PROBLEM 6.2

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

\[ \pm \Sigma F_x = 0: \quad B_x = 0 \]

\[ \Sigma M_B = 0: \quad C(15.75 \text{ ft}) - (945 \text{ lb})(12 \text{ ft}) = 0 \]

\[ C = 720 \text{ lb} \uparrow \]

\[ \Sigma F_y = 0: \quad B_y + 720 \text{ lb} - 945 \text{ lb} = 0 \]

\[ B_y = 225 \text{ lb} \uparrow \]

Free body: Joint B:

\[ F_{AB} = \frac{F_{BC}}{4} = \frac{225 \text{ lb}}{3} \]

\[ F_{AB} = 375 \text{ lb} \quad C \downarrow \]

\[ F_{BC} = 300 \text{ lb} \quad T \downarrow \]

Free body: Joint C:

\[ F_{AC} = \frac{F_{BC}}{9} = \frac{720 \text{ lb}}{9} \]

\[ F_{AC} = 80 \text{ lb} \quad \] (Checks)

\[ F_{BC} = 300 \text{ lb} \quad T \]

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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:

\[ \sum M_D = 0: \quad F_y(24) - (4 + 2.4)(12) - 1(24) = 0 \]
\[ F_y = 4.2 \text{ kips} \]

\[ \sum F_x = 0: \quad F_x = 0 \]
\[ + \sum F_y = 0: \quad D - (1 + 4 + 1 + 2.4) + 4.2 = 0 \]
\[ D = 4.2 \text{ kips} \]

Joint A:

\[ \sum F_x = 0: \quad F_{AB} = 0 \]
\[ + \sum F_y = 0: \quad -1 - F_{AD} = 0 \]
\[ F_{AD} = -1 \text{ kip} \]
\[ F_{AB} = 0 \]
\[ F_{AD} = 1.000 \text{ kip} \]

Joint D:

\[ + \sum F_y = 0: \quad -1 + 4.2 + \frac{8}{17}F_{BD} = 0 \]
\[ F_{BD} = -6.8 \text{ kips} \]
\[ F_{DE} = 6.00 \text{ kips} \]

\[ \sum F_x = 0: \quad \frac{15}{17}(-6.8) + F_{DE} = 0 \]
\[ F_{DE} = 6.00 \text{ kips} \]
PROBLEM 6.4 (Continued)

Joint E:

\[ F_{DE} = 3 \text{ kips} \quad F_{BE} \quad 2.4 \text{ kips} \]

\[ + \Sigma F_y = 0: \quad F_{BE} - 2.4 = 0 \]

\[ F_{BE} = 2.4 \text{ kips} \quad F_{BE} = 2.40 \text{ kips} \]

Truss and loading symmetrical about \( E \).
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

$\Sigma F_y = 0: \quad B_y = 0$

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

$D = -8.4 \text{ kN} \quad D = 8.4 \text{ kN} \leftarrow$

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

$B_x = +25.2 \text{ kN} \quad B_x = 25.2 \text{ kN} \rightarrow$

Free body: Joint A:

$F_{AB} \quad F_{AC}$

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

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

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

Free body: Joint C:

$F_{BC}$

$\Sigma F_y = 0: \quad 13.50 \text{ kN} - 8.4 \text{ kN} = \frac{4.5}{5.3} F_{CD} = 0$

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

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

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

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PROBLEM 6.7 (Continued)

Free body: Joint D:

\[
\begin{align*}
F_{BD} &= 8.4 \text{kN} \\
\text{Equilibrium:} \\
F_{BD} &= 13.50 \text{kN} \\
\end{align*}
\]

We can also write the proportion

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

\[F_{BD} = 13.50 \text{kN} \quad C \text{ (Checks)}\]
PROBLEM 6.12

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

SOLUTION

Free body: Truss

\[ \Sigma F_y = 0: \quad H_y = 0 \]

Because of the symmetry of the truss and loading

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

\[ A = H_y = 1200 \text{ lb} \]

Free body: Joint A:

\[ F_{AB} = \frac{F_{AC} \times 900 \text{ lb}}{5} = \frac{F_{AC} \times 3}{4} = 900 \text{ lb} \]

\[ F_{AB} = 1500 \text{ lb} \quad C \quad \Delta \]

\[ F_{AC} = 1200 \text{ lb} \quad T \quad \Delta \]

Free body: Joint C:

\[ F_{BC} = 0 \]

Free body: Joint B:

\[ + \Sigma F_x = 0: \quad \frac{24}{25} F_{BD} + \frac{4}{5} F_{BE} + \frac{4}{5} (1500 \text{ lb}) = 0 \]

or

\[ 24F_{BD} + 20F_{BE} = -30,000 \text{ lb} \quad (1) \]

\[ + \Sigma F_y = 0: \quad \frac{7}{25} F_{BD} - \frac{3}{5} F_{BE} + \frac{3}{5} (1500) - 600 = 0 \]

or

\[ 7F_{BD} - 15F_{BE} = -7,500 \text{ lb} \quad (2) \]
PROBLEM 6.12 (Continued)

Multiply (1) by (3), (2) by 4, and add:

\[ 100F_{BD} = -120,000 \text{ lb} \quad F_{BD} = 1200 \text{ lb} \quad C \ △ \\

Multiply (1) by 7, (2) by −24, and add:

\[ 500F_{BE} = -30,000 \text{ lb} \quad F_{BE} = 60.0 \text{ lb} \quad C \ △ \\

Free body: Joint D:

\[ \sum F_y = 0: \quad \frac{24}{25} (1200 \text{ lb}) + \frac{24}{25} F_{DF} = 0 \]
\[ F_{DF} = -1200 \text{ lb} \quad F_{DF} = 1200 \text{ lb} \quad C \ △ \\

\[ \sum F_y = 0: \quad \frac{7}{25} (1200 \text{ lb}) - \frac{7}{25} (-1200 \text{ lb}) - 600 \text{ lb} - F_{DE} = 0 \]
\[ F_{DE} = 72.0 \text{ lb} \quad F_{DE} = 72.0 \text{ lb} \quad T \ △ \\

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

\[ F_{EF} = F_{BE} \quad F_{EF} = 60.0 \text{ lb} \quad C \ △ \\
\[ F_{EG} = F_{CE} \quad F_{EG} = 1200 \text{ lb} \quad T \ △ \\
\[ F_{FG} = F_{BC} \quad F_{FG} = 0 \ △ \\
\[ F_{FH} = F_{AB} \quad F_{FH} = 1500 \text{ lb} \quad C \ △ \\
\[ F_{GH} = F_{AC} \quad F_{GH} = 1200 \text{ lb} \quad T \ △ \\

Note: Compare results with those of Problem 6.9.
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

$\Sigma F_x = 0: \quad A_x = 0$

Due to symmetry of truss and loading

$A_y = G = \frac{1}{2} \text{ Total load} = 6 \text{ kips}$

Free body: Joint A:

$\frac{F_{AB}}{3} = \frac{F_{AC}}{3} = \frac{6 \text{ kips}}{4}$

$F_{AB} = 7.50 \text{ kips} \quad C \downarrow$

$F_{AC} = 4.50 \text{ kips} \quad T \downarrow$

Free body: Joint B:

$\frac{F_{BC}}{5} = \frac{F_{BD}}{6} = \frac{7.5 \text{ kips}}{5}$

$F_{BC} = 7.50 \text{ kips} \quad T \downarrow$

$F_{BD} = 9.00 \text{ kips} \quad C \downarrow$

Free body: Joint C:

$\uparrow \Sigma F_y = 0: \quad \frac{4}{5}(7.5) + \frac{4}{5}F_{CD} - 6 = 0$

$F_{CD} = 0 \quad \downarrow$

$\downarrow \Sigma F_x = 0: \quad F_{CE} - 4.5 - \frac{3}{5}(7.5) = 0$

$F_{CE} = 9.00 \text{ kips} \quad T \downarrow$

Truss and loading symmetrical about $\downarrow$.
PROBLEM 6.43
A Warren bridge truss is loaded as shown. Determine the force in members CE, DE, and DF.

SOLUTION
Free body: Truss
\[ + \sum F_x = 0: \quad k_x = 0 \]
\[ + \sum M_A = 0: \quad k_x (62.5 \text{ ft}) - (6000 \text{ lb})(12.5 \text{ ft}) - (6000 \text{ lb})(25 \text{ ft}) = 0 \]
\( k = k_x = 3600 \text{ lb} \)
\[ + \sum F_y = 0: \quad A + 3600 \text{ lb} - 6000 \text{ lb} - 6000 \text{ lb} = 0 \]
\( A = 8400 \text{ lb} \)

We pass a section through members CE, DE, and DF and use the free body shown.
\[ + \sum M_D = 0: \quad F_{CE} (15 \text{ ft}) - (8400 \text{ lb})(18.75 \text{ ft}) + (6000 \text{ lb})(6.25 \text{ ft}) = 0 \]
\( F_{CE} = +8000 \text{ lb} \)
\( F_{CE} = 8000 \text{ lb} \)
\[ + \sum F_y = 0: \quad 8400 \text{ lb} - 6000 \text{ lb} - \frac{15}{16.25} F_{DE} = 0 \]
\( F_{DE} = +2600 \text{ lb} \)
\( F_{DE} = 2600 \text{ lb} \)
\[ + \sum M_E = 0: \quad 6000 \text{ lb}(12.5 \text{ ft}) - (8400 \text{ lb})(25 \text{ ft}) - F_{DF}(15 \text{ ft}) = 0 \]
\( F_{DF} = -9000 \text{ lb} \)
\( F_{DF} = 9000 \text{ lb} \)