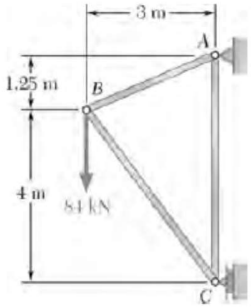


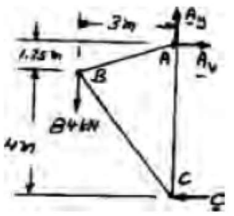
PROBLEM 6.1

Using the method of joints, determine the force in each member of the truss shown. State whether each member is in tension or compression.

SOLUTION

$$AB = \sqrt{3^2 + 1.25^2} = 3.25 \text{ m}$$

$$BC = \sqrt{3^2 + 4^2} = 5 \text{ m}$$



Reactions:

$$+\circlearrowleft \Sigma M_A = 0: \quad (84 \text{ kN})(3 \text{ m}) - C(5.25 \text{ m}) = 0$$

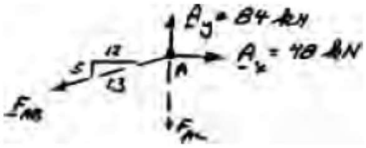
$$\mathbf{C} = 48 \text{ kN} \leftarrow$$

$$\pm\rightarrow \Sigma F_x = 0: \quad A_x - C = 0$$

$$\mathbf{A}_x = 48 \text{ kN} \rightarrow$$

$$+\uparrow \Sigma F_y = 0: \quad A_y = 84 \text{ kN} = 0$$

$$\mathbf{A}_y = 84 \text{ kN} \uparrow$$



Joint *A*:

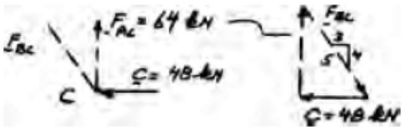
$$\pm\rightarrow \Sigma F_x = 0: \quad 48 \text{ kN} - \frac{12}{13} F_{AB} = 0$$

$$F_{AB} = +52 \text{ kN} \qquad F_{AB} = 52 \text{ kN} \quad T \blacktriangleleft$$

$$+\uparrow \Sigma F_y = 0: \quad 84 \text{ kN} - \frac{5}{13}(52 \text{ kN}) - F_{AC} = 0$$

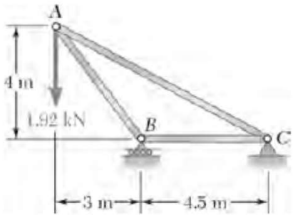
$$F_{AC} = +64.0 \text{ kN} \qquad F_{AC} = 64.0 \text{ kN} \quad T \blacktriangleleft$$

Joint *C*:



$$\frac{F_{BC}}{5} = \frac{48 \text{ kN}}{3}$$

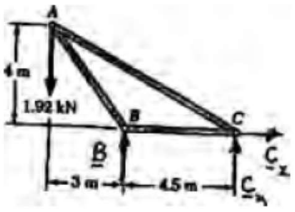
$$F_{BC} = 80.0 \text{ kN} \quad C \blacktriangleleft$$



PROBLEM 6.3

Using the method of joints, determine the force in each member of the truss shown. State whether each member is in tension or compression.

SOLUTION



Free body: Entire truss

$$\rightarrow \Sigma F_x = 0: \quad C_x = 0 \quad \mathbf{C}_x = 0$$

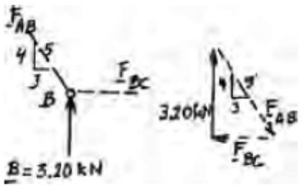
$$+\circlearrowleft \Sigma M_B = 0: \quad (1.92\ \text{kN})(3\ \text{m}) + C_y(4.5\ \text{m}) = 0$$

$$C_y = -1.28\ \text{kN} \quad \mathbf{C}_y = 1.28\ \text{kN}\downarrow$$

$$+\uparrow \Sigma F_y = 0: \quad B - 1.92\ \text{kN} - 1.28\ \text{kN} = 0$$

$$\mathbf{B} = 3.20\ \text{kN}\uparrow$$

Free body: Joint *B*:

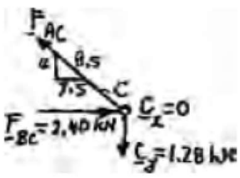


$$\frac{F_{AB}}{5} = \frac{F_{BC}}{3} = \frac{3.20\ \text{kN}}{4}$$

$$F_{AB} = 4.00\ \text{kN} \quad C \blacktriangleleft$$

$$F_{BC} = 2.40\ \text{kN} \quad C \blacktriangleleft$$

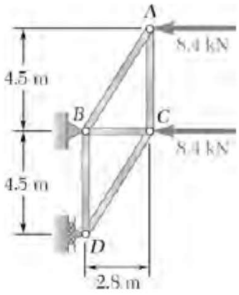
Free body: Joint *C*:



$$\rightarrow \Sigma F_x = 0: \quad -\frac{7.5}{8.5} F_{AC} + 2.40\ \text{kN} = 0$$

$$F_{AC} = +2.72\ \text{kN} \qquad F_{AC} = 2.72\ \text{kN} \quad T \blacktriangleleft$$

$$+\uparrow \Sigma F_y = \frac{4}{8.5}(2.72\ \text{kN}) - 1.28\ \text{kN} = 0 \quad \text{(Checks)}$$

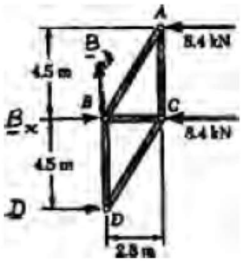


PROBLEM 6.7

Using the method of joints, determine the force in each member of the truss shown. State whether each member is in tension or compression.

SOLUTION

Free body: Truss



$+\uparrow \Sigma F_y = 0: \quad \mathbf{B}_y = 0$

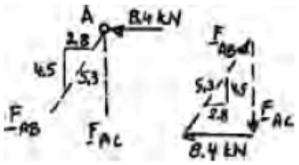
$+\circlearrowleft \Sigma M_B = 0: \quad D(4.5\text{ m}) + (8.4\text{ kN})(4.5\text{ m}) = 0$

$D = -8.4\text{ kN} \qquad \mathbf{D} = 8.4\text{ kN} \leftarrow$

$\pm\rightarrow \Sigma F_x = 0: \quad B_x - 8.4\text{ kN} - 8.4\text{ kN} - 8.4\text{ kN} = 0$

$B_x = +25.2\text{ kN} \qquad \mathbf{B}_x = 25.2\text{ kN} \rightarrow$

Free body: Joint A:

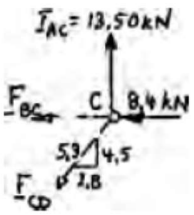


$$\frac{F_{AB}}{5.3} = \frac{F_{AC}}{4.5} = \frac{8.4\text{ kN}}{2.8}$$

$F_{AB} = 15.90\text{ kN} \quad C \blacktriangleleft$

$F_{AC} = 13.50\text{ kN} \quad T \blacktriangleleft$

Free body: Joint C:



$+\uparrow \Sigma F_y = 0: \quad 13.50\text{ kN} - \frac{4.5}{5.3} F_{CD} = 0$

$F_{CD} = +15.90\text{ kN}$

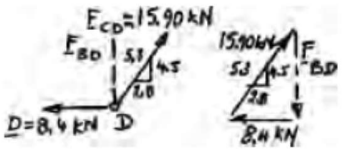
$F_{CD} = 15.90\text{ kN} \quad T \blacktriangleleft$

$\pm\rightarrow \Sigma F_x = 0: \quad -F_{BC} - 8.4\text{ kN} - \frac{2.8}{5.3}(15.90\text{ kN}) = 0$

$F_{BC} = -16.80\text{ kN} \qquad F_{BC} = 16.80\text{ kN} \quad C \blacktriangleleft$

PROBLEM 6.7 (Continued)

Free body: Joint D:



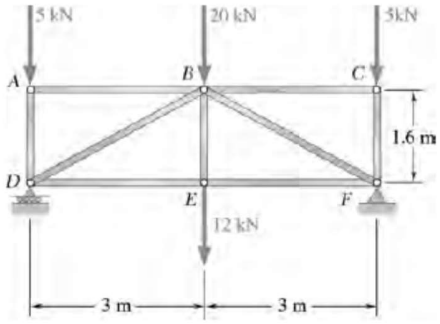
$$\frac{F_{BD}}{4.5} = \frac{8.4\text{ kN}}{2.8}$$

$$F_{BD} = 13.50\text{ kN} \quad C \blacktriangleleft$$

We can also write the proportion

$$\frac{F_{BD}}{4.5} = \frac{15.90\text{ kN}}{5.3}$$

$$F_{BD} = 13.50\text{ kN} \quad C \quad \text{(Checks)}$$

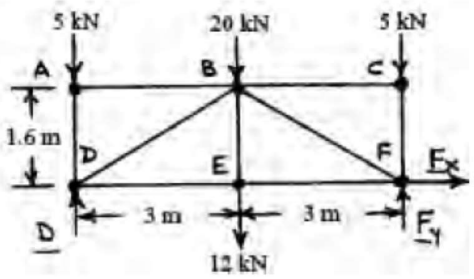


PROBLEM 6.4

Using the method of joints, determine the force in each member of the truss shown. State whether each member is in tension or compression.

SOLUTION

Reactions:



$$\circlearrowleft \Sigma M_D = 0: \quad F_y(6) - (20+12)(3) - (5)(6) = 0$$

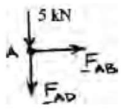
$$\mathbf{F}_y = 21\ \text{kN} \uparrow$$

$$\Sigma F_x = 0: \quad \mathbf{F}_x = 0$$

$$+\uparrow \Sigma F_y = 0: \quad D - (5+20+5+12) + (21) = 0$$

$$\mathbf{D} = 21\ \text{kN} \uparrow$$

Joint *A*:

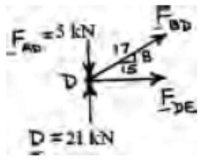


$$\Sigma F_x = 0: \quad F_{AB} = 0 \qquad F_{AB} = 0 \blacktriangleleft$$

$$+\uparrow \Sigma F_y = 0: \quad -5 - F_{AD} = 0$$

$$F_{AD} = -5\ \text{kN} \qquad F_{AD} = 5.00\ \text{kN} \quad C \blacktriangleleft$$

Joint *D*:



$$+\uparrow \Sigma F_y = 0: \quad -5 + 21 + \frac{8}{17} F_{BD} = 0$$

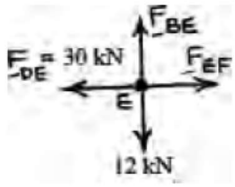
$$F_{BD} = -34\ \text{kN} \qquad F_{BD} = 34.0\ \text{kN} \quad C \blacktriangleleft$$

$$+\rightarrow \Sigma F_x = 0: \quad \frac{15}{17}(-34) + F_{DE} = 0$$

$$F_{DE} = +30\ \text{kN} \qquad F_{DE} = 30.0\ \text{kN} \quad T \blacktriangleleft$$

PROBLEM 6.4 (Continued)

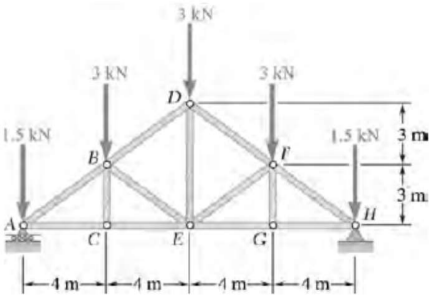
Joint *E*:



$+\uparrow \Sigma F_y = 0: \quad F_{BE} - 12 = 0$

$F_{BE} = +12$ kN $\qquad F_{BE} = 12.00$ kN T ◀

Truss and loading symmetrical about ℄

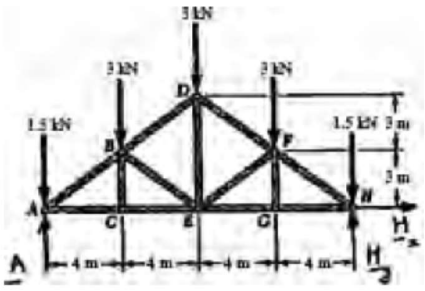


PROBLEM 6.11

Determine the force in each member of the Howe roof truss shown. State whether each member is in tension or compression.

SOLUTION

Free body: Truss



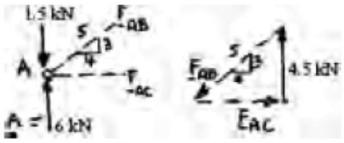
$$\Sigma F_x = 0: \quad \mathbf{H}_x = 0$$

Because of the symmetry of the truss and loading:

$$A = H_y = \frac{1}{2} \text{ Total load}$$

$$\mathbf{A} = \mathbf{H}_y = 6 \text{ kN} \uparrow$$

Free body: Joint A:



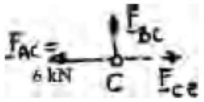
$$\frac{F_{AB}}{5} = \frac{F_{AC}}{4} = \frac{4.5 \text{ kN}}{3}$$

$\mathbf{F}_{AB} = 7.50$ kN C ◀

$\mathbf{F}_{AC} = 6.00$ kN T ◀

Free body: Joint C:

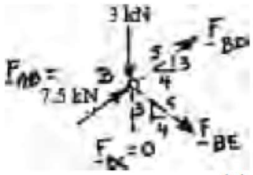
BC is a zero-force member



$\mathbf{F}_{BC} = 0$

$\mathbf{F}_{CE} = 6.00$ kN T ◀

PROBLEM 6.11 (Continued)



Free body: Joint B:

$$\stackrel{+}{\rightarrow}\Sigma F_x = 0: \quad \frac{4}{5}F_{BD} + \frac{4}{5}F_{BC} + \frac{4}{5}(7.5\text{ kN}) = 0$$

or $$F_{BD} + F_{BE} = -7.5\text{ kN} \qquad (1)$$

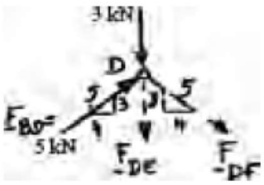
$$+\uparrow \Sigma F_y = 0: \quad \frac{3}{5}F_{BD} - \frac{3}{5}F_{BE} + \frac{3}{5}(7.5\text{ kN}) - 3\text{ kN} = 0$$

or $$F_{BD} - F_{BE} = -2.5\text{ kN} \qquad (2)$$

Add Eqs. (1) and (2): $2F_{BD} = -10\text{ kN}$ $\qquad F_{BD} = 5.00\text{ kN}\quad C$ ◀

Subtract (2) from (1): $2F_{BE} = -5\text{ kN}$ $\qquad F_{BE} = 2.50\text{ kN}\quad C$ ◀

Free Body: Joint D:



$$\stackrel{+}{\rightarrow}\Sigma F_x = 0: \quad \frac{4}{5}(5\text{ kN}) + \frac{4}{5}F_{DF} = 0$$

$F_{DF} = -5\text{ kN}$ $\qquad F_{DF} = 5.00\text{ kN}\quad C$ ◀

$$+\uparrow \Sigma F_y = 0: \quad \frac{3}{5}(5\text{ kN}) - \frac{3}{5}(-5\text{ kN}) - 3\text{ kN} - F_{DE} = 0$$

$F_{DE} = +3\text{ kN}$ $\qquad F_{DE} = 3.00\text{ kN}\quad T$ ◀

Because of the symmetry of the truss and loading, we deduce that

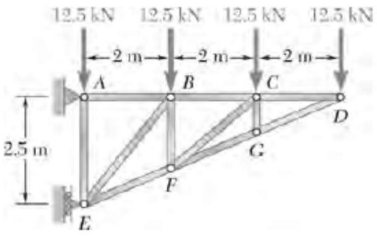
$F_{EF} = F_{BE}$ $\qquad F_{EF} = 2.50\text{ kN}\quad C$ ◀

$F_{EG} = F_{CE}$ $\qquad F_{EG} = 6.00\text{ kN}\quad T$ ◀

$F_{FG} = F_{BC}$ $\qquad F_{FG} = 0$ ◀

$F_{FH} = F_{AB}$ $\qquad F_{FH} = 7.50\text{ kN}\quad C$ ◀

$F_{GH} = F_{AC}$ $\qquad F_{GH} = 6.00\text{ kN}\quad T$ ◀



PROBLEM 6.13

Determine the force in each member of the truss shown.

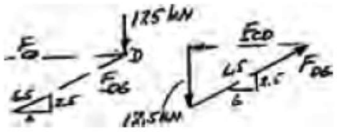
SOLUTION

Joint D:

$$\frac{12.5\text{ kN}}{2.5}=\frac{F_{CD}}{6}=\frac{F_{DG}}{6.5}$$

$F_{CD}=30$ kN T ◀

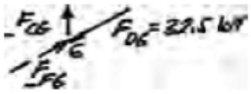
$F_{DG}=32.5$ kN C ◀



Joint G:

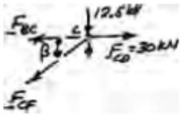
$\nwarrow \Sigma F=0$: $F_{CG}=0$ ◀

$\nearrow \Sigma F=0$: $F_{FG}=32.5$ kN C ◀



Joint C:

$$BF=\frac{2}{3}(2.5\text{ m})=1.6667\text{ m}\quad \beta=\angle BCF=\tan^{-1}\frac{BF}{2}=39.81^\circ$$



$+\uparrow \Sigma F_y=0$: $-12.5\text{ kN}-F_{CF}\sin\beta=0$

$-12.5\text{ kN}-F_{CF}\sin 39.81^\circ=0$

$F_{CF}=-19.526$ kN $F_{CF}=19.53$ kN C ◀

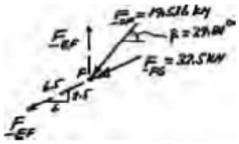
$\xrightarrow{+} \Sigma F_x=0$: $30\text{ kN}-F_{BC}-F_{CF}\cos\beta=0$

$30\text{ kN}-F_{BC}-(-19.526\text{ kN})\cos 39.81^\circ=0$

$F_{BC}=+45.0$ kN $F_{BC}=45.0$ kN T ◀

Joint F:

$$\xrightarrow{+} \Sigma F_x=0:\quad -\frac{6}{6.5}F_{EF}-\frac{6}{6.5}(32.5\text{ kN})-F_{CF}\cos\beta=0$$



$$F_{EF}=-32.5\text{ kN}-\left(\frac{6.5}{6}\right)(19.526\text{ kN})\cos 39.81^\circ$$

$F_{EF}=-48.75$ kN $F_{EF}=48.8$ kN C ◀

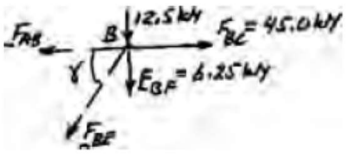
$$+\uparrow \Sigma F_y=0:\quad F_{BF}-\frac{2.5}{6.5}F_{EF}-\frac{2.5}{6.5}(32.5\text{ kN})-(19.526\text{ kN})\sin 39.81^\circ=0$$

$$F_{BF}-\frac{2.5}{6.5}(-48.75\text{ kN})-12.5\text{ kN}-12.5\text{ kN}=0$$

$F_{BF}=+6.25$ kN $F_{BF}=6.25$ kN T ◀

PROBLEM 6.13 (Continued)

Joint B:



$$\tan\alpha = \frac{2.5\text{ m}}{2\text{ m}}; \quad \gamma = 51.34^\circ$$

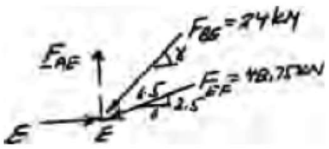
$$+\uparrow \Sigma F_y = 0: \quad -12.5\text{ kN} - 6.25\text{ kN} - F_{BE}\sin 51.34^\circ = 0$$

$$F_{BE} = -24.0\text{ kN} \qquad F_{BE} = 24.0\text{ kN} \quad C \blacktriangleleft$$

$$\pm\rightarrow \Sigma F_x = 0: \quad 45.0\text{ kN} - F_{AB} + (24.0\text{ kN})\cos 51.34^\circ = 0$$

$$F_{AB} = +60\text{ kN} \qquad F_{AB} = 60.0\text{ kN} \quad T \blacktriangleleft$$

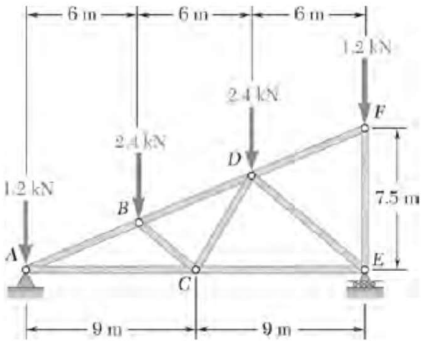
Joint E:



$$\gamma = 51.34^\circ$$

$$\pm\rightarrow \Sigma F_y = 0: \quad F_{AE} - (24\text{ kN})\sin 51.34^\circ - (48.75\text{ kN})\frac{2.5}{6.5} = 0$$

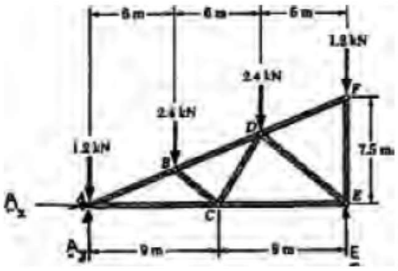
$$F_{AE} = +37.5\text{ kN} \qquad F_{AE} = 37.5\text{ kN} \quad T \blacktriangleleft$$



PROBLEM 6.14

Determine the force in each member of the roof truss shown. State whether each member is in tension or compression.

SOLUTION



Free body: Truss

$$\Sigma F_x = 0: \quad \mathbf{A}_x = 0$$

From symmetry of loading:

$$\mathrm{A}_y = \mathrm{E} = \frac{1}{2}\,\text{Total load}$$

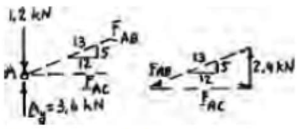
$$\mathrm{A}_y = \mathrm{E} = 3.6\ \text{kN} \uparrow$$

We note that DF is a zero-force member and that EF is aligned with the load. Thus

$$F_{DF} = 0 \blacktriangleleft$$

$$F_{EF} = 1.2\ \text{kN} \quad C \blacktriangleleft$$

Free body: Joint A:

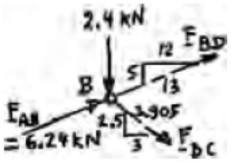


$$\frac{F_{AB}}{13} = \frac{F_{AC}}{12} = \frac{2.4\ \text{kN}}{5}$$

$$F_{AB} = 6.24\ \text{kN} \quad C \blacktriangleleft$$

$$F_{AC} = 2.76\ \text{kN} \quad T \blacktriangleleft$$

Free body: Joint B:



$$\xrightarrow{+} \Sigma F_x = 0: \quad \frac{3}{3.905}F_{BC} + \frac{12}{13}F_{BD} + \frac{12}{13}(6.24\ \text{kN}) = 0 \qquad (1)$$

$$+\uparrow \Sigma F_y = 0: \quad -\frac{2.5}{3.905}F_{BC} + \frac{5}{13}F_{BD} + \frac{5}{13}(6.24\ \text{kN}) - 2.4\ \text{kN} = 0 \qquad (2)$$

PROBLEM 6.14 (Continued)

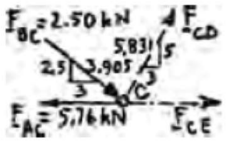
Multiply (1) by 2.5, (2) by 3, and add:

$$\frac{45}{13}F_{BD}+\frac{45}{13}(6.24\text{ kN})-7.2\text{ kN}=0,\quad F_{BD}=-4.16\text{ kN},\qquad F_{BD}=4.16\text{ kN}\quad C\blacktriangleleft$$

Multiply (1) by 5, (2) by –12, and add:

$$\frac{45}{3.905}F_{BC}+28.8\text{ kN}=0,\quad F_{BC}=-2.50\text{ kN},\qquad F_{BC}=2.50\text{ kN}\quad C\blacktriangleleft$$

Free body: Joint C:



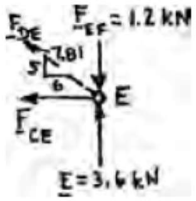
$$+\uparrow\Sigma F_y=0:\quad\frac{5}{5.831}F_{CD}-\frac{2.5}{3.905}(2.50\text{ kN})=0$$

$$F_{CD}=1.867\text{ kN}\quad T\blacktriangleleft$$

$$\overset{+}{\rightarrow}\Sigma F_x=0:\quad F_{CE}-5.76\text{ kN}+\frac{3}{3.905}(2.50\text{ kN})+\frac{3}{5.831}(1.867\text{ kN})=0$$

$$F_{CE}=2.88\text{ kN}\quad T$$

Free body: Joint E:

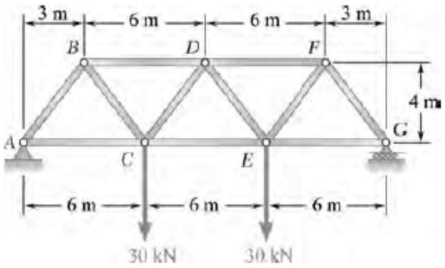


$$+\uparrow\Sigma F_y=0:\quad\frac{5}{7.81}F_{DE}+3.6\text{ kN}-1.2\text{ kN}=0$$

$$F_{DE}=-3.75\text{ kN}\quad F_{DE}=3.75\text{ kN}\quad C\blacktriangleleft$$

$$\overset{+}{\rightarrow}\Sigma F_x=0:\quad -F_{CE}-\frac{6}{7.81}(-3.75\text{ kN})=0$$

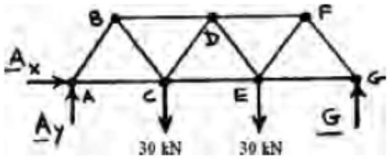
$$F_{CE}=+2.88\text{ kN}\quad F_{CE}=2.88\text{ kN}\quad T\quad\text{(Checks)}$$



PROBLEM 6.15

Determine the force in each member of the Warren bridge truss shown. State whether each member is in tension or compression.

SOLUTION



Free body: Truss $\quad \Sigma F_x = 0: \quad A_x = 0$

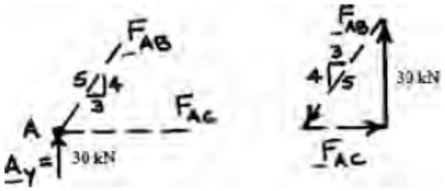
Due to symmetry of truss and loading

$$A_y = G = \frac{1}{2}\text{Total load} = 30\text{ kN}\uparrow$$

Free body: Joint A: $\quad \dfrac{F_{AB}}{5} = \dfrac{F_{AC}}{3} = \dfrac{30}{4}\text{kN}$

$F_{AB} = 37.5\text{ kN} \quad C$ ◀

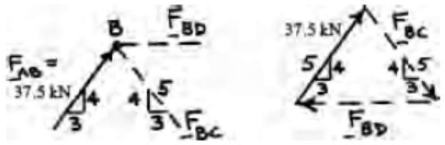
$F_{AC} = 22.5\text{ kN} \quad T$ ◀



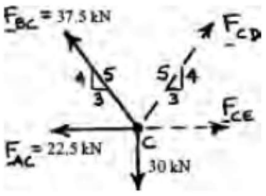
Free body: Joint B: $\quad \dfrac{F_{BC}}{5} = \dfrac{F_{BD}}{6} = \dfrac{37.5}{5}\text{kN}$

$F_{BC} = 37.5\text{ kN} \quad T$ ◀

$F_{BD} = 45\text{ kN} \quad C$ ◀



Free body: Joint C:



$+\uparrow \Sigma F_y = 0: \quad \dfrac{4}{5}(37.5) + \dfrac{4}{5}F_{CD} - 30 = 0$

$F_{CD} = 0$ ◀

$\rightarrow \Sigma F_x = 0: \quad F_{CE} - 22.5 - \dfrac{3}{5}(37.5) = 0$

$+\uparrow F_{CE} = +45\text{ kN}$

$F_{CE} = 45\text{ kN} \quad T$ ◀

Truss and loading symmetrical about ℄