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:

\[ + \sum F_y = 0: \quad -A_y - 2.8 \text{kN} = 0 \quad A_y = -2.8 \text{kN} \]

\[ \sum M_x = 0: \quad C(1.4 \text{ m}) - (2.8 \text{kN})(0.75 \text{ m}) = 0 \]

\[ C = 1.500 \text{ kN} \quad C = 1.500 \text{ kN} \]

\[ + \sum F_x = 0: \quad A_x + 1.500 \text{kN} = 0 \]

\[ A_x = -1.500 \text{kN} \quad A_x = 1.500 \text{kN} \]

Free body: Joint C:

\[ \frac{F_{BC}}{1.25} = \frac{F_{AC}}{1} = \frac{1.500 \text{kN}}{0.75} \]

\[ F_{AC} = 2.00 \text{kN} \quad T \uparrow \]

\[ F_{BC} = 2.50 \text{kN} \quad T \uparrow \]
PROBLEM 6.2 (Continued)

Free body: Joint $A$:

\[ \pm \Sigma F_x = 0: \begin{pmatrix} 7.5 \\ 8.5 \end{pmatrix} F_{AB} - 1.500 \text{ kN} = 0 \]

\[ F_{AB} = 1.700 \text{ kN} \quad T \]
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:

\[ + \sum M_D = 0: \quad F_y (3 \text{ m}) - (24 \text{ kN} + 8 \text{ kN})(1.5 \text{ m}) - (7 \text{ kN})(3 \text{ m}) = 0 \]

\[ F_y = 23.0 \text{ kN} \uparrow \]

\[ \sum F_x = 0: \quad F_x = 0 \]

\[ + \sum F_y = 0: \quad D - (7 + 24 + 8 + 7) + 23 = 0 \]

\[ D = 23.0 \text{ kN} \uparrow \]

Joint A:

\[ \sum F_x = 0: \quad F_{AB} = 0 \]

\[ + \sum F_y = 0: \quad -7 - F_{AD} = 0 \]

\[ F_{AD} = -7 \text{ kN} \quad F_{AD} = 7.00 \text{ kN} \quad C \uparrow \]

Joint D:

\[ + \sum F_y = 0: \quad -7 + 23.0 + \frac{8}{17} F_{BD} = 0 \]

\[ F_{BD} = -34.0 \text{ kN} \quad F_{BD} = 34.0 \text{ kN} \quad C \uparrow \]
PROBLEM 6.4 (Continued)

\[ \sum F_x = 0: \quad \frac{15}{17} (-34.0) + F_{DE} = 0 \]

\[ F_{DE} = +30.0 \text{ kN} \quad F_{DE} = 30.0 \text{ kN} \quad T \uparrow \]

Joint E:

\[ \sum F_y = 0: \quad F_{BE} - 8 = 0 \]

\[ F_{BE} = +8.00 \text{ kN} \quad F_{BE} = 8.00 \text{ kN} \quad T \uparrow \]

Truss and loading symmetrical about \( \Phi \).
PROBLEM 6.6

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:

\[ DE = \sqrt{(6 \text{ m})^2 + (3.2 \text{ m})^2} = 6.80 \text{ m} \]

\[ + \Sigma M_B = 0: \quad \left(\frac{4}{5}\right) F_{AC} (4.5 \text{ m}) - (24 \text{ kN})(12 \text{ m}) = 0 \]

\[ F_{AC} = 80.0 \text{ kN} \quad \uparrow \]

\[ - \Sigma F_x = 0: \quad B_x - \left(\frac{4}{5}\right)(80 \text{ kN}) = 0 \]

\[ B_x = 64 \text{ kN} \quad \rightarrow \]

\[ + \Sigma F_y = 0: \quad B_y + \left(\frac{3}{5}\right)(80 \text{ kN}) - 24 \text{ kN} = 0 \]

\[ B_y = 24 \text{ kN} \quad \uparrow \]

Joint E:

\[ \frac{F_{CE}}{6} = \frac{F_{DE}}{6.8} = 24 \text{ kN} \]

\[ F_{CE} = 45.0 \text{ kN} \quad \uparrow \]

\[ F_{DE} = 51.0 \text{ kN} \quad \downarrow \]

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PROBLEM 6.6 (Continued)

Joint D:

$$\sum \Sigma F_x = 0: \quad \left( \frac{6}{6.8} \right) F_{BD} - \left( \frac{6}{6.8} \right) (51.0 \text{ kN}) = 0$$

$$F_{BD} = 51.0 \text{ kN} \quad C \downarrow$$

$$F_{CD} = 48.0 \text{ kN} \quad T \downarrow$$

Joint C:

$$\sum \Sigma F_y = 0: \quad - F_{BC} - \left( \frac{4}{5} \right) (80 \text{ kN}) + (45.0 \text{ kN}) = 0$$

$$F_{BC} = 19.00 \text{ kN} \quad C \downarrow$$

$$\sum \Sigma F_y = 0: \quad \left( \frac{3}{5} \right) (80 \text{ kN}) - 48.0 \text{ kN} = 0 \quad \text{(checks)}$$
PROBLEM 6.17

Determine the force in each member of the Pratt roof 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 load,

\[ A_y = H = \frac{1}{2} \text{ total load} = 21 \text{kN} \uparrow \]

Free body: Joint A:

\[ \frac{F_{AB}}{37} = \frac{F_{AC}}{35} = \frac{15.3 \text{kN}}{12} \]

\[ F_{AB} = 47.175 \text{kN}, \quad F_{AC} = 44.625 \text{kN} \]

Free body: Joint B:

\[ F_{BD} = 47.175 \text{kN}, \quad F_{BC} = 10.5 \text{kN} \]

From force polygon:

\[ F_{BD} = 47.2 \text{kN} \quad C \uparrow \]

\[ F_{BC} = 10.5 \text{kN} \quad C \uparrow \]

\[ F_{BD} = 47.2 \text{kN} \quad C \uparrow \]

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PROBLEM 6.17 (Continued)

Free body: Joint C:

\[ + \sum F_y = 0: \quad \frac{3}{5} F_{CD} - 10.5 = 0 \]

\[ F_{CD} = 17.50 \text{ kN} \quad T \uparrow \]

\[ \pm \sum F_x = 0: \quad F_{CE} + \frac{4}{5} (17.50) - 44.625 = 0 \]

\[ F_{CE} = 30.625 \text{ kN} \quad F_{CE} = 30.6 \text{ kN} \quad T \uparrow \]

Free body: Joint E:

\[ F_{DE} = 0 \uparrow \]

DE is a zero-force member.

Truss and loading symmetrical about E.
PROBLEM 6.45

Determine the force in members $BD$ and $CD$ of the truss shown.

SOLUTION

Reactions from Free body of entire truss:

$A = A_y = 27$ kips $\uparrow <$

$H = 45$ kips $\uparrow <$

We pass a section through members $BD$, $CD$, and $CE$ and use the free body shown.

$\sum M_C = 0: \quad F_{BD}(7.5 \text{ ft}) - (27 \text{ kips})(10 \text{ ft}) = 0$

$F_{BD} = -36.0 \text{ kips} \quad F_{BD} = 36.0 \text{ kips} \quad C \uparrow$

$\sum F_y = 0: \quad 27 \text{ kips} + \left(\frac{3}{5}\right)F_{CD} = 0$

$F_{CD} = -45.0 \text{ kips} \quad F_{CD} = 45.0 \text{ kips} \quad C \uparrow$
PROBLEM 6.53

Determine the force in members $DF$ and $DE$ of the truss shown.

SOLUTION

\[
\alpha = \tan^{-1}\left(\frac{1}{8}\right) = 7.1^\circ
\]

Member $CE$:

\[+\sum M_F = 0: \quad -F_{DF}(1.75 \text{ m}) + (30 \text{ kN})(4 \text{ m}) + (20 \text{ kN})(2 \text{ m}) = 0\]

\[F_{DF} = +91.4 \text{ kN} \quad F_{DF} = 91.4 \text{ kN} \quad T \downarrow\]

Member $EF$:

\[+\sum M_O = 0: \quad -F_{DE}(14 \text{ m}) - (30 \text{ kN})(10 \text{ m}) - 20 \text{ kN}(12 \text{ m}) = 0\]

\[F_{DE} = -38.6 \text{ kN} \quad F_{DE} = 38.6 \text{ kN} \quad C \uparrow\]
**PROBLEM 6.77**

For the frame and loading shown, determine the force acting on member $ABC$ (a) at $B$, (b) at $C$.

**SOLUTION**

FBD ABC:

Note: $BD$ is a two-force member

(a) \[ \sum M_C = 0: \ (0.09 \text{ m})(200 \text{ N}) - (2.4 \text{ m}) \left( \frac{3}{5} F_{BD} \right) = 0 \]

\[ F_{BD} = 125.0 \text{ N} \geq 36.9^\circ \]

(b) \[ \sum F_x = 0: \ 200 \text{ N} - \frac{4}{5}(125 \text{ N}) - C_x = 0 \quad C_x = 100 \text{ N} \]

\[ \sum F_y = 0: \ \frac{3}{5} F_{BD} - C_y = 0 \quad C_y = \frac{3}{5}(125 \text{ N}) = 75 \text{ N} \]

\[ C = 125.0 \text{ N} \geq 36.9^\circ \]

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PROBLEM 6.79
For the frame and loading shown, determine the components of all forces acting on member ABC.

SOLUTION
Free body: Entire frame:
\[ \pm \Sigma F_x = 0: \quad A_x + 18 \text{kN} = 0 \]
\[ A_x = -18 \text{kN} \quad \text{A}_x = 18.00 \text{kN} \]
\[ \pm \Sigma M_E = 0: \quad -\left(18 \text{kN}\right)(4 \text{ m}) - A_y(3.6 \text{ m}) = 0 \]
\[ A_y = -20 \text{kN} \quad \text{A}_y = 20.0 \text{kN} \]
\[ \pm \Sigma F_y = 0: \quad -20 \text{kN} + F = 0 \]
\[ F = +20 \text{kN} \quad \text{F} = 20 \text{kN} \]

Free body: Member ABC
Note: BE is a two-force member, thus B is directed along line BE.
\[ \pm \Sigma M_C = 0: \quad B(4 \text{ m}) - (18 \text{kN})(6 \text{ m}) + (20 \text{kN})(3.6 \text{ m}) = 0 \]
\[ B = 9 \text{kN} \quad \text{B} = 9.00 \text{kN} \]
\[ \pm \Sigma F_x = 0: \quad C_x - 18 \text{kN} + 9 \text{kN} = 0 \]
\[ C_x = 9 \text{kN} \quad \text{C}_x = 9.00 \text{kN} \]
\[ \pm \Sigma F_y = 0: \quad C_y - 20 \text{kN} = 0 \]
\[ C_y = 20 \text{kN} \quad \text{C}_y = 20.0 \text{kN} \]
PROBLEM 6.101

For the frame and loading shown, determine the components of all forces acting on member $ABE$.

SOLUTION

FBD Frame:

$\sum M_E = 0: \quad (1.8 \text{ m})F_y - (2.1 \text{ m})(12 \text{ kN}) = 0$

$F_y = 14.00 \text{ kN}\uparrow$

$\sum F_y = 0: \quad -E_y + 14.00 \text{ kN} - 12 \text{ kN} = 0$

$E_y = 2 \text{ kN}\downarrow$

FBD member $BCD$:

$\sum M_B = 0: \quad (1.2 \text{ m})C_y - (12 \text{ kN})(1.8 \text{ m}) = 0 \quad C_y = 18.00 \text{ kN}\uparrow$

But $C$ is $\perp ACF$, so $\quad C_x = 2C_y; \quad C_x = 36.0 \text{ kN}\longrightarrow$

$\sum F_x = 0: \quad -B_x + C_x = 0 \quad B_x = C_x = 36.0 \text{ kN}\longrightarrow$ on $BCD$

$\sum F_y = 0: \quad -B_y + 18.00 \text{ kN} - 12 \text{ kN} = 0 \quad B_y = 6.00 \text{ kN}\downarrow$ on $BCD$

On $ABE$:

$B_x = 36.0 \text{ kN}\longrightarrow$

$B_y = 6.00 \text{ kN}\uparrow$

FBD member $ABE$:

$\sum M_A = 0: \quad (1.2 \text{ m})(36.0 \text{ kN}) - (0.6 \text{ m})(6.00 \text{ kN})$

$+(0.9 \text{ m})(2.00 \text{ kN}) - (1.8 \text{ m})(E_x) = 0$

$E_x = 23.0 \text{ kN}\longrightarrow$

$\sum F_x = 0: \quad -23.0 \text{ kN} + 36.0 \text{ kN} - A_x = 0$

$A_x = 13.00 \text{ kN}\longrightarrow$

$\sum F_y = 0: \quad -2.00 \text{ kN} + 6.00 \text{ kN} - A_y = 0$

$A_y = 4.00 \text{ kN}\downarrow$

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PROBLEM 6.143

The tongs shown are used to apply a total upward force of 45 kN on a pipe cap. Determine the forces exerted at $D$ and $F$ on tong $ADF$.

SOLUTION

FBD whole:

By symmetry, \[ A = B = 22.5 \text{ kN} \]

FBD $ADF$:

\[ \sum M_F = 0: \quad (75 \text{ mm})D - (100 \text{ mm})(22.5 \text{ kN}) = 0 \]

\[ D = 30.0 \text{ kN} \]

\[ \sum F_x = 0: \quad F_x - D = 0 \]

\[ F_x = D = 30 \text{ kN} \]

\[ \sum F_y = 0: \quad 22.5 \text{ kN} - F_y = 0 \]

\[ F_y = 22.5 \text{ kN} \]

so

\[ F = 37.5 \text{ kN} \angle 36.9^\circ \]
PROBLEM 6.145

The pliers shown are used to grip a 0.3-in.-diameter rod. Knowing that two 60-lb forces are applied to the handles, determine (a) the magnitude of the forces exerted on the rod, (b) the force exerted by the pin at A on portion AB of the pliers.

SOLUTION

Free body: Portion AB:

(a) \( \sum M_A = 0: \ Q(1.2 \text{ in.}) - (60 \text{ lb})(9.5 \text{ in.}) = 0 \)

\[ Q = 475 \text{ lb} \]

(b) \( \sum F_x = 0: \ Q(\sin 30^\circ) + A_x = 0 \)

\[ (475 \text{ lb})(\sin 30^\circ) + A_x = 0 \]

\[ A_x = -237.5 \text{ lb} \quad A_x = 237.5 \text{ lb} \]

\( \sum F_y = 0: \ -Q(\cos 30^\circ) + A_y - 60 \text{ lb} = 0 \)

\[ -(475 \text{ lb})(\cos 30^\circ) + A_y - 60 \text{ lb} = 0 \]

\[ A_y = +471.4 \text{ lb} \quad A_y = 471.4 \text{ lb} \]

\[ A = 528 \text{ lb} \quad 63.3^\circ \]

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