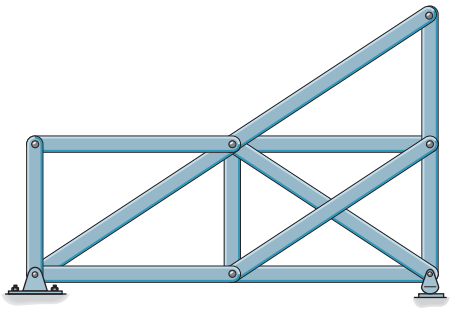
3–3. Classify each of the following trusses as statically determinate, indeterminate, or unstable. If indeterminate, state its degree.



(a)



(b)



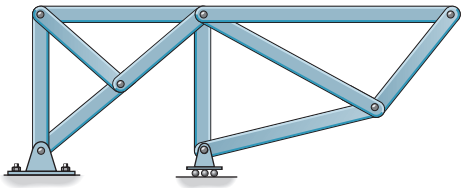
(c)

a) By inspection, the truss is **internally and externally stable**. Here, $b = 11$, $r = 3$ and $j = 6$. Since $b + r > 2j$ and $(b + r) - 2j = 14 - 12 = 2$, the truss is **statically indeterminate to the second degree**.

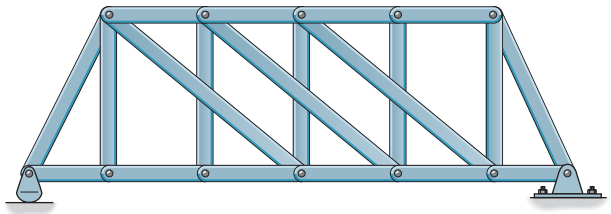
b) By inspection, the truss is **internally and externally stable**. Here, $b = 11$, $r = 4$ and $j = 7$. Since $b + r > 2j$ and $(b + r) - 2j = 15 - 14 = 1$, the truss is **statically indeterminate to the first degree**.

c) By inspection, the truss is **internally and externally stable**. Here, $b = 12$, $r = 3$ and $j = 7$. Since $b + r > 2j$ and $(b + r) - 2j = 15 - 14 = 1$, the truss is **statically indeterminate to the first degree**.

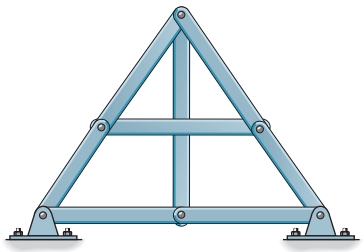
***3–4.** Classify each of the following trusses as statically determinate, statically indeterminate, or unstable. If indeterminate, state its degree.



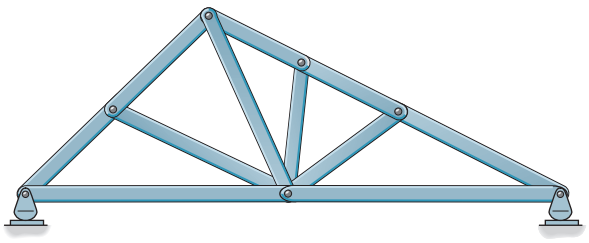
(a)



(b)



(c)



(d)

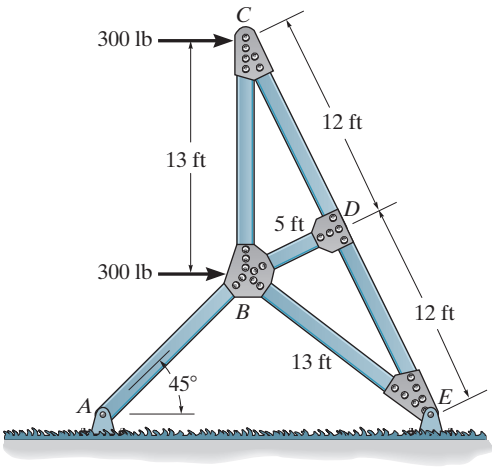
a) Here $b = 10$, $r = 3$ and $j = 7$. Since $b + r < 2j$, the truss is **unstable**.

b) Here $b = 20$, $r = 3$ and $j = 12$. Since $b + r < 2j$, the truss is **unstable**.

c) By inspection, the truss is **internally and externally stable**. Here, $b = 8$, $r = 4$ and $j = 6$. Since $b + r = 2j$, the truss is **statically determinate**.

d) By inspection, the truss is **unstable externally** since the line of action of all the support reactions are parallel.

3–5. 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*: Fig. *a*.

$$\stackrel{+}{\rightarrow}\sum F_x = 0;\quad 300 - F_{CD}\left(\frac{5}{13}\right) = 0 \quad F_{CD} = 780\text{ lb (C)} \qquad \textbf{Ans.}$$

$$+\uparrow \sum F_y = 0;\quad 780\left(\frac{12}{13}\right) - F_{CB} = 0 \quad F_{CB} = 720\text{ lb (T)} \qquad \textbf{Ans.}$$

Joint *D*: Fig. *b*.

$$+\nearrow \sum F_x = 0;\qquad F_{DB} = 0 \qquad \textbf{Ans.}$$

$$+\nwarrow \sum F_y = 0;\qquad F_{DE} - 780 = 0 \qquad F_{DE} = 780\text{ lb (C)} \qquad \textbf{Ans.}$$

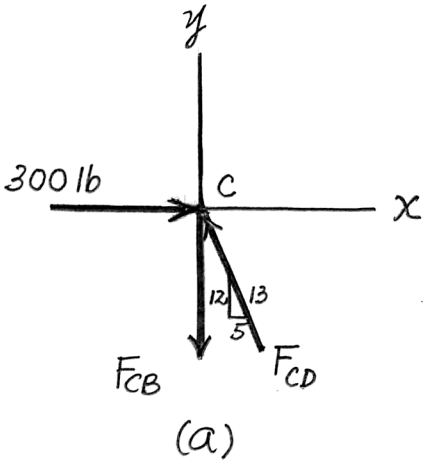
Joint *B*: Fig. *c*.

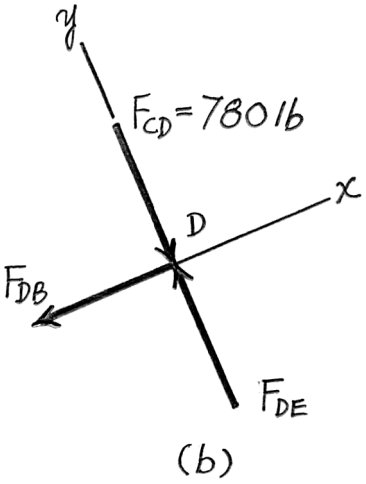
$$\stackrel{+}{\rightarrow}\sum F_x = 0;\qquad 300 + F_{BE}\sin 45.24° - F_{BA}\cos 45° = 0$$

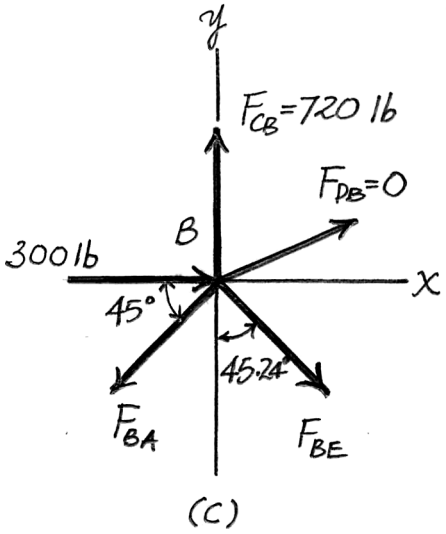
$$+\uparrow \sum F_y = 0;\qquad 720 - F_{BE}\cos 45.24° - F_{BA}\sin 45° = 0$$

Solving

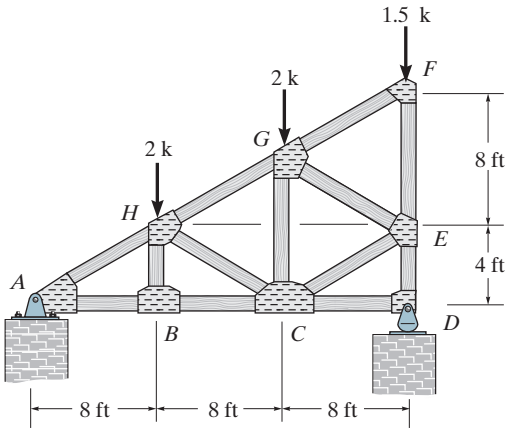
$$F_{BE} = 296.99\text{ lb} = 297\text{ lb (T)} \qquad F_{BA} = 722.49\text{ lb (T)} = 722\text{ lb (T)} \qquad \textbf{Ans.}$$







3–6. Determine the force in each member of the truss. Indicate if the members are in tension or compression. Assume all members are pin connected.



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

$$\zeta + \sum M_D = 0; \quad 2(8) + 2(16) - A_y(24) = 0 \quad A_y = 2.0 \text{ k}$$

$$\pm\rightarrow \sum F_x = 0; \quad A_x = 0$$

Method of Joint.

Joint *A*: Fig. *b*,

$$+\uparrow \sum F_y = 0; \quad 2.0 - F_{AH}\left(\frac{1}{\sqrt{5}}\right) = 0 \quad F_{AH} = 4.472 \text{ k (C)} = 4.47\text{k (C)} \quad \textbf{Ans.}$$

$$\pm\rightarrow \sum F_x = 0; \quad F_{AB} - 4.472\left(\frac{2}{\sqrt{5}}\right) = 0 \quad F_{AB} = 4.00 \text{ k (T)} \quad \textbf{Ans.}$$

Joint *B*: Fig. *c*,

$$\pm\rightarrow \sum F_x = 0; \quad F_{BC} - 4.00 = 0 \quad F_{BC} = 4.00 \text{ k (T)} \quad \textbf{Ans.}$$

$$+\uparrow \sum F_y = 0; \quad F_{BH} = 0 \quad \textbf{Ans.}$$

Joint *H*: Fig. *d*,

$$+\uparrow \sum F_y = 0; \quad F_{HC} \sin 53.13° - 2 \sin 63.43° = 0 \quad F_{HC} = 2.236 \text{ k (C)} = 2.24 \text{ k (C)} \quad \textbf{Ans.}$$

$$\pm\rightarrow \sum F_x = 0; \quad 4.472 - 2\cos 63.43° - 2.236 \cos 53.13° - F_{HG} = 0$$

$$F_{HG} = 2.236 \text{ k (C)} = 2.24 \text{ k (C)} \quad \textbf{Ans.}$$

Joint *F*: Fig. *e*,

$$\pm\rightarrow \sum F_x = 0; \quad F_{FG} = 0 \quad \textbf{Ans.}$$

$$+\uparrow \sum F_y = 0; \quad F_{FE} - 1.5 = 0 \quad F_{FE} = 1.5 \text{ k (C)} \quad \textbf{Ans.}$$

Joint *G*: Fig. *f*,

$$\pm\rightarrow \sum F_x = 0; \quad 2.236\left(\frac{2}{\sqrt{5}}\right) - F_{GE} = \left(\frac{2}{\sqrt{5}}\right) = 0 \quad F_{GE} = 2.236 \text{ k (C)} = 2.24 \text{ k (C)} \quad \text{Ans.}$$

$$+\uparrow \sum F_y = 0; \quad 2.236\left(\frac{1}{\sqrt{5}}\right) + 2.236\left(\frac{1}{\sqrt{5}}\right) - 2 - F_{GC} = 0 \quad F_{GC} = 0 \quad \textbf{Ans.}$$

Joint *E*: Fig. *g*,

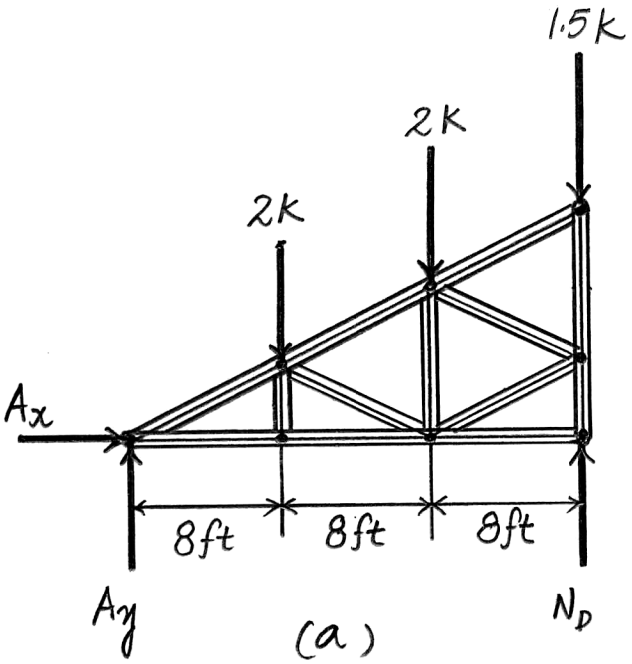
$$\pm\rightarrow \sum F_x = 0; \quad 2.236\left(\frac{2}{\sqrt{5}}\right) - F_{EC}\left(\frac{2}{\sqrt{5}}\right) = 0 \quad F_{EC} = 2.236 \text{ k (T)} = 2.24 \text{ k (T)} \quad \textbf{Ans.}$$

$$+\uparrow \sum F_y = 0; \quad F_{ED} = 2.236\left(\frac{1}{\sqrt{5}}\right) - 2.236\left(\frac{1}{\sqrt{5}}\right) - 1.5 = 0 \quad F_{ED} = 3.5 \text{ k (C)} \quad \textbf{Ans.}$$

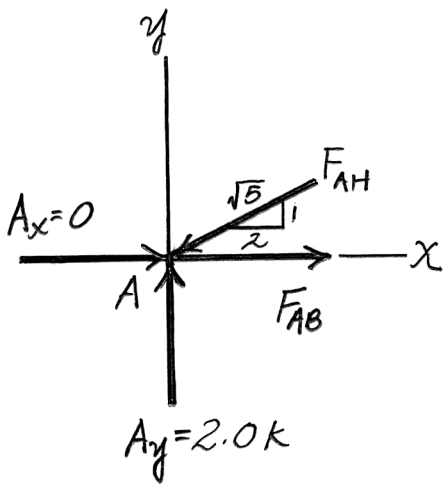
Joint *D*: Fig. *h*,

$$\pm\rightarrow \sum F_x = 0; \quad F_{DC} = 0 \quad \textbf{Ans.}$$

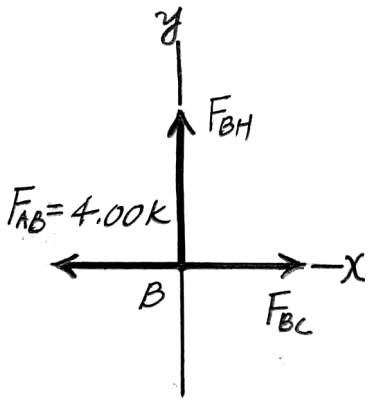
3–6. Continued



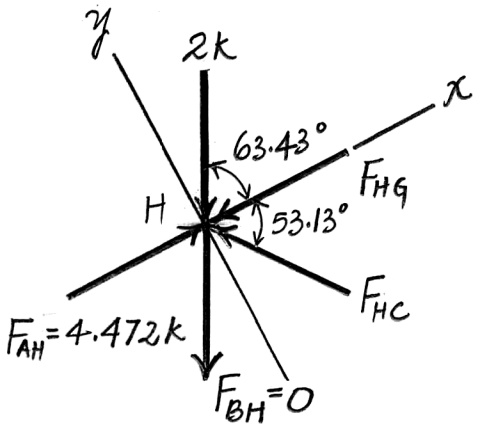
(a)



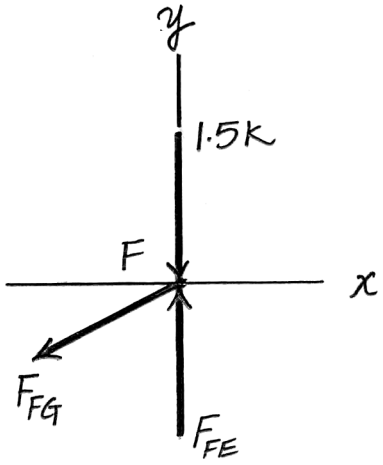
(b)



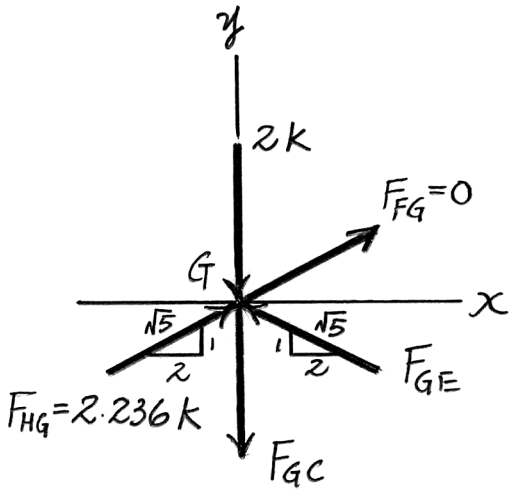
(c)



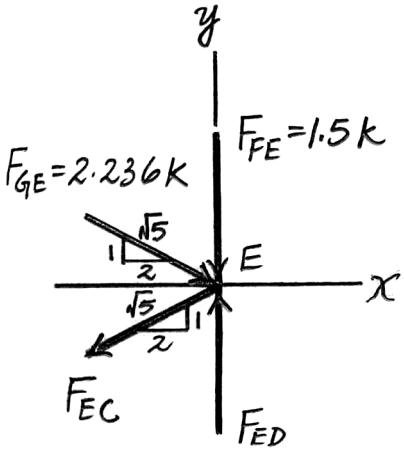
(d)



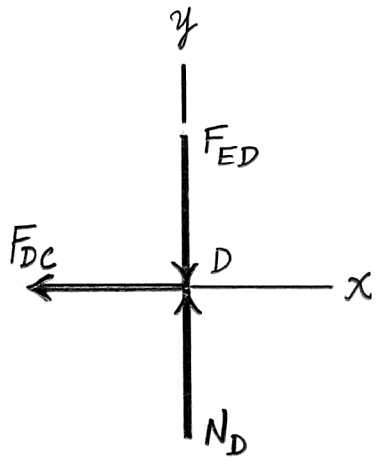
(e)



(f)

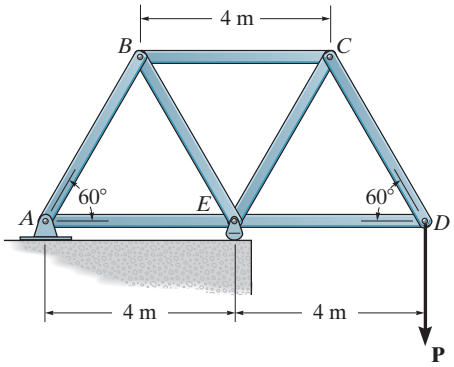


(g)



(h)

3–7. Determine the force in each member of the truss. State whether the members are in tension or compression. Set $P = 8$ kN.

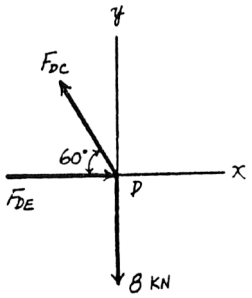


***Method of Joints*:** In this case, the support reactions are not required for determining the member forces.

Joint *D*:

$+\uparrow \sum F_y = 0; \quad F_{DC} \sin 60° - 8 = 0$

$F_{DC} = 9.238 \text{ kN (T)} = 9.24 \text{ kN (T)}$ **Ans.**



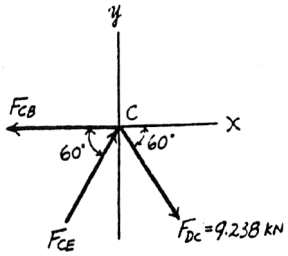
$\pm\rightarrow \sum F_x = 0; \quad F_{DE} - 9.238 \cos 60° = 0$

$F_{DE} = 4.619 \text{ kN (C)} = 4.62 \text{ kN (C)}$ **Ans.**

Joint *C*:

$+\uparrow \sum F_y = 0; \quad F_{CE} \sin 60° - 9.328 \sin 60° = 0$

$F_{CE} = 9.238 \text{ kN (C)} = 9.24 \text{ kN (C)}$ **Ans.**



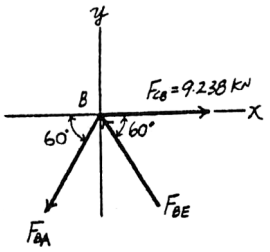
$\pm\rightarrow \sum F_x = 0; \quad 2(9.238 \cos 60°) - F_{CB} = 0$

$F_{CB} = 9.238 \text{ kN (T)} = 9.24 \text{ kN (T)}$ **Ans.**

Joint *B*:

$+\uparrow \sum F_y = 0; \quad F_{BE} \sin 60° - F_{BA} \sin 60° = 0$

$F_{BE} = F_{BA} = F$



$\pm\rightarrow \sum F_x = 0; \quad 9.238 - 2F\cos 60° = 0$

$F = 9.238 \text{ kN}$

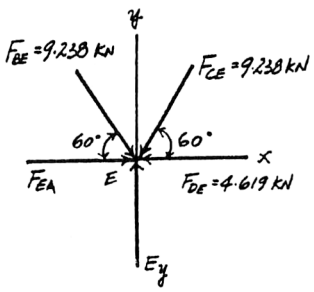
Thus, $F_{BE} = 9.24 \text{ kN (C)} \quad F_{BA} = 9.24 \text{ kN (T)}$ **Ans.**

Joint *E*:

$+\uparrow \sum F_y = 0; \quad E_y - 2(9.238 \sin 60°) = 0 \quad E_y = 16.0 \text{ kN}$

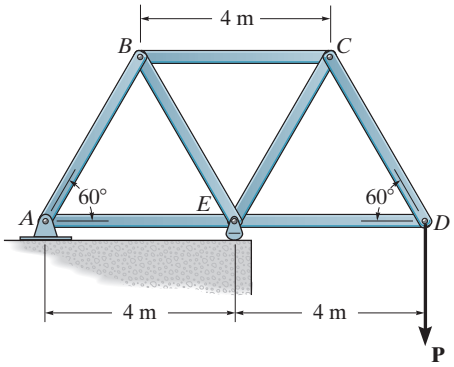
$\pm\rightarrow \sum F_x = 0; \quad F_{BA} + 9.238 \cos 60° - 9.238 \cos 60° - 4.619 = 0$

$F_{EA} = 4.62 \text{ kN (C)}$ **Ans.**



Note: The support reactions A_x and A_y can be determined by analyzing Joint *A* using the results obtained above.

***3–8.** If the maximum force that any member can support is 8 kN in tension and 6 kN in compression, determine the maximum force P that can be supported at joint D.

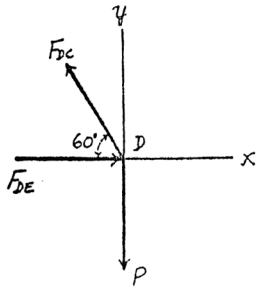


Method of Joints: In this case, the support reactions are not required for determining the member forces.

Joint *D*:

$$+\uparrow \sum F_y = 0; \quad F_{DC} \sin 60° - P = 0 \quad F_{DC} = 1.1547P \text{ (T)}$$

$$\overset{+}{\rightarrow} \sum F_x = 0; \quad F_{DE} - 1.1547P \cos 60° = 0 \quad F_{DE} = 0.57735P \text{ (C)}$$

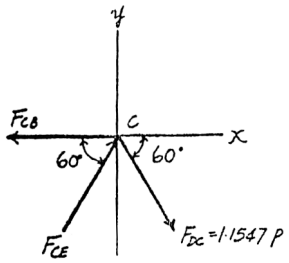


Joint *C*:

$$+\uparrow \sum F_y = 0; \quad F_{CE} \sin 60° - 1.1547P \sin 60° = 0$$

$$F_{CE} = 1.1547P \text{ (C)}$$

$$\overset{+}{\rightarrow} \sum F_x = 0; \quad 2(1.1547P \cos 60° - F_{CB} = 0 \quad F_{CB} = 1.1547P \text{ (T)}$$

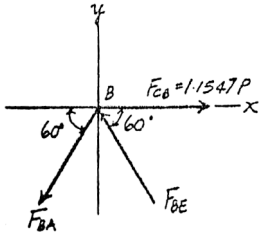


Joint *B*:

$$+\uparrow \sum F_y = 0; \quad F_{BE} \sin 60° - F_{BE} \sin 60° = 0 \quad F_{BE} = F_{BA} = F$$

$$\overset{+}{\rightarrow} \sum F_x = 0; \quad 1.1547P - 2F \cos 60° = 0 \quad F = 1.1547P$$

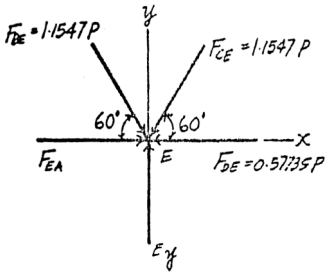
Thus, $F_{BE} = 1.1547P \text{ (C)} \quad F_{BA} = 1.1547P \text{ (T)}$



Joint *E*:

$$\overset{+}{\rightarrow} \sum F_x = 0; \quad F_{EA} + 1.1547P \cos 60° - 1.1547P \cos 60° - 0.57735P = 0$$

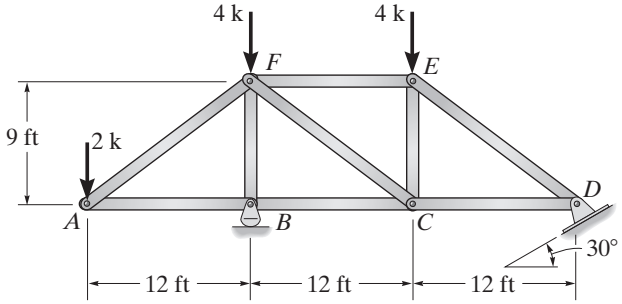
$$F_{EA} = 0.57735P \text{ (C)}$$



From the above analysis, the maximum compression and tension in the truss members is $1.1547P$. For this case, compression controls which requires

$$1.1547P = 6$$
$$P = 5.20 \text{ kN} \quad \textbf{Ans.}$$

3–9. Determine the force in each member of the truss. State if the members are in tension or compression.



Reactions:

$B_y = 9.00\text{ k}, \quad D_x = 0, \quad D_y = 1.00\text{ k}$

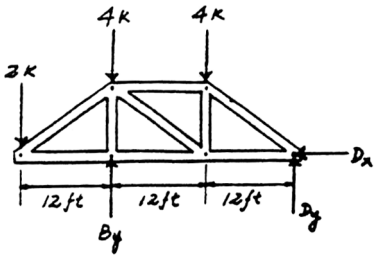
Joint *A*:

$+\uparrow \sum F_y = 0; \quad \frac{3}{5}(F_{AF}) - 2 = 0$

$F_{AF} = 3.333\text{ k} = 3.33\text{ k (T)}$ **Ans.**

$\stackrel{+}{\rightarrow} \sum F_x = 0; \quad -F_{AB} + \frac{4}{5}(3.333) = 0$

$F_{AB} = 2.667\text{ k} = 2.67\text{ k (C)}$ **Ans.**



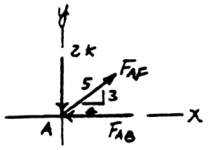
Joint *B*:

$+\uparrow \sum F_y = 0; \quad 9.00 - (F_{BF}) = 0$

$F_{BF} = 9.00\text{ k (C)}$ **Ans.**

$\stackrel{+}{\rightarrow} \sum F_x = 0; \quad 2.667 - F_{BC} = 0$

$F_{BC} = 2.667\text{ k} = 2.67\text{ k (C)}$ **Ans.**



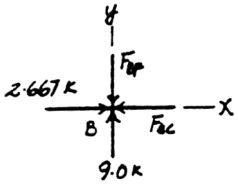
Joint *F*:

$+\uparrow \sum F_y = 0; \quad -\frac{3}{5}(F_{FC}) - 4 - \frac{3}{5}(3.333) + 9 = 0$

$F_{FC} = 5.00\text{ k (T)}$ **Ans.**

$\stackrel{+}{\rightarrow} \sum F_x = 0; \quad -F_{FE} - \frac{4}{5}(3.333) + \frac{4}{5}(5.00) = 0$

$F_{FE} = 1.333\text{ k} = 1.33\text{ k (C)}$ **Ans.**



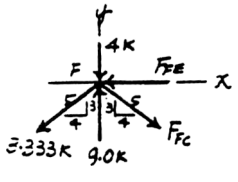
Joint *C*:

$+\uparrow \sum F_y = 0; \quad -F_{CE} + \frac{3}{5}(5.00) = 0$

$F_{CE} = 3.00\text{ k (C)}$ **Ans.**

$\stackrel{+}{\rightarrow} \sum F_x = 0; \quad F_{CD} + (2.667) - \frac{4}{5}(5.00) = 0$

$F_{CD} = 1.333\text{ k} = 1.33\text{ k (T)}$ **Ans.**

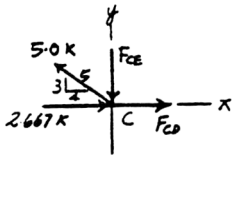


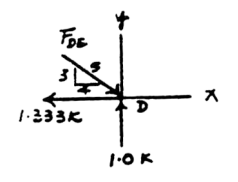
Joint *D*:

$+\uparrow \sum F_y = 0; \quad -\frac{3}{5}(F_{DE}) + 1 = 0$

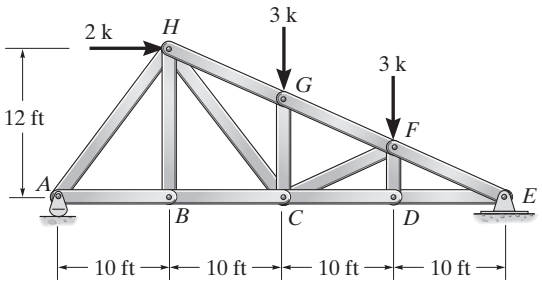
$F_{DE} = 1.667\text{ k} = 1.67\text{ k (C)}$ **Ans.**

$\stackrel{+}{\rightarrow} \sum F_x = 0; \quad \frac{4}{5}(1.667) - 1.333 = 0 \quad \text{(Check)}$



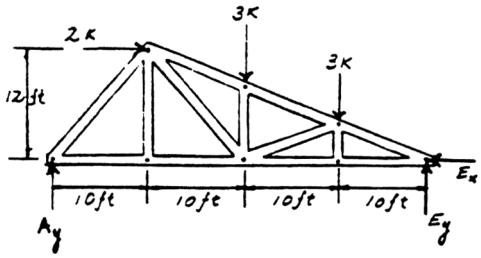


3–10. Determine the force in each member of the truss. State if the members are in tension or comprehension.



Reactions:

$A_y = 1.65$ k, $E_x = 2.00$ k, $E_y = 4.35$ k



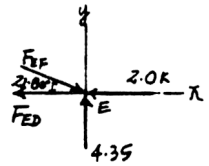
Joint *E*:

$+\uparrow \sum F_y = 0; \quad -(F_{EF}) \sin 21.80° + 4.35 = 0$

$F_{EF} = 11.71 \text{ k} = 11.7 \text{ k (C)}$ **Ans.**

$\pm\rightarrow \sum F_x = 0; \quad -F_{ED} - 2 + 11.71 \cos 21.80° = 0$

$F_{ED} = 8.875 \text{ k (T)}$ **Ans.**

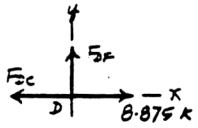


Joint *D*:

$+\uparrow \sum F_y = 0; \quad F_{DF} = 0$ **Ans.**

$\pm\rightarrow \sum F_x = 0; \quad -F_{DC} + 8.875 = 0$

$F_{DC} = 8.875 \text{ k (T)}$ **Ans.**



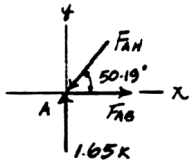
Joint *A*:

$+\uparrow \sum F_y = 0; \quad -F_{AH} \sin 50.19° + 1.65 = 0$

$F_{AH} = 2.148\,k = 2.15 \text{ k (C)}$ **Ans.**

$\pm\rightarrow \sum F_x = 0; \quad F_{AB} - 2.148 (\cos 50.19°) = 0$

$F_{AB} = 1.375 \text{ k (T)}$ **Ans.**

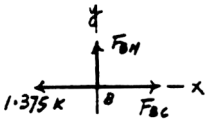


Joint *B*:

$+\uparrow \sum F_y = 0; \quad F_{BH} = 0$ **Ans.**

$\pm\rightarrow \sum F_x = 0; \quad F_{BC} - 1.375 = 0$

$F_{BC} = 1.375 \text{ k (T)}$ **Ans.**



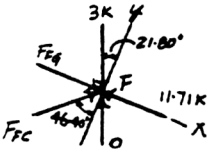
Joint *F*:

$+\nearrow \sum F_y = 0; \quad F_{FC} \cos 46.40° - 3 \cos 21.80° = 0$

$F_{FC} = 4.039 \text{ k} = 4.04 \text{ k (C)}$ **Ans.**

$+\searrow \sum F_x = 0; \quad F_{FG} + 3 \sin 21.80° + 4.039 \sin 46.40° - 11.71 = 0$

$F_{FG} = 7.671 \text{ k} = 7.67 \text{ k (C)}$ **Ans.**

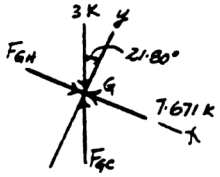


Joint *G*:

$+\nearrow \sum F_y = 0; \quad F_{GC} \cos 21.80° - 3 \cos 21.80° = 0 \quad F_{GC} = 3.00 \text{ k (C)}$ **Ans.**

$+\searrow \sum F_x = 0; \quad F_{GH} + 3 \sin 21.80° - 3 \sin 21.80° - 7.671 = 0;$

$F_{GH} = 7.671 \text{ k} = 7.67 \text{ k (C)}$ **Ans.**

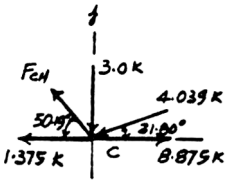


Joint *C*:

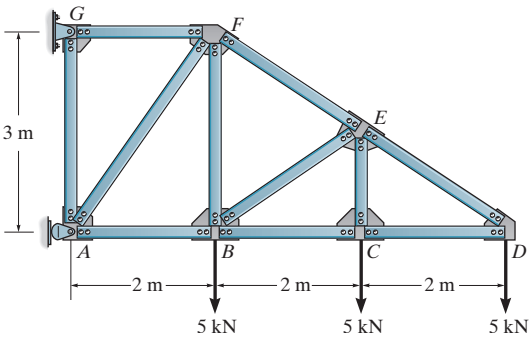
$+\uparrow \sum F_y = 0; \quad F_{CH} \sin 50.19° - 3.00 - 4.039 \sin 21.80° = 0$

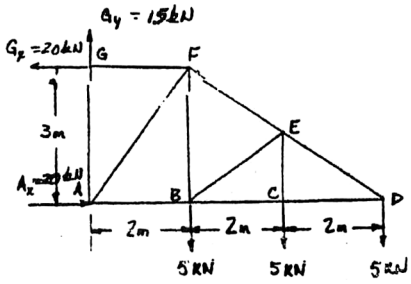
$F_{CH} = 5.858 \text{ k} = 5.86 \text{ k (T)}$ **Ans.**

$\pm\rightarrow \sum F_x = 0; \quad -4.039 \cos 21.80° - 5.858 \cos 51.9° - 1.375 + 8.875 = 0$ (Check)



3–11. Determine the force in each member of the truss. State if the members are in tension or compression. Assume all members are pin connected.



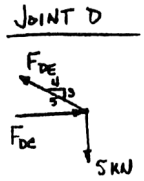


Joint *D*:

$+\uparrow \sum F_y = 0; \quad F_{ED}\left(\frac{3}{5}\right) - 5 = 0; \quad F_{ED} = 8.33 \text{ kN (T)}$ **Ans.**

$\pm\rightarrow \sum F_x = 0; \quad F_{CD} - \frac{4}{5}(8.33) = 0;$

$F_{CD} = 6.67 \text{ kN (C)}$ **Ans.**



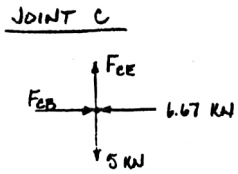
Joint *C*:

$\pm\rightarrow \sum F_x = 0; \quad F_{BC} - 6.67 = 0;$

$F_{BC} = 6.67 \text{ kN (C)}$ **Ans.**

$+\uparrow \sum F_y = 0; \quad F_{CE} - 5 = 0;$

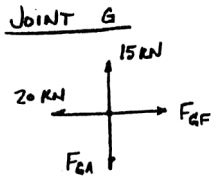
$F_{CE} = 5 \text{ kN (T)}$ **Ans.**



Joint *G*:

$\pm\rightarrow \sum F_x = 0; \quad F_{GF} - 20 = 0; \quad F_{GF} = 20 \text{ kN (T)}$ **Ans.**

$+\uparrow \sum F_y = 0; \quad 15 - F_{GA} = 0; \quad F_{GA} = 15 \text{ kN (T)}$ **Ans.**



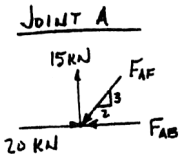
Joint *A*:

$+\uparrow \sum F_y = 0; \quad 15 - F_{AF}(\sin 56.3°) = 0;$

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

$\pm\rightarrow \sum F_x = 0; \quad -F_{AB} - 18.0(\cos 56.3°) + 20 = 0;$

$F_{AB} = 10.0 \text{ kN (C)}$ **Ans.**



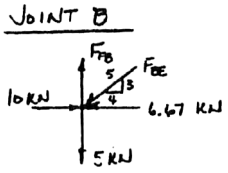
Joint *B*:

$\pm\rightarrow \sum F_x = 0; \quad -F_{BE}\left(\frac{4}{5}\right) + 10.0 - 6.67 = 0;$

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

$+\uparrow \sum F_y = 0; \quad F_{FB} - 5 - 4.17\left(\frac{3}{5}\right) = 0;$

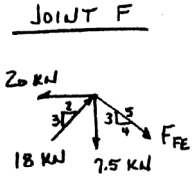
$F_{FB} = 7.50 \text{ kN (T)}$ **Ans.**



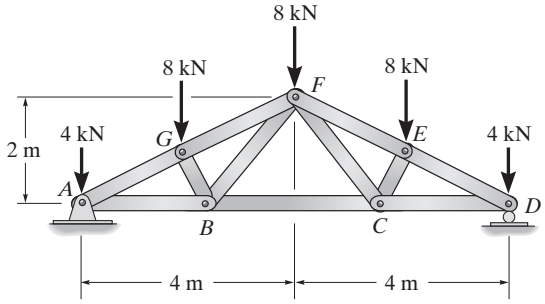
Joint *F*:

$+\uparrow \sum F_y = 0; \quad 18(\sin 56.3°) - 7.5 - F_{FE}\left(\frac{3}{5}\right) = 0;$

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

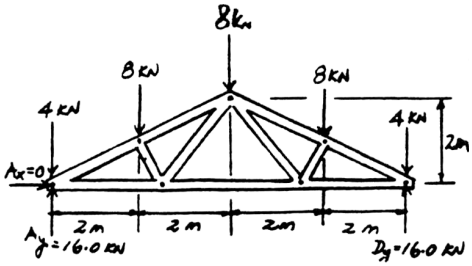


***3–12.** Determine the force in each member of the truss. State if the members are in tension or compression. Assume all members are pin connected. $AG = GF = FE = ED$.



Reactions:

$A_x = 0, \qquad A_y = 16.0 \text{ kN}$



Joint *A*:

$+\uparrow \sum F_y = 0; \qquad 16 - 4 - F_{AG} \sin 26.565° = 0$

$F_{AG} = 26.83 \text{ kN} = 26.8 \text{ kN (C)}$ **Ans.**

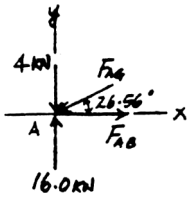
$\stackrel{+}{\rightarrow} \sum F_x = 0; \qquad -26.83 \cos 26.565° + F_{AB} = 0$

$F_{AB} = 24.0 \text{ kN (T)}$ **Ans.**

Joint *G*:

$+\nwarrow \sum F_y = 0; \qquad -8 \cos 26.565° + F_{GB} = 0$

$F_{GB} = 7.155 \text{ kN} = 7.16 \text{ kN (C)}$ **Ans.**



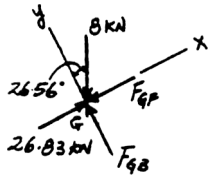
$+\nearrow \sum F_x = 0; \qquad 26.83 - F_{GF} - 8 \sin 26.56° = 0$

$F_{GF} = 23.36 \text{ kN} = 23.3 \text{ kN (C)}$ **Ans.**

Joint *B*:

$+\uparrow \sum F_y = 0; \qquad F_{BF} \sin 53.13° - 7.155 \sin 63.43° = 0$

$F_{BF} = 8.00 \text{ kN (T)}$ **Ans.**



$\stackrel{+}{\rightarrow} \sum F_x = 0; \qquad F_{BC} - 24.0 + 7.155 \cos 63.43° + 8.00 \cos 53.13° = 0$

$F_{BC} = 16.0 \text{ kN (T)}$ **Ans.**

Due to symmetrical loading and geometry:

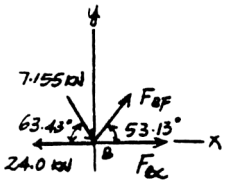
$F_{CD} = F_{AB} = 24.0 \text{ kN (T)}$ **Ans.**

$F_{EF} = F_{GF} = 23.3 \text{ kN (C)}$ **Ans.**

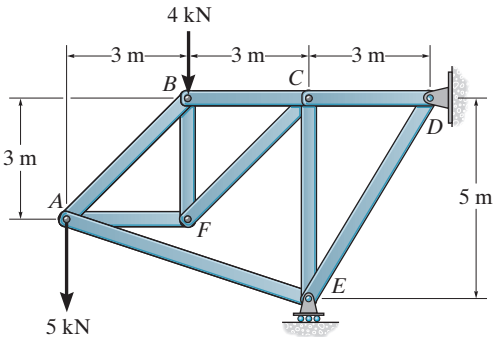
$F_{DE} = F_{AG} = 26.8 \text{ kN (C)}$ **Ans.**

$F_{EC} = F_{GB} = 7.16 \text{ kN (C)}$ **Ans.**

$F_{CF} = F_{BF} = 8.00 \text{ kN (T)}$ **Ans.**



3–13. Determine the force in each member of the truss and state if the members are in tension or compression.



Support Reactions:

$\zeta + \sum M_D = 0; \quad 4(6) + 5(9) - E_y(3) = 0 \quad E_y = 23.0 \text{ kN}$

$+\uparrow \sum F_y = 0; \quad 23.0 - 4 - 5 - D_y = 0 \quad D_y = 14.0 \text{ kN}$

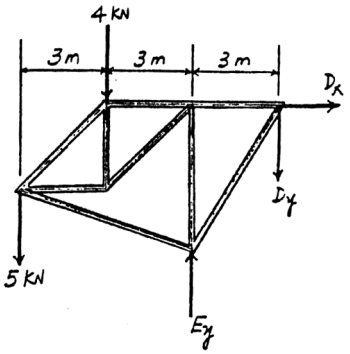
$\overset{+}{\rightarrow} \sum F_x = 0; \quad D_x = 0$

Method of Joints:

Joint *D*:

$+\uparrow \sum F_y = 0; \quad F_{DE}\left(\frac{5}{\sqrt{34}}\right) - 14.0 = 0$

$F_{DE} = 16.33 \text{ kN (C)} = 16.3 \text{ kN (C)}$ **Ans.**



$\overset{+}{\rightarrow} \sum F_x = 0; \quad 16.33\left(\frac{3}{\sqrt{34}}\right) - F_{DC} = 0$

$F_{DC} = 8.40 \text{ kN (T)}$ **Ans.**

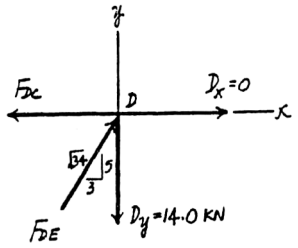
Joint *E*:

$\overset{+}{\rightarrow} \sum F_x = 0; \quad F_{EA}\left(\frac{3}{\sqrt{10}}\right) - 16.33\left(\frac{3}{\sqrt{34}}\right) = 0$

$F_{EA} = 8.854 \text{ kN (C)} = 8.85 \text{ kN (C)}$ **Ans.**

$+\uparrow \sum F_y = 0; \quad 23.0 - 16.33\left(\frac{5}{\sqrt{34}}\right) - 8.854\left(\frac{1}{\sqrt{10}}\right) - F_{EC} = 0$

$F_{EC} = 6.20 \text{ kN (C)}$ **Ans.**



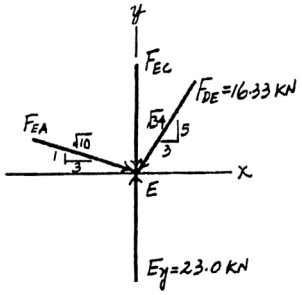
Joint *C*:

$+\uparrow \sum F_y = 0; \quad 6.20 - F_{CF}\sin 45° = 0$

$F_{CF} = 8.768 \text{ kN (T)} = 8.77 \text{ kN (T)}$ **Ans.**

$\overset{+}{\rightarrow} \sum F_x = 0; \quad 8.40 - 8.768\cos 45° - F_{CB} = 0$

$F_{CB} = 2.20 \text{ kN (T)}$ **Ans.**



Joint *B*:

$\overset{+}{\rightarrow} \sum F_x = 0; \quad 2.20 - F_{BA}\cos 45° = 0$

$F_{BA} = 3.111 \text{ kN (T)} = 3.11 \text{ kN (T)}$ **Ans.**

$+\uparrow \sum F_y = 0; \quad F_{BF} - 4 - 3.111\sin 45° = 0$

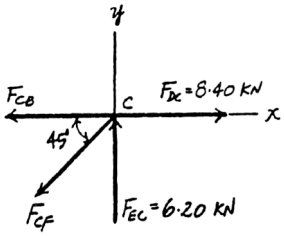
$F_{BF} = 6.20 \text{ kN (C)}$ **Ans.**

Joint *F*:

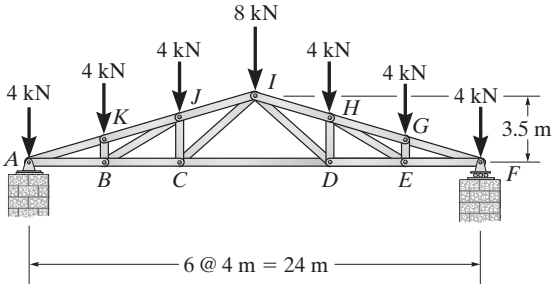
$+\uparrow \sum F_y = 0; \quad 8.768\sin 45° - 6.20 = 0 \text{ (Check!)}$

$\overset{+}{\rightarrow} \sum F_x = 0; \quad 8.768\cos 45° - F_{FA} = 0$

$F_{FA} = 6.20 \text{ kN (T)}$ **Ans.**



3–14. Determine the force in each member of the roof truss. State if the members are in tension or compression.



Reactions:

$A_y = 16.0\text{ kN}, \quad A_x = 0, \quad F_y = 16.0\text{ kN}$

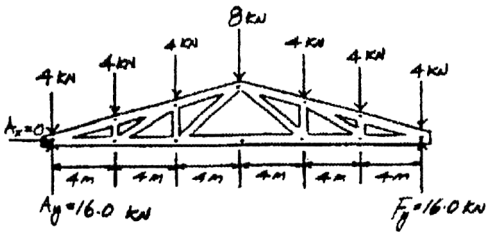
Joint *A*:

$+\uparrow \sum F_y = 0; \quad -F_{AK} \sin 16.26° - 4 + 16 = 0$

$F_{AK} = 42.86\text{ kN} = 42.9\text{ kN (C)}$ **Ans.**

$\stackrel{+}{\rightarrow} \sum F_x = 0; \quad F_{AB} - 42.86 \cos 16.26° = 0$

$F_{AB} = 41.14\text{ kN} = 41.1\text{ kN (T)}$ **Ans.**



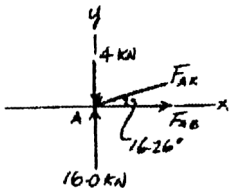
Joint *K*:

$+\nwarrow \sum F_y = 0; \quad -4 \cos 16.26° + F_{KB} \cos 16.26° = 0$

$F_{KB} = 4.00\text{ kN (C)}$ **Ans.**

$+\nearrow \sum F_x = 0; \quad 42.86 + 4.00 \sin 16.26° - 4.00 \sin 16.26° - F_{KJ} = 0$

$F_{KJ} = 42.86\text{ kN} = 42.9\text{ kN (C)}$ **Ans.**



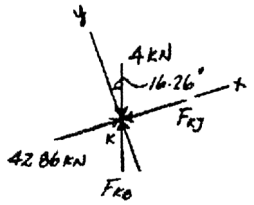
Joint *B*:

$+\uparrow \sum F_y = 0; \quad F_{BJ} \sin 30.26° - 4 = 0$

$F_{BJ} = 7.938\text{ kN} = 7.94\text{ kN (T)}$ **Ans.**

$\stackrel{+}{\rightarrow} \sum F_x = 0; \quad F_{BC} + 7.938 \cos 30.26° - 41.14 = 0$

$F_{BC} = 34.29\text{ kN} = 34.3\text{ kN (T)}$ **Ans.**



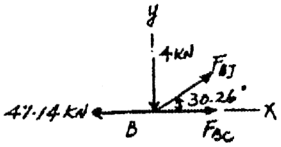
Joint *J*:

$\stackrel{+}{\rightarrow} \sum F_x = 0; \quad -F_{JI} \cos 16.26° - 7.939 \sin 59.74° + 42.86 \cos 16.26° = 0$

$F_{JI} = 35.71\text{ kN} = 35.7\text{ kN (C)}$ **Ans.**

$+\uparrow \sum F_y = 0; \quad F_{JC} + 42.86 \sin 16.26° - 7.939 \cos 59.74° - 4 - 35.71 \sin 16.26° = 0$

$F_{JC} = 6.00\text{ kN (C)}$ **Ans.**



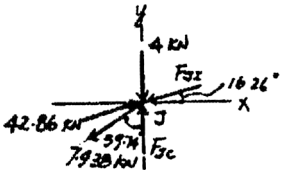
Joint *C*:

$+\uparrow \sum F_y = 0; \quad F_{CI} \sin 41.19° - 6.00 = 0$

$F_{CI} = 9.111\text{ kN} = 9.11\text{ kN (T)}$ **Ans.**

$\stackrel{+}{\rightarrow} \sum F_x = 0; \quad F_{CD} + 9.111 \cos 41.19° - 34.29 = 0$

$F_{CD} = 27.4\text{ kN (T)}$ **Ans.**



Due to symmetrical loading and geometry

$F_{IH} = 35.7\text{ kN (C)}$ **Ans.**

$F_{HD} = 6.00\text{ kN (C)}$ **Ans.**

$F_{HE} = 7.94\text{ kN (T)}$ **Ans.**

$F_{HG} = 42.9\text{ kN (C)}$ **Ans.**

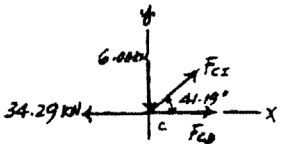
$F_{ED} = 34.3\text{ kN (T)}$ **Ans.**

$F_{ID} = 9.11\text{ kN (T)}$ **Ans.**

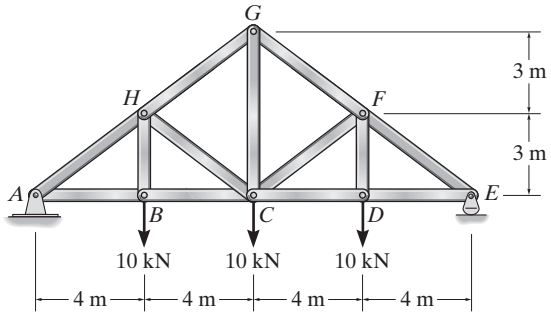
$F_{FG} = 42.9\text{ kN (C)}$ **Ans.**

$F_{GE} = 4.00\text{ kN (C)}$ **Ans.**

$F_{FE} = 41.1\text{ kN (T)}$ **Ans.**



3–15. Determine the force in each member of the roof truss. State if the members are in tension or compression. Assume all members are pin connected.



Joint *A*:

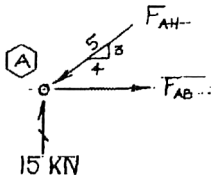
$$\sum F_y = 0; \quad -\frac{3}{5}F_{AH} + 15\text{ kN} = 0$$

$$F_{AH} = 25\text{ kN (C)} \quad \textbf{Ans.}$$

$$\sum F_x = 0; \quad -\frac{4}{5}(25\text{ kN}) + F_{AB} = 0$$

$$F_{AB} = 20\text{ kN (T)} \quad \textbf{Ans.}$$

JOINT A:

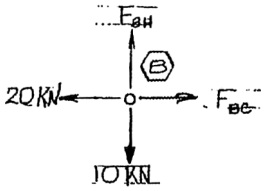


Joint *B*:

$$\sum F_x = 0; \quad F_{BC} = 20\text{ kN (T)} \quad \textbf{Ans.}$$

$$\sum F_y = 0; \quad F_{BH} = 10\text{ kN (T)} \quad \textbf{Ans.}$$

JOINT B:



Joint *H*:

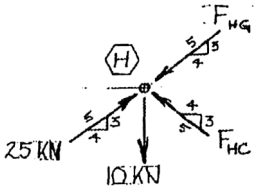
$$\sum F_y = 0; \quad \frac{3}{5}(25\text{ kN}) - 10\text{ kN} + \frac{3}{5}F_{HC} - \frac{3}{5}F_{HG} = 0$$

$$\sum F_x = 0; \quad \frac{4}{5}(25\text{ kN}) - \frac{4}{5}F_{HC} - \frac{4}{5}F_{HG} = 0$$

$$F_{HG} = 16.7\text{ kN (C)} \quad \textbf{Ans.}$$

$$F_{HC} = 8.33\text{ kN (C)} \quad \textbf{Ans.}$$

JOINT H



Joint *G*:

$$\sum F_x = 0; \quad \frac{4}{5}(16.67\text{ kN}) - \frac{4}{5}F_{GF} = 0$$

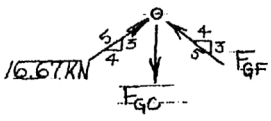
$$F_{GF} = 16.7\text{ kN (C)} \quad \textbf{Ans.}$$

$$\sum F_x = 0; \quad \frac{3}{5}(16.67\text{ kN}) + \frac{3}{5}(16.67\text{ kN}) - F_{GC} = 0$$

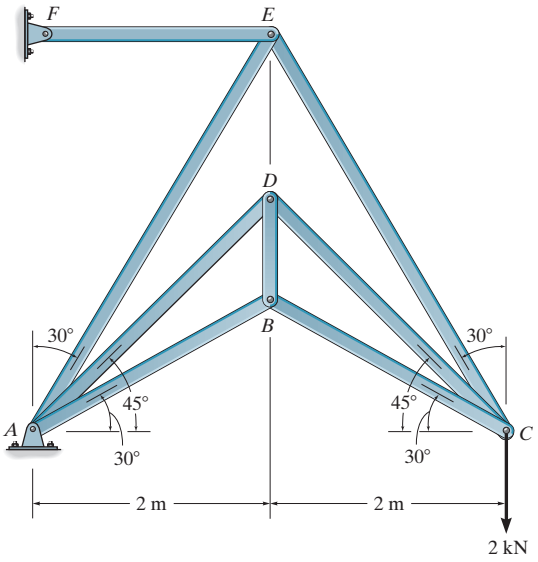
$$F_{GC} = 20\text{ kN (C)} \quad \textbf{Ans.}$$

The other members are determined from symmetry.

JOINT G:



***3–16.** Determine the force in each member of the truss. State if the members are in tension or compression.



Joint *E*:

$+\uparrow \sum F_y = 0; \quad F_{EA} = F_{EC}$

$\overset{+}{\rightarrow} \sum F_x = 0; \quad 2.31 - 2\,F_{EA} \sin 30° = 0$

$F_{EA} = 2.31$ kN (C) **Ans.**

$F_{EC} = 2.31$ kN (T) **Ans.**

Joint *A*:

$\overset{+}{\rightarrow} \sum F_x = 0; \quad 2.31 - 2.31 \sin 30° - F_{AB} \cos 30° + F_{AD} \cos 45° = 0$

$+\uparrow \sum F_y = 0; \quad 2 - 2.31 \cos 30° + F_{AD} \sin 45° - F_{AB} \sin 30° = 0$

$F_{AD} = 2.24$ kN (T) **Ans.**

$F_{AB} = 3.16$ kN (C) **Ans.**

Joint *B*:

$\overset{+}{\rightarrow} \sum F_x = 0; \quad F_{BC} = 3.16$ kN (C) **Ans.**

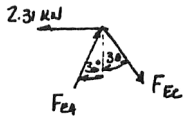
$+\uparrow \sum F_y = 0; \quad 2(3.16) \sin 30° - F_{BD} = 0$

$F_{BD} = 3.16$ kN (C) **Ans.**

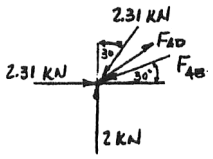
Joint *D*:

$F_{DC} = 2.24$ kN (T) **Ans.**

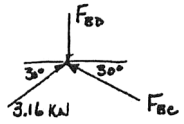
JOINT E

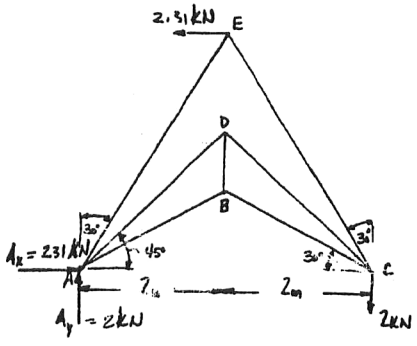


JOINT A

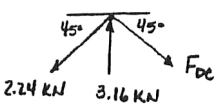


JOINT B

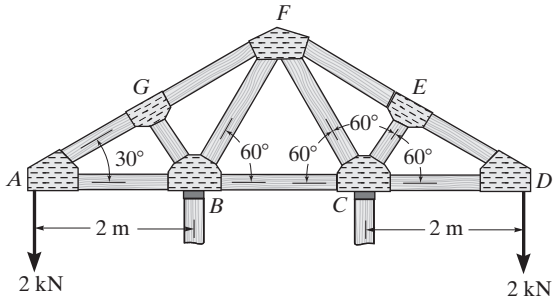




JOINT D



3–17. Determine the force in each member of the roof truss. State if the members are in tension or compression. Assume B is a pin and C is a roller support.



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

$$\zeta + \sum M_C = 0; \quad 2(4) - 2(2) - N_B(2) = 0 \quad N_B = 2.00 \text{ kN}$$

Method of joint.

Joint *A*: Fig. *b*,

$$+\uparrow \sum F_y = 0; \quad F_{AG} \sin 30° - 2 = 0 \quad F_{AG} = 4.00 \text{ kN (T)} \qquad \textbf{Ans.}$$

$$\pm\rightarrow \sum F_x = 0; \quad 4.00 \cos 30° - F_{AB} = 0 \quad F_{AB} = 3.464 \text{ kN (C)} = 3.46 \text{ kN (C)} \qquad \textbf{Ans.}$$

Joint *G*: Fig. *c*,

$$+\nearrow \sum F_x = 0; \quad F_{GF} - 4.00 = 0 \quad F_{GF} = 4.00 \text{ kN (T)} \qquad \textbf{Ans.}$$

$$+\nwarrow \sum F_y = 0; \quad F_{GB} = 0 \qquad \textbf{Ans.}$$

Joint *B*: Fig. *d*,

$$+\uparrow \sum F_y = 0; \quad 2 - F_{BF} \sin 60° = 0 \quad F_{BF} = 2.309 \text{ kN (C)} = 2.31 \text{ kN (C)} \qquad \textbf{Ans.}$$

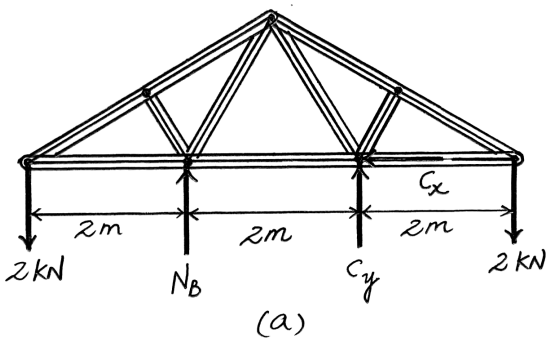
$$\pm\rightarrow \sum F_x = 0; \quad 3.464 - 2.309 \cos 60° - F_{BC} = 0 \quad F_{BC} = 2.309 \text{ kN (C)} - 2.31 \text{ kN (C)} \qquad \textbf{Ans.}$$

Due to symmetry,

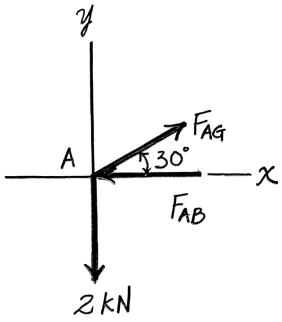
$F_{DE} = F_{AG} = 4.00$ kN (T) $\quad F_{DC} = F_{AB} = 3.46$ kN (C) **Ans.**

$F_{EF} = F_{GF} = 4.00$ kN (T) $\quad F_{EC} = F_{GB} = 0$ **Ans.**

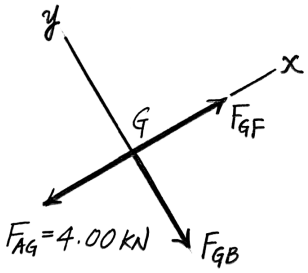
$F_{CF} = F_{BF} = 2.31$ kN (C)



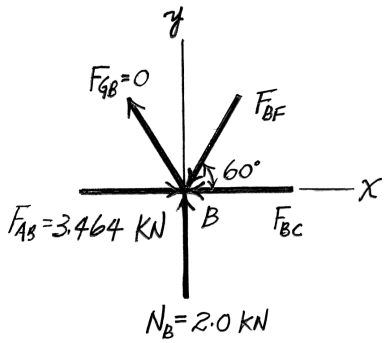
(a)



(b)

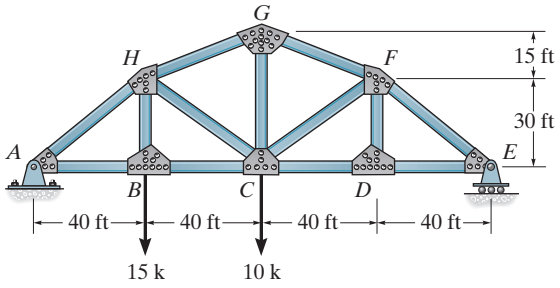


(c)



(d)

3–18. Determine the force in members *GF*, *FC*, and *CD* of the bridge truss. State if the members are in tension of compression. Assume all members are pin connected.



$\circlearrowleft + \sum M_F = 0; \quad -F_{DC}(30) + 8.75\,(40) = 0$

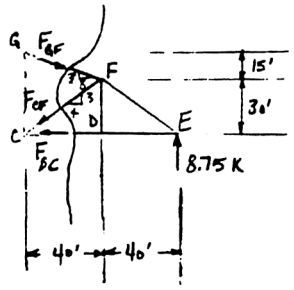
$F_{DC} = 11.7$ k (T) **Ans.**

$\circlearrowleft + \sum M_C = 0; \quad -F_{FC}\left(\frac{8}{\sqrt{73}}\right)(45) + 8.75\,(80) = 0$

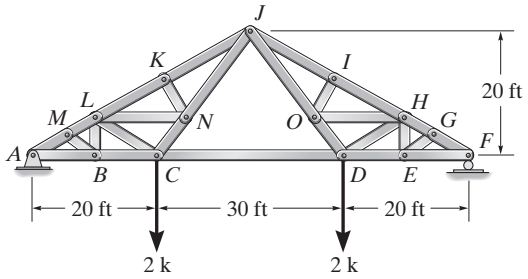
$F_{FG} = 16.6$ k (C) **Ans.**

$+\uparrow \sum F_y = 0; \quad 8.75 - 16.6\left(\frac{3}{\sqrt{73}}\right) \cdot F_{FC}\left(\frac{3}{5}\right) = 0$

$F_{FC} = 4.86$ k (T) **Ans.**



3–19. Determine the force in members *JK*, *JN*, and *CD*. State if the members are in tension of compression. Identify all the zero-force members.

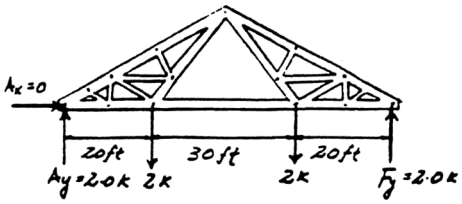


Reactions:

$A_x = 0, \quad A_y = 2.0$ k, $\quad F_y = 2.0$ k

$\circlearrowleft + \sum M_J = 0; \quad F_{CD}(20) + 2(15) - 2(35) = 0$

$F_{CD} = 2.00$ k (T) **Ans.**



$+\uparrow \sum F_y = 0; \quad J_y = 0$

$\overset{+}{\rightarrow} \sum F_x = 0; \quad -J_x + 2.00 = 0; \quad J_x = 2.00$ k

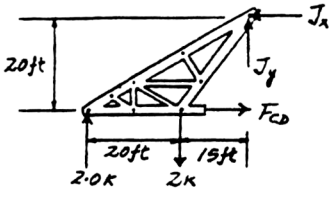
Joint *J*:

$\nwarrow + \sum F_y = 0; \quad -F_{JN} \sin 23.39° + 2 \sin 29.74° = 0$

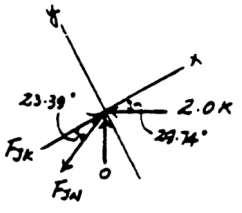
$F_{JN} = 2.50$ k (T) **Ans.**

$+\nearrow \sum F_x = 0; \quad F_{JK} \cos 29.74° - 2.50 \cos 23.39°$

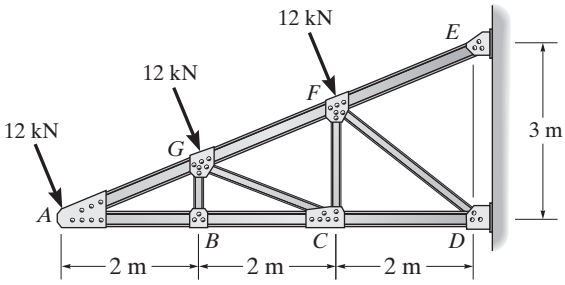
$F_{JK} = 4.03$ k (C) **Ans.**



Members *KN*, *NL*, *MB*, *BL*, *CL*, *IO*, *OH*, *GE*, *EH*, *HD* are zero force members. **Ans.**



***3–20.** Determine the force in members *GF*, *FC*, and *CD* of the cantilever truss. State if the members are in tension of compression. Assume all members are pin connected.



$\zeta + \sum M_C = 0;$ 12 kN (cos 26.57°) (4 m) + 12 kN (cos 26.57°)(2m)
-12 kN (sin 26.57°) (1 m) $- F_{GF}$ sin 26.57° (4 m) $= 0$

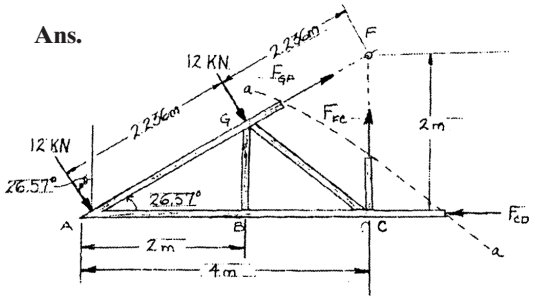
$F_{GF} = 33.0$ kN (T) **Ans.**

$\zeta + \sum M_A = 0;$ -12 kN (2.236 m) $+ F_{FC}$ (4 m) $= 0$

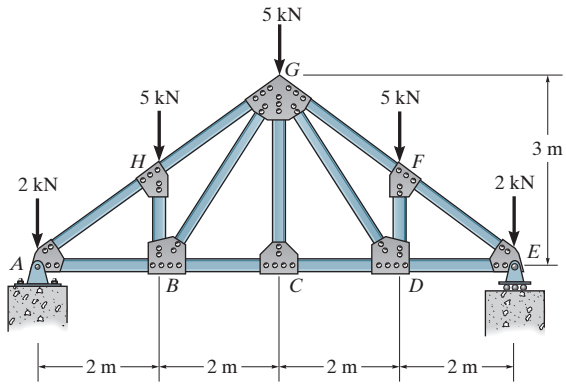
$F_{FC} = 6.71$ kN (T) **Ans.**

$\zeta + \sum M_F = 0;$ 12 kN (2.236 m) + 12 kN (2)(2.236 m) $- F_{CD}$ (2 m) $= 0$

$F_{CD} = 40.2$ kN (C) **Ans.**



3–21. The *Howe* truss is subjected to the loading shown. Determine the forces in members *GF*, *CD*, and *GC*. State if the members are in tension or compression. Assume all members are pin connected.

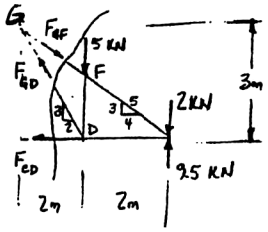


$\zeta + \sum M_G = 0;$ $F_{CD}(3) - 9.5(4) + 5(2) + 2(4) = 0$

$F_{CD} = 6.67$ kN (T) **Ans.**

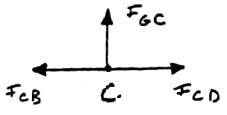
$\zeta + \sum M_D = 0;$ $-9.5(2) + 2(2) + \frac{4}{5}(1.5)\, F_{GF} = 0$

$F_{GF} = 12.5$ kN (C) **Ans.**

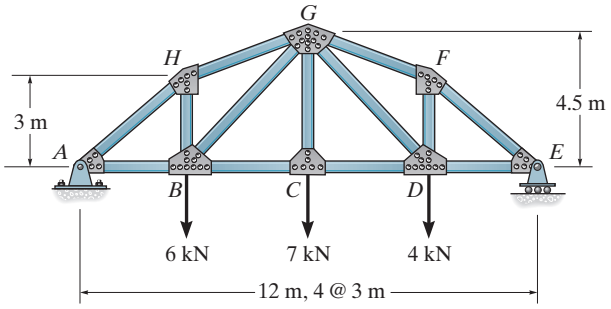


Joint *C*:

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

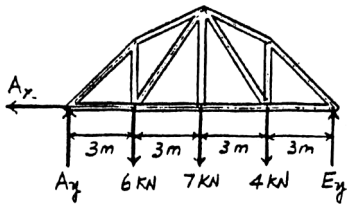


3–22. Determine the force in members *BG*, *HG*, and *BC* of the truss and state if the members are in tension or compression.



$\zeta + \sum M_E = 0; \quad 6(9) + 7(6) + 4(3) - A_y(12) = 0 \quad A_y = 9.00 \text{ kN}$

$\stackrel{+}{\rightarrow} \sum F_x = 0; \quad A_x = 0$



Method of Sections:

$\zeta + \sum M_G = 0; \quad F_{BC}(4.5) + 6(3) - 9(6) = 0$

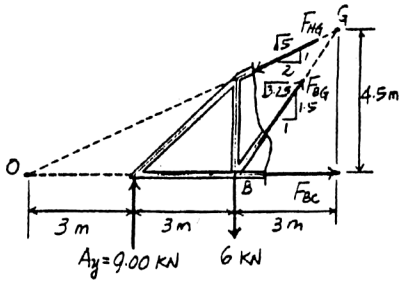
$F_{BC} = 8.00 \text{ kN (T)}$ **Ans.**

$\zeta + \sum M_B = 0; \quad F_{HG}\left(\frac{1}{\sqrt{5}}\right)(6) - 9(3) = 0$

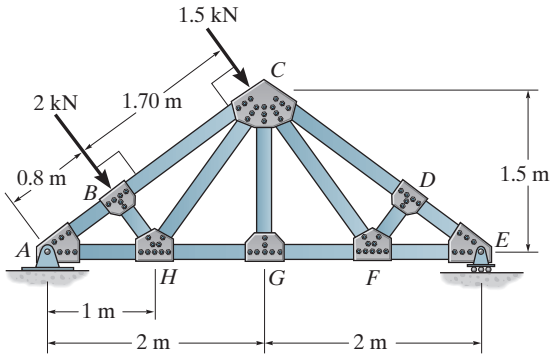
$F_{HG} = 10.1 \text{ kN (C)}$ **Ans.**

$\zeta + \sum M_O = 0; \quad F_{BG}\left(\frac{1.5}{\sqrt{3.25}}\right)(6) + 9(3) - 6(6) = 0$

$F_{BG} = 1.80 \text{ kN (T)}$ **Ans.**



3–23. Determine the force in members *GF*, *CF*, and *CD* of the roof truss and indicate if the members are in tension or compression.



$\zeta + \sum M_A = 0; \quad E_y(4) - 2(0.8) - 1.5(2.50) = 0 \quad E_y = 1.3375 \text{ kN}$

Method of Sections:

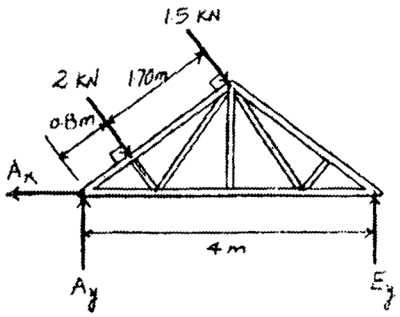
$\zeta + \sum M_C = 0; \quad 1.3375(2) - F_{GF}(1.5) = 0$

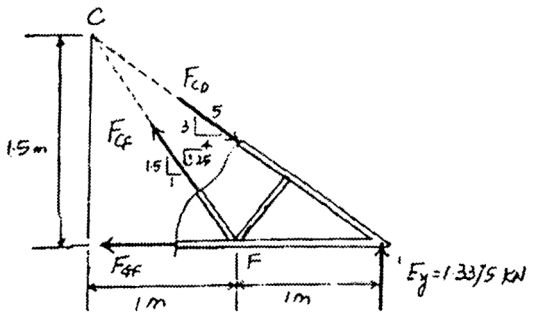
$F_{GF} = 1.78 \text{ kN(T)}$ **Ans.**

$\zeta + \sum M_F = 0; \quad 1.3375(1) - F_{CD}\left(\frac{3}{5}\right)(1) = 0$

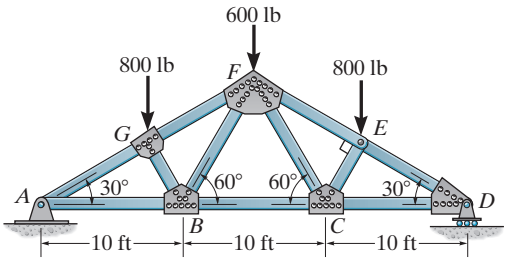
$F_{CD} = 2.23 \text{ kN (C)}$ **Ans.**

$\zeta + \sum M_E = 0 \quad F_{CF}\left(\frac{1.5}{\sqrt{3.25}}\right)(1) = 0 \quad F_{CF} = 0$ **Ans.**





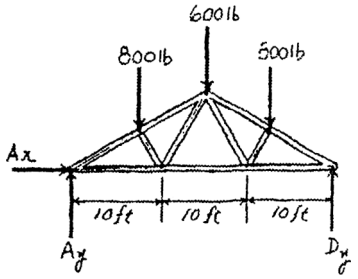
***3–24.** Determine the force in members *GF*, *FB*, and *BC* of the *Fink* truss and state if the members are in tension or compression.



Support Reactions: Due to symmetry. $D_y = A_y$.

$+\uparrow \sum F_y = 0; \quad 2A_y - 800 - 600 - 800 = 0 \quad A_y = 1100 \text{ lb}$

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



Method of Sections:

$\circlearrowleft + \sum M_B = 0; \quad F_{GF} \sin 30° (10) + 800(10 - 10 \cos^2 30°) - 1100(10) = 0$

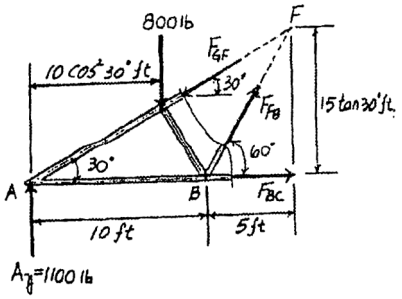
$F_{GF} = 1800 \text{ lb (C)} = 1.80 \text{ k (C)}$ **Ans.**

$\circlearrowleft + \sum M_A = 0; \quad F_{FB} \sin 60° (10) - 800(10 \cos^2 30°) = 0$

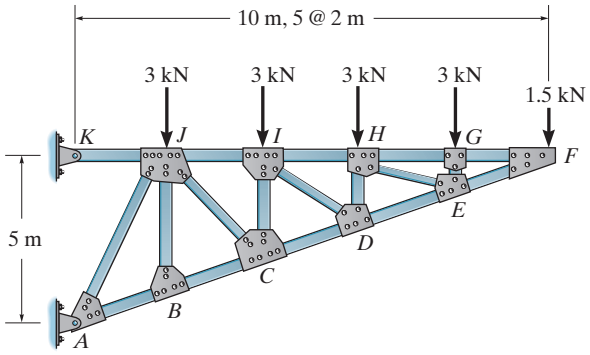
$F_{FB} = 692.82 \text{ lb (T)} = 693 \text{ lb (T)}$ **Ans.**

$\circlearrowleft + \sum M_F = 0; \quad F_{BC} (15 \tan 30°) + 800(15 - 10 \cos^2 30°) - 1100(15) = 0$

$F_{BC} = 1212.43 \text{ lb (T)} = 1.21 \text{ k (T)}$ **Ans.**



3–25. Determine the force in members *IH*, *ID*, and *CD* of the truss. State if the members are in tension or compression. Assume all members are pin connected.



Referring to the FBD of the right segment of the truss sectioned through a–a, Fig. *a*,

$\circlearrowleft + \sum M_D = 0; \quad F_{IH}(2) - 3(2) - 1.5(4) = 0$

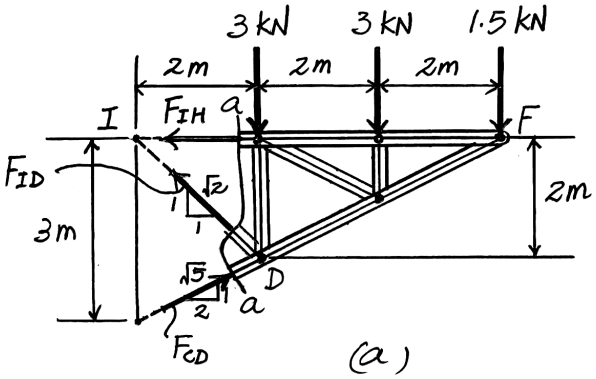
$F_{IH} = 6.00 \text{ kN (T)}$ **Ans.**

$\circlearrowleft + \sum M_F = 0; \quad 3(2) + 3(4) - F_{ID}\left(\frac{1}{\sqrt{2}}\right)(6) = 0$

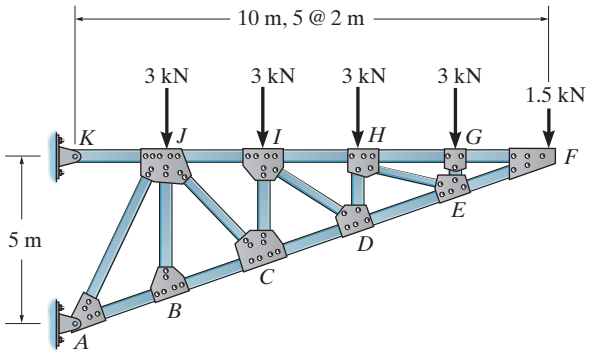
$F_{ID} = 4.243 \text{ kN (T)} = 4.24 \text{ kN (T)}$ **Ans.**

$\circlearrowleft + \sum M_I = 0; \quad F_{CD}\left(\frac{1}{\sqrt{5}}\right)(6) - 3(2) - 3(4) - 1.5(6) = 0$

$F_{CD} = 10.06 \text{ kN} = 10.1 \text{ kN (C)}$ **Ans.**



3–26. Determine the force in members *JI*, *IC*, and *CD* of the truss. State if the members are in tension or compression. Assume all members are pin connected.



Consider the FBD of the right segment of the truss sectioned through a–a, Fig. *a*,

$\zeta + \sum M_C = 0; \quad F_{JI}(3) - 3(2) - 3(4) - 1.5(6) = 0$

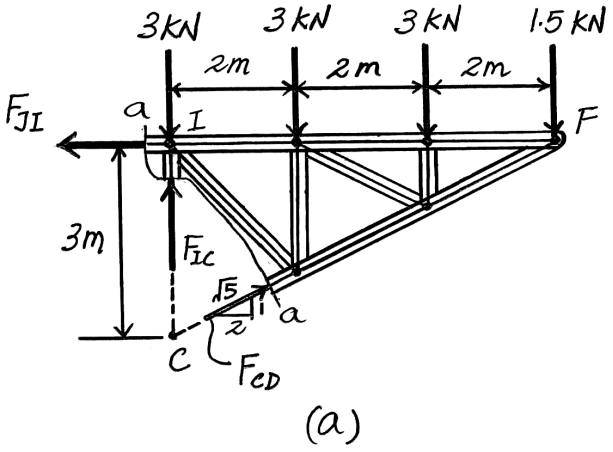
$F_{JI} = 9.00 \text{ kN (T)}$ **Ans.**

$\zeta + \sum M_F = 0; \quad 3(6) + 3(4) + 3(2) - F_{IC}(6) = 0$

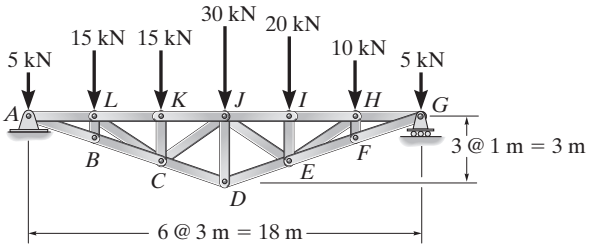
$F_{IC} = 6.00 \text{ kN (C)}$ **Ans.**

$\zeta + \sum M_I = 0; \quad F_{CD}\left(\frac{1}{\sqrt{5}}\right)(6) - 1.5(6) - 3(4) - 3(2) = 0$

$F_{CD} = 10.06 \text{ kN (C)} = 10.1 \text{ kN (C)}$ **Ans.**



3–27. Determine the forces in members *KJ*, *CD*, and *CJ* of the truss. State if the members are in tension or compression.

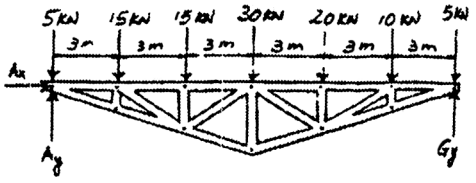


Entire truss:

$\stackrel{+}{\rightarrow} \sum F_x = 0; \quad A_x = 0$

$\zeta + \sum M_A = 0; \quad -15(3) - 15(6) - 30(9) - 20(12) - 10(15) - 5(18) + G_y(18) = 0$

$G_y = 49.17 \text{ kN}$



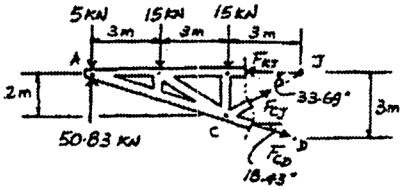
$+\uparrow \sum F_y = 0; \quad A_y - 5 - 15 - 15 - 30 - 20 - 10 - 5 + 49.167 = 0$

$A_y = 50.83 \text{ kN}$

Section:

$\zeta + \sum M_C = 0; \quad 15(3) + 5(6) - 50.83(6) + F_{KJ}(2) = 0$

$F_{KJ} = 115 \text{ kN (C)}$ **Ans.**



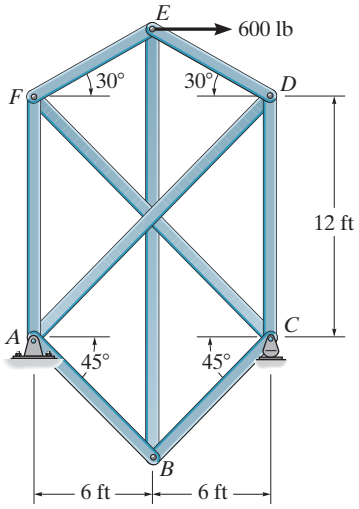
$\zeta + \sum M_A = 0; \quad -15(3) - 15(6) + F_{CJ} \sin 33.69°\,(9) = 0$

$F_{CJ} = 27.0 \text{ kN (T)}$ **Ans.**

$\zeta + \sum M_J = 0; \quad -50.83(9) + 5(9) + 15(6) + 15(3) + F_{CD} \cos 18.43°\,(3) = 0$

$F_{CD} = 97.5 \text{ kN (T)}$ **Ans.**

***3–28.** Determine the forces in all the members of the complex truss. State if the members are in tension or compression. *Hint:* Substitute member AD with one placed between E and C.



$S_i = S'_i + \chi(S_i)$

$F_{EC} = S'_{EC} + (x)\, S_{EC} = 0$

$747.9 + x(0.526) = 0$

$x = 1421.86$

Thus:

$F_{AF} = S_{AF} + (x)\, S_{AF}$

$= 1373.21 + (1421.86)(-1.41)$

$= -646.3$ lb

$F_{AF} = 646$ lb (C) **Ans.**

In a similar manner:

$F_{AB} = 580$ lb(C) **Ans.**

$F_{EB} = 820$ lb(T) **Ans.**

$F_{BC} = 580$ lb(C) **Ans.**

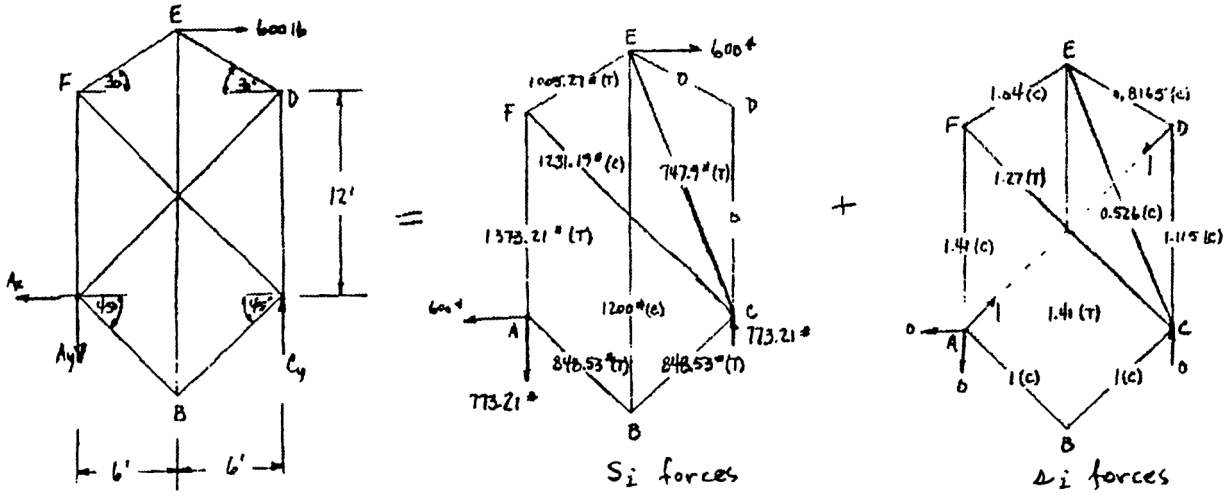
$F_{EF} = 473$ lb(C) **Ans.**

$F_{CF} = 580$ lb(T) **Ans.**

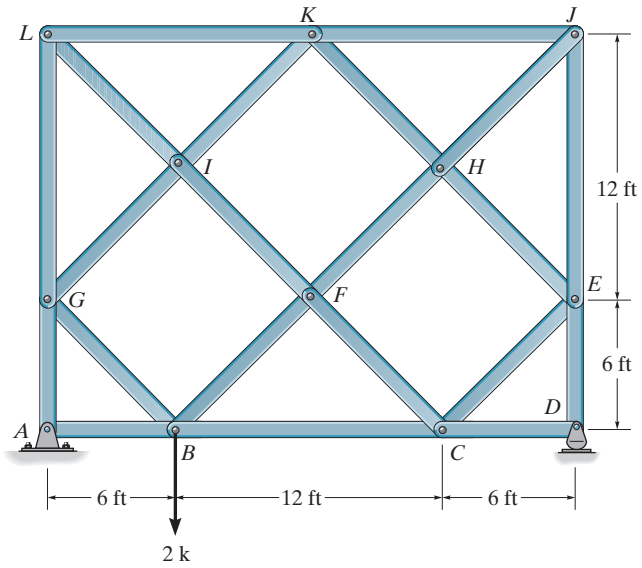
$F_{CD} = 1593$ lb(C) **Ans.**

$F_{ED} = 1166$ lb(C) **Ans.**

$F_{DA} = 1428$ lb(T) **Ans.**



3–29. Determine the forces in all the members of the lattice (complex) truss. State if the members are in tension or compression. *Hint:* Substitute member *JE* by one placed between *K* and *F*.



$S_i = S'_i + X\,(S_i)$

$F_{KF} = 1.5 + 1(x) = 0; \qquad x = -1.5$

Thus:

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

$F_{AG} = 1.50$ k (C) **Ans.**

$F_{GB} = 0.707$ k (T) **Ans.**

$F_{GL} = 0.500$ k (C) **Ans.**

$F_{GI} = 0.707$ k (C) **Ans.**

$F_{LI} = 0.707$ k (T) **Ans.**

$F_{LK} = 0.500$ k (C) **Ans.**

$F_{IK} = 0.707$ k (C) **Ans.**

$F_{IF} = 0.707$ k (T) **Ans.**

$F_{BF} = 2.12$ k (T) **Ans.**

$F_{BC} = 1.00$ k (C) **Ans.**

$F_{FC} = 0.707$ k (T) **Ans.**

$F_{FH} = 2.12$ k (T) **Ans.**

$F_{KH} = 0.707$ k (T) **Ans.**

$F_{KJ} = 1.50$ k (C) **Ans.**

$F_{JH} = 2.12$ k (T) **Ans.**

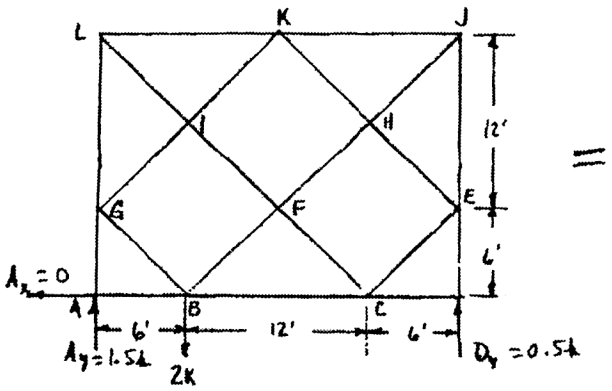
$F_{CD} = 0$ **Ans.**

$F_{DE} = 0.500$ k (C) **Ans.**

$F_{CE} = 0.707$ k (C) **Ans.**

$F_{HE} = 0.707$ k (T) **Ans.**

$F_{JE} = 1.50$ k (C) **Ans.**



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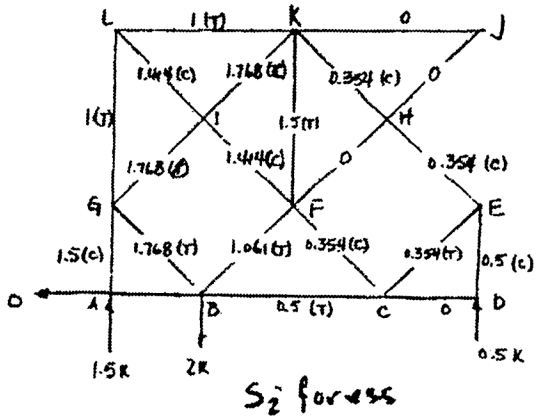
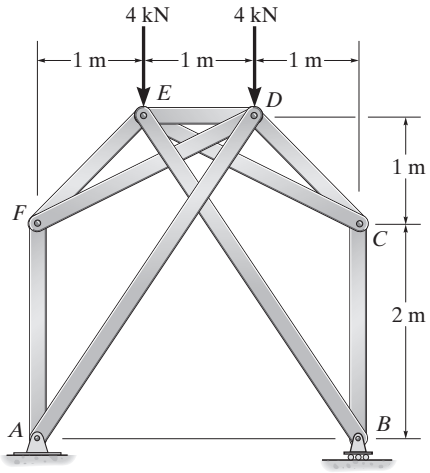


3–30. Determine the force in each member and state if the members are in tension or compression.



Reactions:

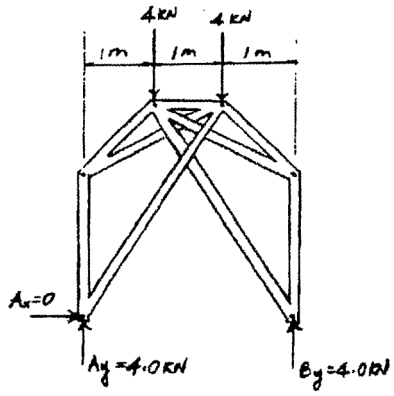
$A_x = 0, \quad A_y = 4.00\ \text{kN}, \quad B_y = 4.00\ \text{kN}$

Joint *A*:

$\stackrel{+}{\rightarrow} \sum F_x = 0; \quad F_{AD} = 0$ **Ans.**

$+\uparrow \sum F_y = 0; \quad 4.00 - F_{AF} = 0; \quad F_{AF} = 4.00\ \text{kN (C)}$ **Ans.**

Joint *F*:



$\nwarrow + \sum F_y = 0; \quad 4.00 \sin 45° - F_{FD} \sin 18.43° = 0$

$F_{FD} = 8.944\ \text{kN} = 8.94\ \text{kN (T)}$ **Ans.**

$+\nearrow \sum F_x = 0; \quad 4.00 \cos 45° + 8.94 \cos 18.43° - F_{FE} = 0$

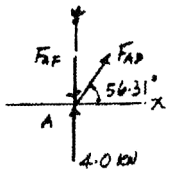
$F_{FE} = 11.313\ \text{kN} = 11.3\ \text{kN (C)}$ **Ans.**

Due to symmetrical loading and geometry

$F_{BC} = 4.00\ \text{kN (C)} \quad F_{CE} = 8.94\ \text{kN (T)}$ **Ans.**

$F_{BE} = 0 \quad F_{CD} = 11.3\ \text{kN (C)}$ **Ans.**

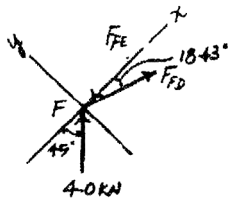
Joint *E*:

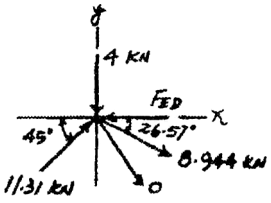


$\stackrel{+}{\rightarrow} \sum F_x = 0; \quad -F_{ED} + 8.944 \cos 26.56° + 11.31 \cos 45° = 0$

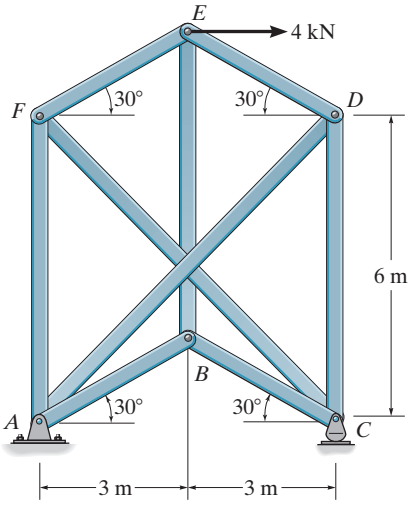
$F_{ED} = 16.0\ \text{kN (C)}$ **Ans.**

$+\uparrow \sum F_y = 0; \quad -4 - 8.944 \sin 26.56° + 11.31 \sin 45° = 0\ \text{(Check)}$





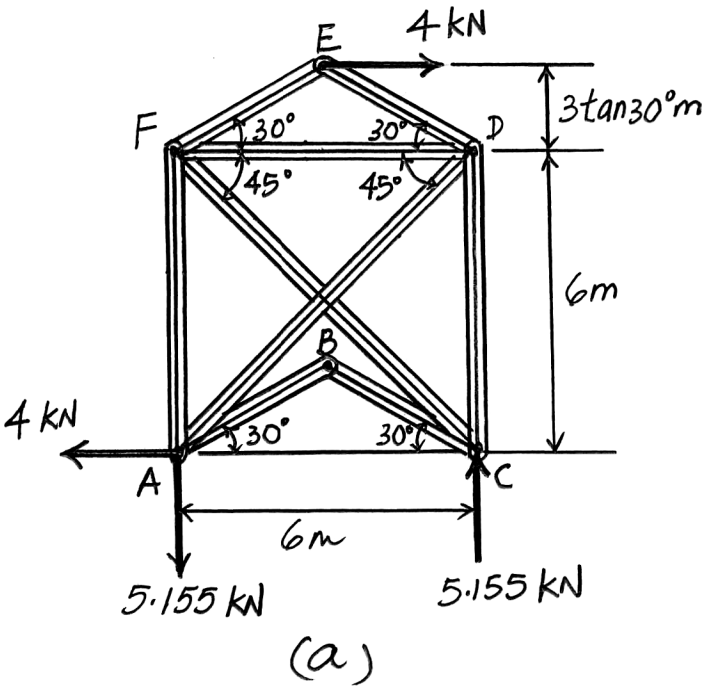
3–31. Determine the force in all the members of the complex truss. State if the members are in tension or compression.

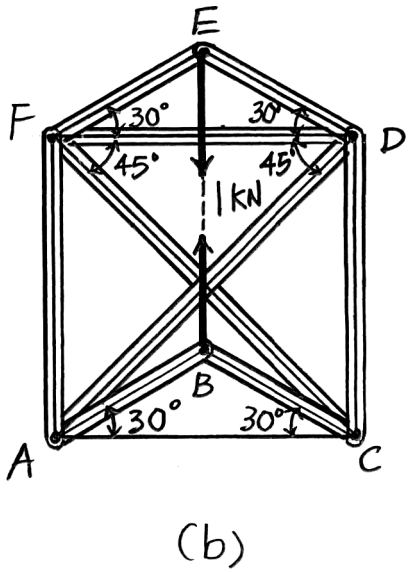


The member forces S_i' and S_i for each member of the reduced simple truss can be determined using method of joints by referring to Fig. *a* and *b*, respectively. Using the forces of the replacing member *DF*,

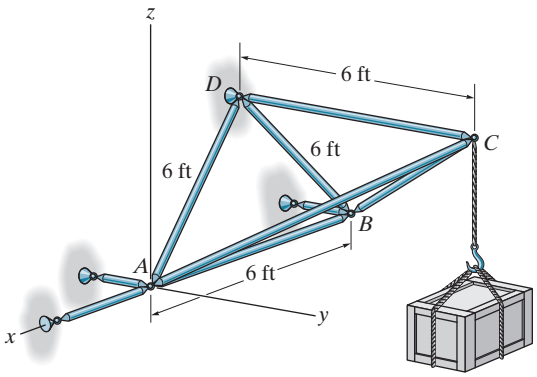
$$S_{DF} = S'_{DF} + XS_{DF}$$
$$0 = -2 + X(1.7320)$$
$$x = 1.1547$$

member	S_i' (kN)	S_i (kN)	XS_i (kN)	S_i (kN)
EF	2.3094	−1	−1.1547	1.15 (T)
ED	−2.3094	−1	−1.1547	3.46 (C)
BA	0	1	1.1547	1.15 (T)
BC	0	1	1.1547	1.15 (T)
AD	5.6569	−1.2247	−1.4142	4.24 (T)
AF	1.1547	0.3660	0.4226	1.58 (T)
CF	0	−1.2247	−1.4142	1.41 (C)
CD	−5.1547	0.3660	0.4226	4.73 (C)
BE	0	1	1.1547	1.15 (T)





***3–32.** 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.



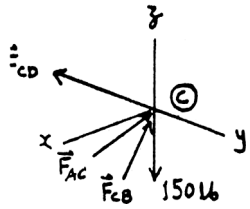
$$F_{CA} = F_{CA}\left[\frac{-1\mathbf{i} + 2\mathbf{j} + 2\sin 60°\,\mathbf{k}}{\sqrt{8}}\right]$$

$$= -0.354\,F_{CA}\mathbf{i} + 0.707\,F_{CA}\mathbf{j} + 0.612\,F_{CA}\mathbf{k}$$

$$F_{CB} = -0.354\,F_{CB}\mathbf{i} + 0.707\,F_{CB}\mathbf{j} + 0.612\,F_{CB}\mathbf{k}$$

$$F_{CD} = -F_{CD}\mathbf{j}$$

$$w = -150\,\mathbf{k}$$



$$\sum F_x = 0; \quad -0.354F_{CA} + 0.354F_{CB} = 0$$

$$\sum F_y = 0; \quad 0.707F_{CA} + 0.707F_{CB} - F_{CD} = 0$$

$$\sum F_z = 0; \quad 0.612F_{CA} + 0.612F_{CB} - 150 = 0$$

Solving:

$$F_{CA} = F_{CB} = 122.5\text{ lb} = 122\text{ lb (C)} \quad \textbf{Ans.}$$

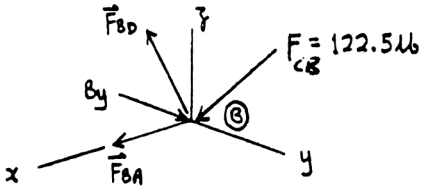
$$F_{CD} = 173\text{ lb (T)} \quad \textbf{Ans.}$$

$$\mathbf{F}_{BA} = F_{BA}\mathbf{i}$$

$$\mathbf{F}_{BD} = F_{BD}\cos 60°\,\mathbf{i} + F_{BD}\sin 60°\,\mathbf{k}$$

$$\mathbf{F}_{CB} = 122.5\,(-0.354\mathbf{i} - 0.707\mathbf{j} - 0.612\,\mathbf{k})$$

$$= -43.3\mathrm{i} - 86.6\mathrm{j} - 75.0\,\mathrm{k}$$



$$\sum F_x = 0; \quad F_{BA} + F_{BD}\cos 60° - 43.3 = 0$$

$$\sum F_z = 0; \quad F_{BD}\sin 60° - 75 = 0$$

Solving:

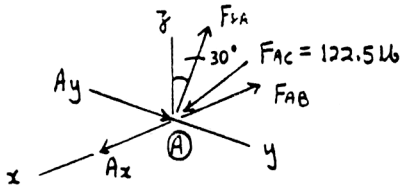
$$F_{BD} = 86.6\text{ lb (T)} \quad \textbf{Ans.}$$

$$F_{BA} = 0 \quad \textbf{Ans.}$$

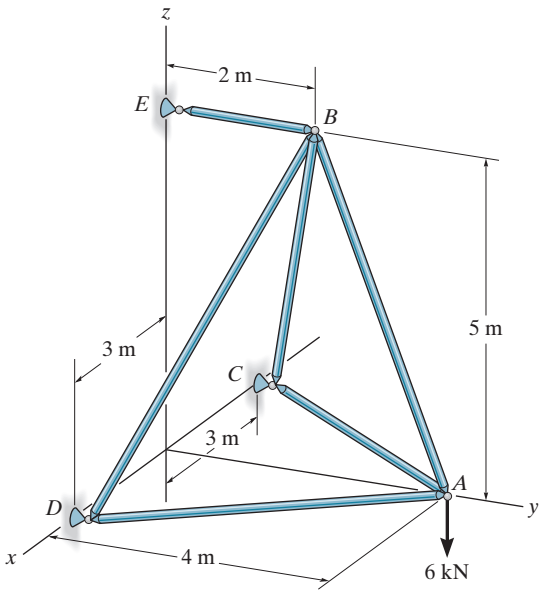
$$F_{AC} = 122.5(0.354F_{AC}\mathbf{i} - 0.707F_{AC}\mathbf{j} - 0.612F_{AC}\mathbf{k})$$

$$\sum F_z = 0; \quad F_{DA}\cos 30° - 0.612(122.5) = 0$$

$$F_{DA} = 86.6\text{ lb (T)} \quad \textbf{Ans.}$$

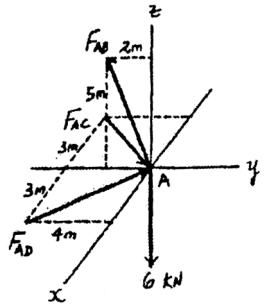


3–33. Determine the force in each member of the space truss and state if the members are in tension or compression. *Hint:* The support reaction at E acts along member EB. Why?



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

Joint *A*:



$$\sum F_x = 0; \qquad F_{AB}\left(\frac{5}{\sqrt{29}}\right) - 6 = 0$$

$$F_{AB} = 6.462 \text{ kN (T)} = 6.46 \text{ kN (T)} \qquad \textbf{Ans.}$$

$$\sum F_z = 0; \qquad F_{AC}\left(\frac{3}{5}\right) - F_{AD}\left(\frac{3}{5}\right) = 0 \qquad F_{AC} = F_{AD} \qquad [1]$$

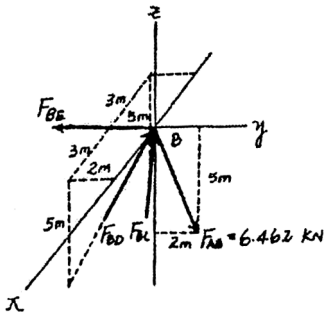
$$\sum F_y = 0; \qquad F_{AC}\left(\frac{4}{5}\right) + F_{AD}\left(\frac{4}{5}\right) - 6.462\left(\frac{2}{\sqrt{29}}\right) = 0$$

$$F_{AC} + F_{AD} = 3.00 \qquad [2]$$

Solving Eqs. [1] and [2] yields

$$F_{AC} = F_{AD} = 1.50 \text{ kN (C)} \qquad \textbf{Ans.}$$

Joint *B*:



$$\sum F_x = 0; \qquad F_{BC}\left(\frac{3}{\sqrt{38}}\right) - F_{BD}\left(\frac{3}{\sqrt{38}}\right) = 0 \qquad F_{BC} = F_{BD} \qquad [1]$$

$$\sum F_z = 0; \qquad F_{BC}\left(\frac{5}{\sqrt{38}}\right) + F_{BD}\left(\frac{5}{\sqrt{38}}\right) - 6.462\left(\frac{5}{\sqrt{29}}\right) = 0$$

$$F_{BC} + F_{BD} = 7.397 \qquad [2]$$

Solving Eqs. [1] and [2] yields

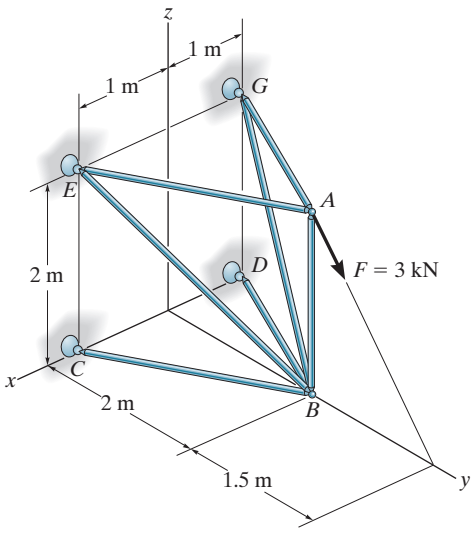
$$F_{BC} = F_{BD} = 3.699 \text{ kN (C)} = 3.70 \text{ kN (C)} \qquad \textbf{Ans.}$$

$$\sum F_y = 0; \qquad 2\left[3.699\left(\frac{2}{\sqrt{38}}\right)\right] + 6.462\left(\frac{2}{\sqrt{29}}\right) - F_{BE} = 0$$

$$F_{BE} = 4.80 \text{ kN (T)} \qquad \textbf{Ans.}$$

Note: The support reactions at supports C and D can be determined by analyzing joints C and D, respectively using the results oriented above.

3–34. 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 C, D, E, and G. *Note:* Although this truss is indeterminate to the first degree, a solution is possible due to symmetry of geometry and loading.



$$\sum (M_{EG})_x = 0; \qquad \frac{2}{\sqrt{5}} F_{BC}(2) + \frac{2}{\sqrt{5}} F_{BD}(2) - \frac{4}{5}(3)(2) = 0$$

$$F_{BC} + F_{BD} = 2.683 \text{ kN}$$

Due to symmetry: $F_{BC} = F_{BD} = 1.342 = 1.34 \text{ kN (C)}$ **Ans.**

Joint *A*:

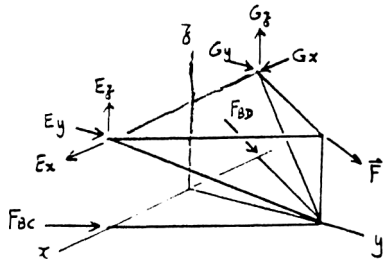
$$\sum F_z = 0; \qquad F_{AB} - \frac{4}{5}(3) = 0$$

$$F_{AB} = 2.4 \text{ kN (C)}$$ **Ans.**

$$\sum F_x = 0; \qquad F_{AG} = F_{AE}$$

$$\sum F_y = 0; \qquad \frac{3}{5}(3) - \frac{3}{\sqrt{5}} F_{AE} - \frac{3}{\sqrt{5}} F_{AG} = 0$$

$$F_{AG} = F_{AE} = 1.01 \text{ kN (T)}$$ **Ans.**



Joint *B*:

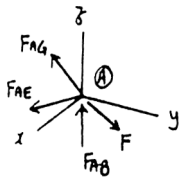
$$\sum F_x = 0; \qquad \frac{1}{\sqrt{5}}(1.342) + \frac{1}{3}F_{BE} - \frac{1}{\sqrt{5}}(1.342) - \frac{1}{3}F_{BG} = 0$$

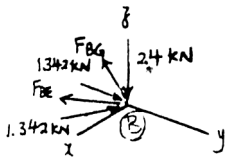
$$\sum F_y = 0; \qquad \frac{2}{\sqrt{5}}(1.342) - \frac{2}{3}F_{BE} + \frac{2}{\sqrt{5}}(1.342) - \frac{2}{3}F_{BG} = 0$$

$$\sum F_z = 0; \qquad \frac{2}{3}F_{BE} + \frac{2}{3}F_{BG} - 2.4 = 0$$

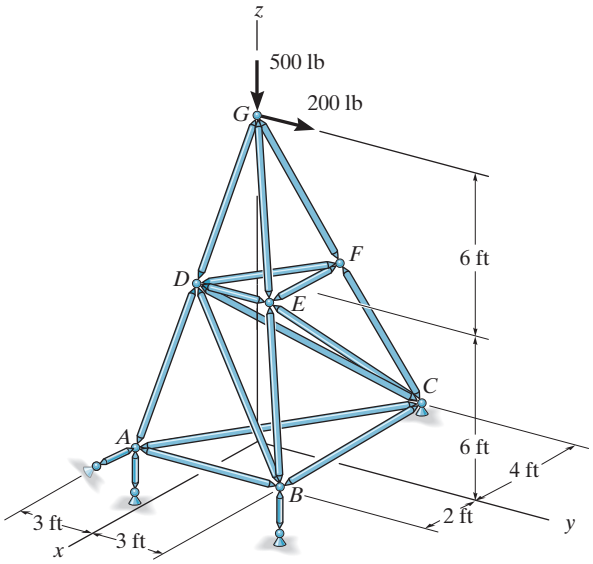
$$F_{BG} = 1.80 \text{ kN (T)}$$ **Ans.**

$$F_{BE} = 1.80 \text{ kN (T)}$$ **Ans.**





3–35. 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*.

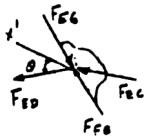


Joint *F*: F_{FG}, F_{FD}, and F_{FC} are lying in the same plane and x'axis is normal to that plane. Thus

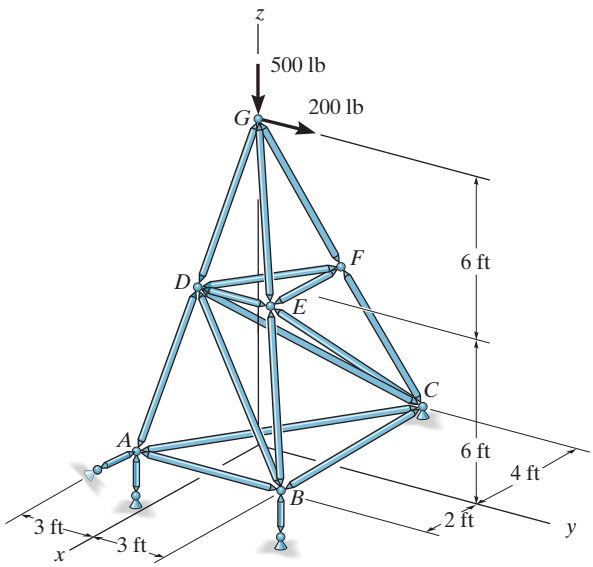
$$\sum F_{x'} = 0; \quad F_{FE}\cos\theta = 0; \quad F_{FE} = 0 \qquad \textbf{Ans.}$$

Joint *E*: F_{EG}, F_{BC}, and F_{EB} are lying in the same plane and x'axis is normal to that plane. Thus

$$\sum F_{x'} = 0; \quad F_{ED}\cos\theta = 0; \quad F_{ED} = 0 \qquad \textbf{Ans.}$$



***3–36.** 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*:

$$F_{GD} = F_{GD}\left(-\frac{2}{12.53}\mathbf{i} + \frac{3}{12.53}\mathbf{j} + \frac{12}{12.53}\mathbf{k}\right)$$

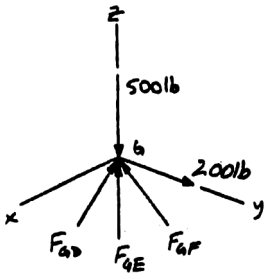
$$F_{GF} = F_{GF}\left(\frac{4}{13}\mathbf{i} - \frac{3}{13}\mathbf{j} + \frac{12}{13}\mathbf{k}\right)$$

$$F_{GE} = F_{GE}\left(-\frac{2}{12.53}\mathbf{i} - \frac{3}{12.53}\mathbf{j} + \frac{12}{12.53}\mathbf{k}\right)$$

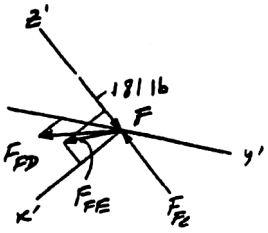
$$\sum F_x = 0; \qquad -F_{GD}\left(\frac{2}{12.53}\right) + F_{GF}\left(\frac{4}{13}\right) - F_{GE}\left(\frac{2}{12.53}\right) = 0$$

$$\sum F_y = 0; \qquad F_{GD}\left(\frac{3}{12.53}\right) + F_{GF}\left(\frac{3}{13}\right) - F_{GE}\left(\frac{3}{12.53}\right) + 200 = 0$$

$$\sum F_z = 0; \qquad F_{GD}\left(\frac{12}{12.53}\right) + F_{GF}\left(\frac{12}{13}\right) - F_{GE}\left(\frac{12}{12.53}\right) - 500 = 0$$



3–36. Continued



Solving,

$F_{GD} = -157 \text{ lb} = 157 \text{ lb (T)}$ **Ans.**

$F_{GF} = 181 \text{ lb (C)}$

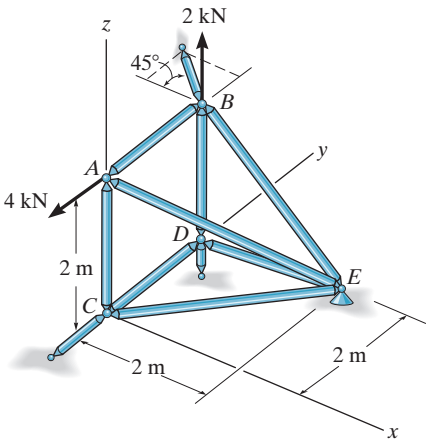
$F_{GE} = 505 \text{ lb (C)}$ **Ans.**

Joint *F*:

Orient the x', y', z' axes as shown.

$\sum F_{y'} = 0; \quad F_{FD} = 0$ **Ans.**

3–37. Determine the force in each member of the space truss. Indicate if the members are in tension or compression.



Joint *A*:

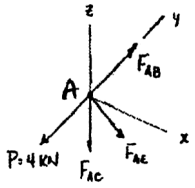
$\sum F_x = 0; \quad 0.577F_{AE} = 0$

$\sum F_y = 0; \quad -4 + F_{AB} + 0.577\, F_{AE} = 0$

$\sum F_z = 0; \quad -F_{AC} - 0.577\, F_{AE} = 0$

$F_{AC} = F_{AE} = 0$ **Ans.**

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



Joint *B*:

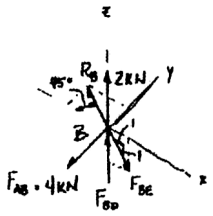
$\sum F_x = 0; \quad -R_B(\cos 45°) + 0.707F_{BE} = 0$

$\sum F_y = 0; \quad -4 + R_B(\sin 45°) = 0$

$\sum F_z = 0; \quad 2 + F_{BD} - 0.707\, F_{BE} = 0$

$R_B = F_{BE} = 5.66 \text{ kN (T)}$ **Ans.**

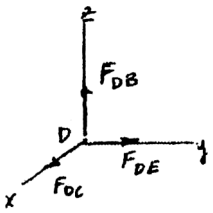
$F_{BD} = 2 \text{ kN (C)}$ **Ans.**



Joint *D*:

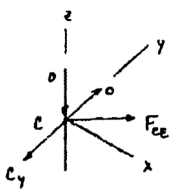
$\sum F_x = 0; \quad F_{DE} = 0$ **Ans.**

$\sum F_y = 0; \quad F_{DC} = 0$ **Ans.**

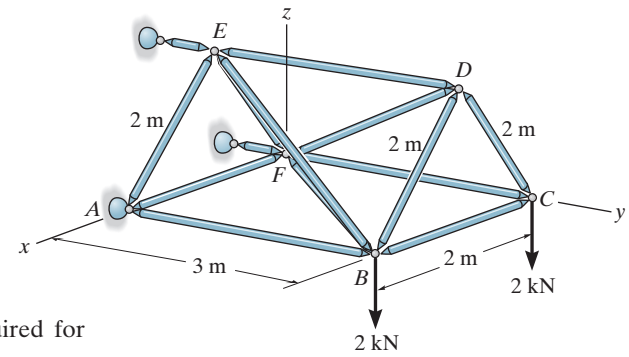


Joint *C*:

$\sum F_x = 0; \quad F_{CE} = 0$ **Ans.**



3–38. Determine the force in members BE, DF, and BC of the space truss and state if the members are in tension or compression.



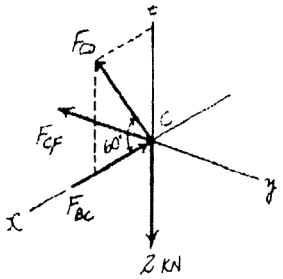
***Method of Joints*:** In this case, the support reactions are not required for determining the member forces.

Joint *C*:

$$\sum F_t = 0; \qquad F_{CD} \sin 60° - 2 = 0 \qquad F_{CD} = 2.309 \text{ kN (T)}$$

$$\sum F_x = 0; \qquad 2.309 \cos 60° - F_{BC} = 0$$

$$F_{BC} = 1.154 \text{ kN (C)} = 1.15 \text{ kN (C)} \qquad \textbf{Ans.}$$



Joint *D*: Since F_{CD}, F_{DE} and F_{DF} lie within the same plane and F_{DE} is out of this plane, then $F_{DE} = 0$.

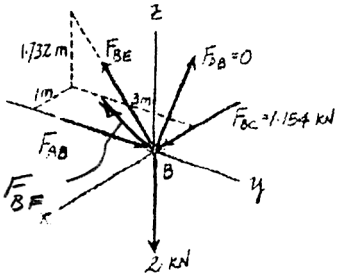
$$\sum F_x = 0; \qquad F_{DF}\left(\frac{1}{\sqrt{13}}\right) - 2.309 \cos 60° = 0$$

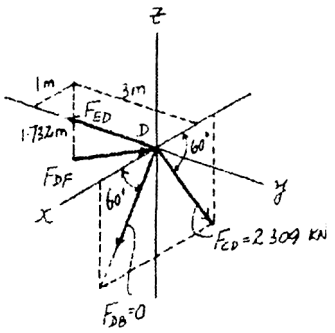
$$F_{DF} = 4.16 \text{ kN (C)} \qquad \textbf{Ans.}$$

Joint *B*:

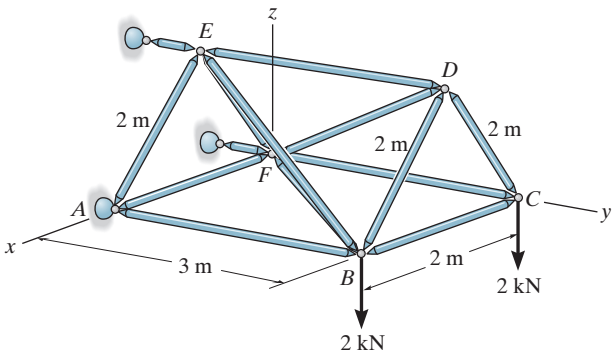
$$\sum F_t = 0; \qquad F_{BE}\left(\frac{1.732}{\sqrt{13}}\right) - 2 = 0$$

$$F_{BE} = 4.16 \text{ kN (T)} \qquad \textbf{Ans.}$$





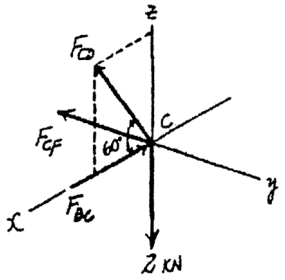
3–39. Determine the force in members *CD*, *ED*, and *CF* of the space truss and state if the members are in tension or compression.



***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

$$F_{CF} = 0 \qquad \textbf{Ans.}$$

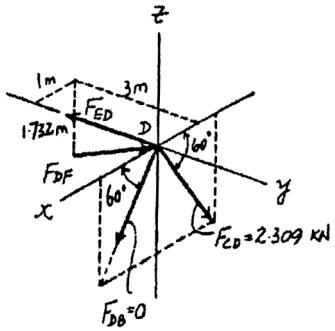


$$\sum F_t = 0; \qquad F_{CD} \sin 60° - 2 = 0$$

$$F_{CD} = 2.309 \text{ kN (T)} = 2.31 \text{ kN (T)} \qquad \textbf{Ans.}$$

$$\sum Fx = 0; \qquad 2.309 \cos 60° - F_{BC} = 0 \qquad F_{BC} = 1.154 \text{ kN (C)}$$

Joint *D*: Since F_{CD}, F_{DE}, and F_{DE} lie within the same plane and F_{DE} is out of this plane, then $F_{DE} = 0$.



$$\sum F_x = 0; \qquad F_{DF}\left(\frac{1}{\sqrt{13}}\right) - 2.309 \cos 60° = 0$$

$$F_{DF} = 4.163 \text{ kN (C)}$$

$$\sum F_y = 0; \qquad 4.163\left(\frac{3}{\sqrt{13}}\right) - F_{ED} = 0$$

$$F_{ED} = 3.46 \text{ kN (T)} \qquad \textbf{Ans.}$$