Chapter 6, Solution 1.

Joint FBDs:

Joint *B*:

$$\frac{F_{AB}}{15} = \frac{800 \text{ lb}}{8} = \frac{F_{BC}}{17}$$

so

$F_{AB} = 1500$ lb T ◀

$F_{BC} = 1700$ lb C ◀

Joint *C*:

$$\frac{F_{AC}}{8} = \frac{C_x}{15} = \frac{1700 \text{ lb}}{17}$$

$F_{AC} = 800$ lb T ◀

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Chapter 6, Solution 2.

Joint FBDs:

Joint *B*:

$$\rightarrow \Sigma F_x = 0: \quad \frac{1}{\sqrt{2}} F_{AB} - \frac{4}{5} F_{BC} = 0$$

$$\uparrow \Sigma F_y = 0: \quad \frac{1}{\sqrt{2}} F_{AB} + \frac{3}{5} F_{BC} - 4.2 \text{ kN} = 0$$

so $\quad \frac{7}{5} F_{BC} = 4.2 \text{ kN} \qquad F_{BC} = 3.00 \text{ kN C} \blacktriangleleft$

$$F_{AB} = \frac{12\sqrt{2}}{5} \text{ kN} \qquad F_{AB} = 3.39 \text{ kN C} \blacktriangleleft$$

Joint *C*:

$$\rightarrow \Sigma F_x = 0: \quad \frac{4}{5}(3.00 \text{ kN}) - \frac{12}{13} F_{AC} = 0$$

$$F_{AC} = \frac{13}{5} \text{ kN} \qquad F_{AC} = 2.60 \text{ kN T} \blacktriangleleft$$

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Chapter 6, Solution 3.

Joint FBDs:

Joint *B*:

$$\frac{F_{AB}}{12} = \frac{F_{BC}}{13} = \frac{450 \text{ lb}}{5}$$

so

$F_{AB} = 1080 \text{ lb T}$ ◀

$F_{BC} = 1170 \text{ lb C}$ ◀

Joint *C*:

$$\rightarrow \Sigma F_x = 0: \quad \frac{3}{5} F_{AC} - \frac{12}{13}(1170 \text{ lb}) = 0$$

$F_{AC} = 1800 \text{ lb C}$ ◀

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Chapter 6, Solution 4.

Joint FBDs:

Joint D:

$$\frac{F_{CD}}{8.4} = \frac{F_{AD}}{11.6} = \frac{500 \text{ lb}}{8}$$

$F_{AD} = 725$ lb T ◀

$F_{CD} = 525$ lb C ◀

Joint C:

$\rightarrow \Sigma F_x = 0$: $\quad F_{BC} - 525 \text{ lb} = 0$

$F_{BC} = 525$ lb C ◀

This is apparent by inspection, as is $F_{AC} = C_y$

$\rightarrow \Sigma F_x = 0$: $\quad \frac{8.4}{11.6}(725 \text{ lb}) - \frac{3}{5} F_{AB} - 375 \text{ lb} = 0$

Joint A:

$F_{AB} = 250$ lb T ◀

$\uparrow \Sigma F_y = 0$: $\quad F_{AC} - \frac{4}{5}(250 \text{ lb}) - \frac{8}{11.6}(725 \text{ lb}) = 0$

$F_{AC} = 700$ lb C ◀

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Chapter 6, Solution 5.

FBD Truss:

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

By symmetry: $\mathbf{C}_y = \mathbf{D}_y = 6 \text{ kN} \uparrow$

Joint FBDs:

Joint *B*:

$\uparrow \Sigma F_y = 0: \qquad -3 \text{ kN} + \frac{1}{\sqrt{5}} F_{AB} = 0$

$F_{AB} = 3\sqrt{5} = 6.71 \text{ kN T} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \qquad \frac{2}{\sqrt{5}} F_{AB} - F_{BC} = 0 \qquad F_{BC} = 6.00 \text{ kN C} \blacktriangleleft$

Joint *C*:

$\uparrow \Sigma F_y = 0: \qquad 6 \text{ kN} - \frac{3}{5} F_{AC} = 0 \qquad F_{AC} = 10.00 \text{ kN C} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \qquad 6 \text{ kN} - \frac{4}{5} F_{AC} + F_{CD} = 0 \qquad F_{CD} = 2.00 \text{ kN T} \blacktriangleleft$

Joint *A*:

$\uparrow \Sigma F_y = 0: \qquad -2\left(\frac{1}{\sqrt{5}} 3\sqrt{5} \text{ kN}\right) + 2\left(\frac{3}{5} 10 \text{ kN}\right) - 6 \text{ kN} = 0 \text{ check}$

By symmetry: $F_{AE} = F_{AB} = 6.71 \text{ kN T} \blacktriangleleft$

$F_{AD} = F_{AC} = 10.00 \text{ kN C} \blacktriangleleft$

$F_{DE} = F_{BC} = 6.00 \text{ kN C} \blacktriangleleft$

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Chapter 6, Solution 6.

FBD Truss:

$$\circlearrowleft \Sigma M_A = 0: \quad (10.2\text{ m})C_y + (2.4\text{ m})(15\text{ kN}) - (3.2\text{ m})(49.5\text{ kN}) = 0$$

$$\mathbf{C}_y = 12.0\text{ kN} \uparrow$$

Joint FBDs:

Joint *C*:

$$\frac{F_{BC}}{7.4} = \frac{F_{CD}}{7.4} = \frac{12\text{ kN}}{8}$$

$F_{BC} = 18.50$ kN C ◀

$F_{CD} = 18.50$ kN T ◀

Joint *B*:

$$\rightarrow \Sigma F_X = 0: \quad \frac{4}{5}F_{AB} - \frac{7}{7.4}(18.5\text{ kN}) = 0$$

$F_{AB} = 21.875$ kN; $\qquad F_{AB} = 21.9$ kN C ◀

$$\uparrow \Sigma F_y = 0: \quad \frac{3}{5}(21.875\text{ kN}) - 49.5\text{ kN} + \frac{2.4}{7.4}(18.5\text{ kN}) + F_{BD} = 0$$

$F_{BD} = 30.375$ kN; $\qquad F_{BD} = 30.4$ kN C ◀

Joint *D*:

$$\rightarrow \Sigma F_x = 0: \quad -\frac{4}{5}F_{AD} + \frac{7}{7.4}(18.5\text{ kN}) + 15\text{ kN} = 0$$

$F_{AD} = 40.625$ kN; $\qquad F_{AD} = 40.6$ kN T ◀

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Chapter 6, Solution 7.

Joint FBDs:

Joint E:

$$\frac{F_{BE}}{5} = \frac{F_{DE}}{4} = \frac{3 \text{ kN}}{3}$$

$F_{BE} = 5.00$ kN T ◀

$F_{DE} = 4.00$ kN C ◀

Joint B:

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

$F_{AB} = 4.00$ kN T ◀

$\uparrow \Sigma F_y = 0: \quad F_{BD} - 6 \text{ kN} - \frac{3}{5}(5 \text{ kN}) = 0$

$F_{BD} = 9.00$ kN C ◀

Joint D:

$\uparrow \Sigma F_y = 0: \quad \frac{3}{5} F_{AD} - 9 \text{ kN} = 0$

$F_{AD} = 15.00$ kN T ◀

$\rightarrow \Sigma F_x = 0: \quad F_{CD} - \frac{4}{5}(15 \text{ kN}) - 4 \text{ kN} = 0$

$F_{CD} = 16.00$ kN C ◀

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Chapter 6, Solution 8.

Joint FBDs:

Joint *B*:

By inspection: $F_{AB} = 12.00$ kips C ◀

$F_{BD} = 0$ ◀

Joint *A*:

$$\frac{F_{AC}}{5} = \frac{F_{AD}}{13} = \frac{12 \text{ kips}}{12}$$

$F_{AC} = 5.00$ kips C ◀

$F_{AD} = 13.00$ kips T ◀

Joint *D*:

$\rightarrow \Sigma F_x = 0$: $F_{CD} - \frac{12}{13}(13 \text{ kips}) - 18 \text{ kips} = 0$

$F_{CD} = 30.0$ kips C ◀

$\uparrow \Sigma F_y = 0$: $\frac{5}{13}(13 \text{ kips}) - F_{DF} = 0$

$F_{DF} = 5.00$ kips T ◀

Joint *C*:

$\rightarrow \Sigma F_x = 0$: $30 \text{ kips} - \frac{12}{13} F_{CF} = 0$

$F_{CF} = 32.5$ kips T ◀

$\uparrow \Sigma F_y = 0$: $F_{CE} - 5 \text{ kips} - \frac{5}{13}(32.5 \text{ kips})$

$F_{CE} = 17.50$ kips C ◀

Joint *E*:

by inspection: $F_{CF} = 0$ ◀

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Chapter 6, Solution 9.

First note that, by inspection of joint H: $F_{CH} = 0$ ◀

and $F_{DH} = F_{GH}$

then, by inspection of joint C: $F_{CG} = 0$ ◀

and $F_{BC} = F_{CD}$

then, by inspection of joint G: $F_{BG} = 0$ ◀

and $F_{FG} = F_{GH}$

then, by inspection of joint B: $F_{BF} = 0$ ◀

and $F_{AB} = F_{BC}$

Joint FBDs:

Joint D:

$$\frac{F_{CD}}{12} = \frac{F_{DH}}{13} = \frac{10 \text{ kips}}{5}$$

so $F_{CD} = 24.0$ kips T ◀

$F_{DH} = 26.0$ kips C ◀

Joint A:

and, from above: $F_{AB} = F_{BC} = 24.0$ kips T ◀

$F_{GH} = F_{FG} = 26.0$ kips C ◀

$$\frac{F_{AF}}{5} = \frac{F_{AE}}{\sqrt{41}} = \frac{24 \text{ kips}}{4}$$

$F_{AF} = 30.0$ kips C ◀

$F_{AE} = 25.6$ kips T ◀

Joint F:

$$\rightarrow \Sigma F_x = 0: \quad F_{EF} - \frac{12}{13}(26 \text{ kips}) = 0$$

$F_{EF} = 24.0$ kips C ◀

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Chapter 6, Solution 10.

FBD Truss:

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

By symmetry: $\mathbf{A}_y = \mathbf{H}_y = 4$ kips ↑

by inspection of joints C and G: $F_{AC} = F_{CE}$ and $F_{BC} = 0$ ◀

$F_{EG} = F_{GH}$ and $F_{FG} = 0$ ◀

also, by symmetry $F_{AB} = F_{FH}$, $F_{BD} = F_{DF}$, $F_{CE} = F_{EG}$ and $F_{BE} = F_{EF}$

Joint FBDs:

Joint A:

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

so $F_{AB} = 5.00$ kips C ◀

$F_{AC} = 4.00$ kips T ◀

and, from above, $F_{FH} = 5.00$ kips C ◀

and $F_{CE} = F_{EG} = F_{GH} = 4.00$ kips T ◀

Joint B:

$\rightarrow \Sigma F_x = 0$: $\frac{4}{5}(5 \text{ kips}) - \frac{4}{5} F_{BE} - \frac{10}{\sqrt{109}} F_{BD} = 0$

↑ $\Sigma F_y = 0$: $\frac{3}{5}(5 \text{ kips}) - 2 - \frac{3}{\sqrt{109}} F_{BD} + \frac{3}{5} F_{BE} = 0$

so $F_{BD} = 3.9772$ kips, $F_{BE} = 0.23810$ kips

or $F_{BD} = 3.98$ kips C ◀

$F_{BE} = 0.238$ kips C ◀

Joint E:

and, from above, $F_{DF} = 3.98$ kips C ◀

$F_{EF} = 0.238$ kips C ◀

↑ $\Sigma F_y = 0$: $F_{DE} - 2\frac{3}{5}(0.23810 \text{ kips}) = 0$

$F_{DE} = 0.286$ kips T ◀

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Chapter 6, Solution 11.

FBD Truss:

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

$\circlearrowleft \Sigma M_G = 0$: $\quad 3a\,A_y - 2a\,(3\text{ kN}) - a\,(6\text{ kN}) = 0$

$\mathbf{A}_y = 4\text{ kN}\uparrow$

by inspection of joint C, $\quad F_{AC} = F_{CE}$ and $F_{BC} = 0$ ◀

by inspection of joint D, $\quad F_{BD} = F_{DF}$ and $F_{DE} = 6.00$ kN C ◀

Joint FBDs:

Joint A:

$$\frac{F_{AC}}{21} = \frac{F_{AB}}{29} = \frac{4\text{kN}}{20}$$

$F_{AB} = 5.80$ kN C ◀

$F_{AC} = 4.20$ kN C ◀

from above, $\quad F_{CE} = 4.20$ kN C ◀

$\uparrow \Sigma F_y = 0$: $\quad \frac{20}{29}(5.80\text{ kN}) - 3\text{ kN} - \frac{20}{29}F_{BE} = 0$

$F_{BE} = \frac{29}{20}$ $\quad F_{BE} = 1.450$ kN T ◀

Joint B:

$\rightarrow \Sigma F_x = 0$: $\quad \frac{21}{29}\left(5.80\text{ kN} + \frac{29}{20}\text{ kN}\right) - F_{BD} = 0$

$F_{BD} = 5.25$ kN C ◀

from above, $\quad F_{DF} = 5.25$ kN C ◀

$\rightarrow \Sigma F_x = 0$: $\quad 5.25\text{ kN} - \frac{21}{29}F_{EF} = 0$

$F_{EF} = 7.25$ kN T ◀

Joint F:

$\uparrow \Sigma F_y = 0$: $\quad F_{FG} - \frac{20}{29}(7.25\text{ kN}) - 1\text{ kN} = 0$

$F_{FG} = 6.00$ kN C ◀

by inspection of joint G, $\quad F_{EG} = 0$ ◀

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Chapter 6, Solution 12.

FBD Truss:

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

By symmetry: $\mathbf{A}_y = \mathbf{B}_y = 4.90$ kN $\uparrow$

and $\quad F_{AB} = F_{EG}, F_{AC} = F_{FG}, F_{BC} = F_{EF}$

$F_{BD} = F_{DE}, F_{CD} = F_{DF}$

Joint FBDs:

Joint A:

$\rightarrow \Sigma F_x = 0$: $\quad \dfrac{5}{\sqrt{29}} F_{AC} - \dfrac{4}{5} F_{AB} = 0$

$\uparrow \Sigma F_y = 0$: $\quad \dfrac{2}{\sqrt{29}} F_{AC} - \dfrac{3}{5} F_{AB} + 4.9 \text{ kN} = 0$

$F_{AC} = 2.8\sqrt{29}$ kN $\qquad F_{AC} = 15.08$ kN T ◀

$F_{AD} = 17.50$ kN C ◀

Joint B:

$\rightarrow \Sigma F_x = 0$: $\quad \dfrac{4}{5}\left(17.5 \text{ kN} - F_{BD}\right) - \dfrac{1}{\sqrt{2}} F_{BC} = 0$

$\uparrow \Sigma F_y = 0$: $\quad \dfrac{3}{5}\left(17.5 \text{ kN} - F_{BD}\right) + \dfrac{1}{\sqrt{2}} F_{BC} - 2.8 \text{ kN} = 0$

$F_{BD} = 15.50$ kN C ◀

$F_{BC} = 1.6\sqrt{2}$ kN; $\qquad F_{BC} = 2.26$ kN C ◀

Joint C:

$\uparrow \Sigma F_y = 0$: $\quad \dfrac{4}{5} F_{CD} - \dfrac{1}{\sqrt{2}}\left(1.6\sqrt{2} \text{ kN}\right) - \dfrac{2}{\sqrt{29}}\left(2.8\sqrt{29} \text{ kN}\right) = 0$

$F_{CD} = 9.00$ kN T ◀

$\rightarrow \Sigma F_x = 0$: $\quad F_{CF} + \dfrac{1}{\sqrt{2}}\left(1.6\sqrt{2} \text{ kN}\right) + \dfrac{3}{5}(9 \text{ kN}) - \dfrac{5}{\sqrt{29}}\left(2.8\sqrt{29} \text{ kN}\right) = 0$

$F_{CF} = 7.00$ kN T ◀

from symmetry, $\qquad F_{EG} = 17.50$ kN C ◀

$F_{FG} = 15.08$ kN T ◀

$F_{EF} = 2.26$ kN C ◀

$F_{DE} = 15.50$ kN C ◀

$F_{DF} = 9.00$ kN T ◀

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Chapter 6, Solution 13.

FBD Truss:

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

$\circlearrowleft \Sigma M_A = 0: \quad (8\text{ m})Gy - (4\text{ m})(4.2\text{ kN}) - (2\text{m})(2.8\text{ kN}) = 0$

$\mathbf{G}_y = 2.80\text{ kN} \uparrow$

$\uparrow \Sigma F_y = 0: \quad A_y - 2.8\text{ kN} - 4.2\text{ kN} + 2.8\text{ kN} = 0$

$\mathbf{A}_y = 4.2\text{ kN} \uparrow$

Joint FBDs:

Joint A:

$\rightarrow \Sigma F_x = 0: \quad \dfrac{5}{\sqrt{29}} F_{AC} - \dfrac{4}{5} F_{AB} = 0$

$\uparrow \Sigma F_y = 0: \quad \dfrac{2}{\sqrt{29}} F_{AC} - \dfrac{3}{5} F_{AB} + 4.2\text{ kN} = 0$

$F_{AB} = 15.00\text{ kN C} \blacktriangleleft$

$F_{AC} = 2.4\sqrt{29} \qquad F_{AC} = 12.92\text{ kN T} \blacktriangleleft$

Joint B:

$\rightarrow \Sigma F_x = 0: \quad \dfrac{4}{5}(15.00\text{ kN} - F_{BD}) - \dfrac{1}{\sqrt{2}} F_{BC} = 0$

$\uparrow \Sigma F_y = 0: \quad \dfrac{3}{5}(15.00\text{ kN} - F_{BD}) + \dfrac{1}{\sqrt{2}} F_{BC} - 2.8\text{ kN} = 0$

$F_{BD} = 13.00\text{ kN C} \blacktriangleleft$

$F_{BC} = 1.6\sqrt{2}\text{ kN}, \qquad F_{BC} = 2.26\text{ kN C} \blacktriangleleft$

Joint C:

$\uparrow \Sigma F_y = 0: \quad \dfrac{4}{5} F_{CD} - \dfrac{2}{\sqrt{29}}\left(2.4\sqrt{29}\text{ kN}\right) - \dfrac{1}{\sqrt{2}}(1.6\sqrt{2}\text{ kN}) = 0$

$F_{CD} = 8.00\text{ kN T} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \quad F_{CF} + \dfrac{3}{5}(8.00\text{ kN}) - \dfrac{5}{\sqrt{29}}(2.4\sqrt{29}\text{ kN})$

$+ \dfrac{1}{\sqrt{2}}(1.6\sqrt{2}\text{ kN}) = 0$

$F_{CF} = 5.60\text{ kN T} \blacktriangleleft$

continued

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By inspection of joint E, $F_{DE} = F_{EG}$ and $F_{EF} = 0$ ◀

Joint F:

$\uparrow \Sigma F_y = 0$: $\frac{4}{5} F_{DF} - \frac{2}{\sqrt{29}} F_{FG} = 0$

$\rightarrow \Sigma F_x = 0$: $-5.6 \text{ kN} - \frac{3}{5} F_{DF} + \frac{5}{\sqrt{29}} F_{FG} = 0$

$F_{DF} = 4.00 \text{ kN T}$ ◀

$F_{FG} = 1.6\sqrt{29} \text{ kN}$ $F_{FG} = 8.62 \text{ kN T}$ ◀

Joint G:

$\rightarrow \Sigma F_x = 0$: $\frac{4}{5} F_{EG} - \frac{5}{\sqrt{29}} (1.6\sqrt{29} \text{ kN}) = 0$

$F_{EG} = 10.00 \text{ kN C}$ ◀

from above (joint E) $F_{DE} = 10.00 \text{ kN C}$ ◀

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Chapter 6, Solution 14.

FBD Truss:

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

$\circlearrowleft \Sigma M_A = 0$: $4a\ H_y - 3a\ (1.5\text{ kN}) - 2a\ (2\text{ kN})$

$- a\ (2\text{ kN}) = 0$ $\qquad \mathbf{H}_y = 3.625\text{ kN} \uparrow$

$\uparrow \Sigma F_y = 0$: $A_y - 1\text{ kN} - 2\text{ kN} - 2\text{ kN} - 1.5\text{ kN} - 1\text{ kN}$

$+ 3.625\text{ kN} = 0$ $\qquad \mathbf{A}_y = 3.875\text{ kN} \uparrow$

Joint FBDs:

Joint A:

$$\frac{F_{AB}}{\sqrt{29}} = \frac{F_{AC}}{\sqrt{26}} = \frac{2.625\text{ kN}}{1}$$

$F_{AB} = 15.4823\text{ kN}$, $\qquad F_{AB} = 15.48\text{ kN C} \blacktriangleleft$

$F_{AC} = 14.6597\text{ kN}$, $\qquad F_{AC} = 14.66\text{ kN T} \blacktriangleleft$

By inspection of joint C: $\quad F_{CE} = F_{AC} = 14.66\text{ kN T}$, $\qquad F_{BC} = 0 \blacktriangleleft$

Joint B:

$\uparrow \Sigma F_y = 0$: $\quad \dfrac{2}{\sqrt{29}}\left(15.4823\text{ kN} - F_{BD}\right) - 2\text{ kN} = 0$

$F_{BD} = 10.0971\text{ kN}$, $\qquad F_{BD} = 10.10\text{ kN C} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0$: $\quad \dfrac{5}{\sqrt{29}}\left(15.4823\text{ kN} - 10.0971\text{ kN}\right) - F_{BE} = 0$

$F_{BE} = 5.0000\text{ kN}$, $\qquad F_{BE} = 5.00\text{ kN C} \blacktriangleleft$

continued

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Joint D: By symmetry: $F_{DF} = 10.0971$ kN, $F_{DF} = 10.10$ kN C ◀

$$\uparrow \Sigma F_y = 0: \quad -F_{DE} + 2\left(\frac{2}{\sqrt{29}}\,10.0971\text{ kN}\right) - 2\text{ kN} = 0$$

$F_{DE} = 5.50$ kN T ◀

Joint H:

$$\frac{F_{GH}}{\sqrt{26}} = \frac{F_{FH}}{\sqrt{29}} = \frac{2.625\text{ kN}}{1}$$

$F_{FH} = 14.1361$ kN $F_{FH} = 14.14$ kN C ◀

$F_{GH} = 13.3849$ kN $F_{GH} = 13.38$ kN T ◀

By inspection of joint G: $F_{EG} = F_{GH} = 13.38$ kN T and $F_{FG} = 0$ ◀

Joint F:

$$\rightarrow \Sigma F_x = 0: \quad F_{EF} + \frac{2}{\sqrt{29}}\left(10.0971\text{ kN} - 14.1361\text{ kN}\right) = 0$$

$F_{EF} = 3.75$ kN C ◀

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Chapter 6, Solution 15.

FBD Truss:

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

$\circlearrowleft \Sigma M_A = 0$: $8a\,(J_y - 1\text{ kN}) - 7a\,(1\text{ kN}) - 6a\,(2.8\text{ kN})$

$- 4a\,(4.5\text{ kN}) - 2a\,(4\text{ kN}) - a(1\text{ kN}) = 0$

$\mathbf{J}_y = 6.7\text{ kN} \uparrow$

$\uparrow \Sigma F_y = 0$: $A_y - 1\text{ kN} - 1\text{ kN} - 1.4\text{ kN} - 4.5\text{ kN} - 2.8\text{ kN}$

$- 1\text{ kN} - 1\text{ kN} + 6.7\text{ kN} = 0$ $\qquad \mathbf{A}_y = 6.0\text{ kN} \uparrow$

Joint FBDs:

Joint A:

$\uparrow \Sigma F_y = 0$: $5\text{ kN} - \dfrac{3}{\sqrt{13}} F_{AB} = 0, \quad F_{AB} = \dfrac{5\sqrt{13}}{3}\text{ kN}$

$F_{AB} = 6.01\text{ kN C} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0$: $F_{AC} - \dfrac{2}{\sqrt{13}}\left(\dfrac{5\sqrt{13}}{3}\text{ kN}\right) = 0,$ $\qquad F_{AC} = 3.33\text{ kN T} \blacktriangleleft$

Joint B:

$\rightarrow \Sigma F_x = 0$: $\dfrac{2}{\sqrt{13}}\left(\dfrac{5\sqrt{13}}{3}\text{kN} - F_{BC} - F_{BD}\right) = 0,$

$F_{BC} + F_{BD} = \dfrac{5\sqrt{13}}{3}\text{ kN}$

$\uparrow \Sigma F_y = 0$: $\dfrac{3}{\sqrt{13}}\left(\dfrac{5\sqrt{13}}{3}\text{ kN} + F_{BC} - F_{BD}\right) - 1\text{ kN} = 0,$

$F_{BD} - F_{BC} = \dfrac{4\sqrt{13}}{3}\text{ kN}$

$F_{BD} = \dfrac{3}{2}\sqrt{13}\text{ kN}$ $\qquad F_{BD} = 5.41\text{ kN C} \blacktriangleleft$

$F_{BC} = \dfrac{1}{6}\sqrt{13}\text{ kN}$ $\qquad F_{BC} = 0.601\text{ kN C} \blacktriangleleft$

continued

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By inspection of joint F: $F_{EF} = 0$ ◀

Joint E:

By symmetry: $F_{DE} = F_{EG}$

$\uparrow \Sigma F_y = 0$: $\quad 2\dfrac{1}{\sqrt{17}} F_{DE} - 4.5 \text{ kN} = 0, \quad F_{DE} = \dfrac{9}{4}\sqrt{17} \text{ kN}$

$F_{DE} = 9.28 \text{ kN C}$ ◀

$\rightarrow \Sigma F_x = 0$: $\quad F_{DF} + \dfrac{2}{\sqrt{13}}\left(\dfrac{3}{2}\sqrt{13} \text{ kN}\right) - \dfrac{4}{\sqrt{17}}\left(\dfrac{9}{4}\sqrt{17} \text{ kN}\right) = 0$

$F_{DF} = 6.00 \text{ kN T}$ ◀

Joint D:

$\uparrow \Sigma F_y = 0$: $\quad \dfrac{3}{\sqrt{13}}\left(\dfrac{3}{2}\sqrt{13} \text{ kN}\right) - 1.4 \text{ kN} - F_{CD} - \dfrac{1}{\sqrt{17}}\left(\dfrac{9}{4}\sqrt{17} \text{ kN}\right) = 0$

$F_{CD} = 0.850 \text{ kN T}$ ◀

Joint C:

$\uparrow \Sigma F_y = 0$: $\quad 0.850 \text{ kN} - \dfrac{3}{\sqrt{13}}\left(\dfrac{\sqrt{13}}{6} \text{ kN}\right) - \dfrac{3}{5} F_{CG} = 0$

$F_{CG} = \dfrac{1.75}{3} \text{ kN}$ $\quad F_{CG} = 0.583 \text{ kN C}$ ◀

$\rightarrow \Sigma F_x = 0$: $\quad F_{CI} - \dfrac{4}{5}\left(\dfrac{1.75}{3} \text{ kN}\right) - \dfrac{2}{\sqrt{13}}\left(\dfrac{\sqrt{13}}{6} \text{ kN}\right) - \dfrac{10}{3} \text{ kN} = 0$

$F_{CI} = 3.47 \text{ kN}$ ◀

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Chapter 6, Solution 16.

FBD Truss:

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

$\circlearrowleft \Sigma M_A = 0: \quad 8a(J_y - 1\text{ kN}) - 7a(1\text{ kN}) - 6a(2.8\text{ kN})$

$-4a(4.5\text{ kN}) - 2a(4\text{ kN}) - a(1\text{ kN}) = 0$

$\mathbf{J}_y = 6.7\text{ kN} \uparrow$

$\uparrow \Sigma F_y = 0: \quad A_y - 1\text{ kN} - 1\text{ kN} - 1.4\text{ kN} - 4.5\text{ kN} - 2.8\text{ kN}$

$-1\text{ kN} - 1\text{ kN} + 6.7\text{ kN} = 0 \qquad \mathbf{A} = 6.0\text{ kN} \uparrow$

Joint FBDs:

Joint J:

$\uparrow \Sigma F_y = 0: \quad (6.7 - 1)\text{ kN} - \dfrac{3}{\sqrt{13}} F_{HJ} = 0, \qquad F_{HJ} = 1.9\sqrt{13}\text{ kN}$

$F_{HJ} = 6.85\text{ kN C} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \quad \dfrac{2}{\sqrt{13}}(1.9\sqrt{13}\text{ kN}) - F_{IJ} = 0, \qquad F_{IJ} = 3.80\text{ kN T} \blacktriangleleft$

Joint H:

$\rightarrow \Sigma F_x = 0: \quad \dfrac{2}{\sqrt{13}}(F_{GH} + F_{HI} - 1.9\sqrt{13}\text{ kN}) = 0$

$\uparrow \Sigma F_y = 0: \quad \dfrac{3}{\sqrt{13}}(F_{HI} - F_{GH} + 1.9\sqrt{13}\text{ kN}) - 1\text{ kN} = 0$

$F_{GH} = \dfrac{26}{15}\sqrt{13}\text{ kN}, \qquad F_{GH} = 6.25\text{ kN C} \blacktriangleleft$

$F_{HI} = \dfrac{\sqrt{13}}{6}\text{ kN}, \qquad F_{HI} = 0.601\text{ kN C} \blacktriangleleft$

Joint I:

$\rightarrow \Sigma F_x = 0: \quad 3.80\text{ kN} - \dfrac{2}{\sqrt{13}}\left(\dfrac{\sqrt{13}}{6}\text{ kN}\right) - F_{CI} = 0$

$F_{CI} = \dfrac{10.4}{3}\text{ kN}, \qquad F_{CI} = 3.47\text{ kN T} \blacktriangleleft$

$\uparrow \Sigma F_y = 0: \quad F_{GI} - \dfrac{3}{\sqrt{13}}\left(\dfrac{\sqrt{13}}{6}\text{ kN}\right) = 0, \qquad F_{GI} = 0.500\text{ kN T} \blacktriangleleft$

continued

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By inspection of joint F, $F_{EF} = 0$ ◀

By symmetry $F_{DE} = F_{EG}$

Joint E:

$$\uparrow \Sigma F_y = 0: \quad 2\left(\frac{1}{\sqrt{17}} F_{EG}\right) - 4.5 \text{ kN} = 0, \qquad F_{EG} = \frac{9}{4}\sqrt{17} \text{ kN}$$

$F_{EG} = 9.28$ kN C ◀

Joint G:

$$\uparrow \Sigma F_y = 0: \quad \frac{3}{\sqrt{13}}\left(\frac{26}{15}\sqrt{13} \text{ kN}\right) - \frac{1}{2} \text{ kN} - \frac{3}{5} F_{CG} - \frac{1}{\sqrt{17}}\left(\frac{9}{4}\sqrt{17} \text{ kN}\right) - 2.8 \text{ kN} = 0$$

$$F_{CG} = -\frac{1.75}{3} \text{ kN}$$

$F_{CG} = 0.583$ kN C ◀

$$\rightarrow \Sigma F_x = 0: \quad \frac{4}{\sqrt{17}}\left(\frac{9}{4}\sqrt{17} \text{ kN}\right) - F_{FG} - \frac{4}{5}\left(-\frac{1.75}{3}\right) - \frac{2}{\sqrt{13}}\left(\frac{26}{15}\sqrt{13} \text{ kN}\right) = 0$$

$F_{FG} = 6.00$ kN T ◀

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Chapter 6, Solution 17.

FBD Truss:

By load symmetry, $\mathbf{A}_y = \mathbf{H}_y = 1600 \text{ lb} \uparrow$

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

$$\theta = \tan^{-1}\frac{6.72 \text{ ft}}{23.04 \text{ ft}} = 16.2602°$$

Joint FBDs:

Joint A:

$\nearrow \Sigma F_{y'} = 0: \quad (1600 \text{ lb} - 400 \text{ lb})\cos\theta - F_{AC}\sin\theta = 0$

$F_{AC} = 4114.3 \text{ lb}$ $\qquad F_{AC} = 4.11 \text{ kips T} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \quad F_{AC}\cos 2\theta - F_{AB}\cos\theta = 0$

$F_{AB} = 3613.5 \text{ lb}$ $\qquad F_{AB} = 3.61 \text{ kips C} \blacktriangleleft$

Joint B:

$\searrow \Sigma F_{x'} = 0: \quad 3613.5 \text{ lb} - F_{BD} + (800 \text{ lb})\sin\theta = 0$

$F_{BD} = 3837.5 \text{ lb}$ $\qquad F_{BD} = 3.84 \text{ kips C} \blacktriangleleft$

$\nearrow \Sigma F_{y'} = 0: \quad F_{BC} - (800 \text{ lb})\cos\theta = 0$

$F_{BC} = 768.00 \text{ lb}$ $\qquad F_{BC} = 0.768 \text{ kips C} \blacktriangleleft$

Joint C:

$\nearrow \Sigma F_{y''} = 0: \quad F_{CD}\sin 2\theta - (768 \text{ lb})\cos\theta = 0$

$F_{CD} = 1371.4 \text{ lb}$ $\qquad F_{CD} = 1.371 \text{ kips T} \blacktriangleleft$

$\searrow \Sigma F_{x''} = 0: \quad F_{CE} + (1371.4 \text{ lb})\cos 2\theta - (768 \text{ lb})\sin\theta - 4114.3 \text{ lb} = 0$

$F_{CE} = 2742.9 \text{ lb}$ $\qquad F_{CE} = 2.74 \text{ kips T} \blacktriangleleft$

continued

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Joint E:

$\uparrow \Sigma F_y = 0: \quad (2742.9 \text{ lb}) \sin 2\theta - F_{DE} \cos\theta = 0$

$F_{DE} = 1536.01 \text{ lb}$

$F_{DE} = 1.536 \text{ kips C}$ ◀

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Chapter 6, Solution 18.

FBD Truss:

By load symmetry, $\mathbf{A}_y = \mathbf{H}_y = 1600 \text{ lb} \uparrow$

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

$$\theta = \tan^{-1}\frac{6.72 \text{ ft}}{23.04 \text{ ft}} = 16.2602°$$

Joint FBDs:

Joint H:

$\uparrow \Sigma F_y = 0: \quad 1600 \text{ lb} - 400 \text{ lb} - F_{FH}\sin\theta = 0$

$F_{FH} = 4285.7 \text{ lb}, \qquad F_{FH} = 4.29 \text{ kips C} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \quad (4285.7 \text{ lb})\cos\theta - F_{GH} = 0$

$F_{GH} = 4114.3 \text{ lb} \qquad F_{GH} = 4.11 \text{ kips T} \blacktriangleleft$

Joint F:

$\nearrow \Sigma F_{y'} = 0: \quad F_{FG} - (800 \text{ lb})\cos\theta = 0$

$F_{FG} = 768.0 \text{ lb} \qquad F_{FG} = 0.768 \text{ kips C} \blacktriangleleft$

$\searrow \Sigma F_{x'} = 0: \quad F_{DF} + (800 \text{ lb})\sin\theta - 4285.7 \text{ lb} = 0$

$F_{DF} = 4061.7 \text{ lb} \qquad F_{DF} = 4.06 \text{ kips C} \blacktriangleleft$

Joint G:

$\uparrow \Sigma F_y = 0: \quad F_{DG}\sin 2\theta - (768 \text{ lb})\cos\theta = 0$

$F_{DG} = 1371.4 \text{ lb} \qquad F_{DG} = 1.371 \text{ kips T} \blacktriangleleft$

$\Sigma F_x = 0: \quad 4114.3 \text{ lb} - (1371.4 \text{ lb})\cos\theta - F_{EG} - (768 \text{ lb})\sin\theta = 0$

$F_{EG} = 2742.9 \text{ lb} \qquad F_{EG} = 2.74 \text{ kips T} \blacktriangleleft$

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Chapter 6, Solution 19.

FBD Truss:

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

$\circlearrowleft \Sigma M_L = 0: \quad (1.5\text{ m})(6.6\text{ kN}) + (3.0\text{ m})(2.2\text{ kN})$

$+ (5.5\text{ m})(6\text{ kN}) - (11\text{ m})\,A_y = 0$

$\mathbf{A}_y = 4.5\text{ kN} \uparrow$

Joint FBDs:

$\uparrow \Sigma F_y = 0: \quad 4.5\text{ kN} - 6\text{ kN} - 2.2\text{ kN} - 6.6\text{ kN} + L = 0$

$\mathbf{L} = 10.3\text{ kN} \uparrow$

Joint A:

$$\frac{4.5\text{ kN}}{1} = \frac{F_{AC}}{2} = \frac{F_{AB}}{\sqrt{5}}, \qquad F_{AC} = 9.00\text{ kN T} \blacktriangleleft$$

$$F_{AB} = 4.5\sqrt{5}, \qquad F_{AB} = 10.06\text{ kN C} \blacktriangleleft$$

Joint C:

$$\frac{9\text{ kN}}{16} = \frac{F_{BC}}{5} = \frac{F_{CE}}{\sqrt{281}}, \qquad F_{BC} = \frac{45}{16}\text{ kN}$$

$$F_{BC} = 2.81\text{ kN C} \blacktriangleleft$$

$$F_{CE} = \frac{9}{16}\sqrt{281}, \qquad F_{CE} = 9.43\text{ kN T} \blacktriangleleft$$

Joint B:

$\rightarrow \Sigma F_x = 0: \quad \frac{2}{\sqrt{5}}\left[F_{BD} + (4.5\sqrt{5})\text{ kN}\right] + \frac{16}{\sqrt{265}}F_{BE} = 0$

$\uparrow \Sigma F_y = 0: \quad \frac{1}{\sqrt{5}}\left[F_{BD} + (4.5\sqrt{5})\text{ kN}\right] - \frac{3}{\sqrt{265}}F_{BE} + \frac{45}{16}\text{ kN} = 0$

Solving:

$$F_{BD} = -\frac{72}{11}\sqrt{5}\text{ kN}, \qquad F_{BD} = 14.64\text{ kN C} \blacktriangleleft$$

$$F_{BE} = \frac{45}{176}\sqrt{265}\text{ kN}, \qquad F_{BE} = 4.16\text{ kN T} \blacktriangleleft$$

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Joint E:

$$\rightarrow \Sigma F_x = 0: \quad \frac{16}{\sqrt{281}}\left[F_{EG} - \left(\frac{9}{16}\sqrt{281}\right)\text{kN}\right] - \frac{16}{\sqrt{265}}\left(\frac{45}{176}\sqrt{265}\right)\text{kN} = 0$$

$$F_{EG} = \frac{9}{11}\sqrt{281}\ \text{kN}, \qquad F_{EG} = 13.72\ \text{kN T} \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad \frac{5}{\sqrt{281}}\left(\frac{9}{11}\sqrt{281}\ \text{kN} - \frac{9}{16}\sqrt{281}\ \text{kN}\right) + \frac{3}{\sqrt{265}}\left(\frac{45}{176}\sqrt{265}\ \text{kN}\right) + F_{DE} = 0,$$

$$F_{DE} = -\frac{45}{22}\ \text{kN}, \qquad F_{DE} = 2.05\ \text{kN C} \blacktriangleleft$$

Joint D:

$$\rightarrow \Sigma F_x = 0: \quad \frac{2}{\sqrt{5}}\left(F_{DF} + \frac{72}{11}\sqrt{5}\ \text{kN}\right) + \frac{10}{\sqrt{101}}F_{DG} = 0$$

$$\uparrow \Sigma F_y = 0: \quad \frac{1}{\sqrt{5}}\left(F_{DF} + \frac{72}{11}\sqrt{5}\ \text{kN}\right) - \frac{1}{\sqrt{101}}F_{DG} + \frac{45}{22}\ \text{kN} = 0$$

Solving:

$$F_{DG} = \frac{7.5}{22}\sqrt{101}\ \text{kN}, \qquad F_{DG} = 3.43\ \text{kN T} \blacktriangleleft$$

$$F_{DF} = -8.25\sqrt{5}\ \text{kN}, \qquad F_{DF} = 18.45\ \text{kN C} \blacktriangleleft$$

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Chapter 6, Solution 20.

FBD Truss:

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

$\circlearrowleft \Sigma M_L = 0: \quad (1.5\text{ m})(6.6\text{ kN}) + (3.0\text{ m})(2.2\text{ kN}) + (5.5\text{ m})(6\text{ kN})$

$- (11\text{ m})\,A_y = 0$

$\mathbf{A}_y = 4.5\text{ kN} \uparrow$

$\uparrow \Sigma F_y = 0: \quad 4.5\text{ kN} - 6\text{ kN} - 2.2\text{ kN} - 6.6\text{ kN} + L = 0$

$\mathbf{L} = 10.3\text{ kN} \uparrow$

Joint FBDs:

Joint L:

$$\frac{10.3\text{ kN}}{1} = \frac{F_{KL}}{2} = \frac{F_{JL}}{\sqrt{5}}, \qquad F_{KL} = 20.6\text{ kN T} \blacktriangleleft$$

$$F_{JL} = 10.3\sqrt{5}\text{ kN}, \qquad F_{JL} = 23.0\text{ kN C} \blacktriangleleft$$

Joint K:

$$\frac{20.6\text{ kN}}{16} = \frac{F_{JK}}{5} = \frac{F_{IK}}{\sqrt{281}}, \qquad F_{JK} = \frac{51.5}{8}\text{kN}$$

$$F_{JK} = 6.44\text{ kN C} \blacktriangleleft$$

$$F_{IK} = \frac{10.3}{8}\sqrt{281}\text{ kN}, \qquad F_{IK} = 21.6\text{ kN T} \blacktriangleleft$$

Joint J:

$\rightarrow \Sigma F_x = 0: \quad -\frac{2}{\sqrt{5}}\left(F_{HJ} + 10.3\sqrt{5}\text{ kN}\right) - \frac{16}{\sqrt{265}}F_{IJ} = 0$

$\uparrow \Sigma F_y = 0: \quad \frac{1}{\sqrt{5}}\left(F_{HJ} + 10.3\sqrt{5}\text{ kN}\right) - \frac{3}{\sqrt{265}}F_{IJ} - 6.6\text{ kN} + \frac{51.5}{8}\text{ kN} = 0$

Solving:

$$F_{HJ} = -\frac{112}{11}\sqrt{5}\text{ kN}, \qquad F_{HJ} = 22.8\text{ kN C} \blacktriangleleft$$

$$F_{IJ} = -\frac{1.3}{88}\sqrt{265}\text{ kN}, \qquad F_{IJ} = 0.240\text{ kN C} \blacktriangleleft$$

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Joint I:

$$\rightarrow \Sigma F_x = 0: \quad \frac{16}{\sqrt{281}}\left(-F_{GI} + \frac{10.3}{8}\sqrt{281}\text{ kN}\right) - \frac{16}{\sqrt{265}}\left(\frac{1.3}{88}\sqrt{265}\text{ kN}\right) = 0$$

$$F_{GI} = \frac{112}{88}\sqrt{281}\text{ kN}, \qquad F_{GI} = 21.3\text{ kN T} \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad \frac{5}{\sqrt{281}}\left(\frac{112}{88}\sqrt{281}\text{ kN} - \frac{10.3}{8}\sqrt{281}\text{ kN}\right) + F_{HI} - \frac{3}{\sqrt{265}}\left(\frac{1.3}{88}\sqrt{265}\text{ kN}\right) = 0$$

$$F_{HI} = \frac{10.4}{88}\text{ kN}, \qquad F_{HI} = 0.1182\text{ kN T} \blacktriangleleft$$

Joint H:

$$\rightarrow \Sigma F_x = 0: \quad -\frac{2}{\sqrt{5}}\left(F_{FH} + \frac{112}{11}\sqrt{5}\text{ kN}\right) - \frac{10}{\sqrt{101}}F_{GH} = 0$$

$$\uparrow \Sigma F_y = 0: \quad \frac{1}{\sqrt{5}}\left(F_{FH} + \frac{112}{11}\sqrt{5}\text{ kN}\right) - \frac{1}{\sqrt{101}}F_{GH} - 2.2\text{ kN} - \frac{10.4}{88}\text{ kN} = 0$$

Solving:

$$F_{FH} = -8.25\sqrt{5}\text{ kN}, \qquad F_{FH} = 18.45\text{ kN C} \blacktriangleleft$$

$$F_{GH} = -\frac{34}{88}\sqrt{101}\text{ kN}, \qquad F_{GH} = 3.88\text{ kN C} \blacktriangleleft$$

By symmetry: $F_{DF} = 8.25\sqrt{5}\text{ kN}$

Joint F:

$$\uparrow \Sigma F_y = 0: \quad \frac{2}{\sqrt{5}}\left(8.25\sqrt{5}\text{ kN}\right) - 6\text{ kN} - F_{FG} = 0$$

$$F_{FG} = 10.50\text{ kN T} \blacktriangleleft$$

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Chapter 6, Solution 21.

Joint FBDs:

Joint F:

$$\frac{F_{DF}}{916} = \frac{F_{EF}}{916} = \frac{500 \text{ lb}}{480}$$

$$F_{DF} = F_{EF} = 954.17 \text{ lb}$$

or

$F_{DF} = 954 \text{ lb T}$ ◀

$F_{EF} = 954 \text{ lb C}$ ◀

Joint D:

$$\frac{F_{BD}}{884} = \frac{F_{DE}}{240} = \frac{954.17 \text{ lb}}{916}$$

$$F_{BD} = 920.84 \text{ lb}$$

$$F_{DE} = 250.00 \text{ lb}$$

or

$F_{BD} = 921 \text{ lb T}$ ◀

$F_{DE} = 250 \text{ lb C}$ ◀

By symmetry of joint A vs. joint F

$F_{AB} = 954 \text{ lb T}$ ◀

$F_{AC} = 954 \text{ lb C}$ ◀

Joint B:

$\xrightarrow{+} \Sigma F_x = 0$: $\quad 920.84 \text{ lb} - \frac{884}{916}(954.17 \text{ lb}) + \frac{4}{5}F_{BE} = 0$

$F_{BE} = 0$ ◀

$+\uparrow \Sigma F_y = 0$: $\quad F_{BC} - \frac{240}{916}(954.17 \text{ lb}) = 0$

$F_{BC} = 250.00 \text{ lb}$ or $F_{BC} = 250 \text{ lb C}$ ◀

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Joint C:

$$\xrightarrow{+} \Sigma F_x = 0: \quad \frac{884}{916}(954.17 \text{ lb}) - F_{CE} = 0$$

$$F_{CE} = 920.84 \text{ lb} \qquad \text{or} \qquad F_{CE} = 921 \text{ lb C} \blacktriangleleft$$

$$+\uparrow \Sigma F_y = 0: \quad F_{CH} - \frac{240}{916}(954.17 \text{ lb}) - 250.00 \text{ lb} = 0$$

$$F_{CH} = 500.00 \text{ lb} \qquad \text{or} \qquad F_{CH} = 500 \text{ lb C} \blacktriangleleft$$

$$\xrightarrow{+} \Sigma F_x = 0: \quad 920.84 \text{ lb} - \frac{884}{916}(954.17 \text{ lb}) - \frac{4}{5}F_{HE} = 0$$

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

Joint E:

$$+\uparrow \Sigma F_y = 0: \quad F_{EJ} - \frac{240}{916}(954.17 \text{ lb}) - 250.00 \text{ lb} = 0$$

$$F_{EJ} = 500.00 \text{ lb} \qquad \text{or} \qquad F_{EJ} = 500 \text{ lb C} \blacktriangleleft$$

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Chapter 6, Solution 22.

Joint FBDs:

Joint L:

$$\frac{F_{JL}}{1212} = \frac{F_{KL}}{1212} = \frac{500 \text{ lb}}{480}$$

$$F_{JL} = F_{KL} = 1262.50 \text{ lb}$$

$F_{JL} = 1263 \text{ lb T}$ ◀

$F_{KL} = 1263 \text{ lb C}$ ◀

Comparing joint G to joint L: $F_{GH} = 1263 \text{ lb T}$ ◀

$F_{GI} = 1263 \text{ lb C}$ ◀

Joint J:

$$\rightarrow \Sigma F_x = 0: \quad \frac{1188}{1212}(1262.50 \text{ lb}) - F_{HJ} = 0$$

$$F_{HJ} = 1237.50 \text{ lb}, \qquad F_{HJ} = 1238 \text{ lb T} ◀$$

$$\uparrow \Sigma F_y = 0: \quad F_{JK} - \frac{240}{1212}(1262.50 \text{ lb}) - 500 \text{ lb} = 0$$

$$F_{JK} = 750.00 \text{ lb}, \qquad F_{JK} = 750 \text{ lb C} ◀$$

Joint H:

$$\rightarrow \Sigma F_x = 0: \quad 1237.50 \text{ lb} - \frac{1188}{1212}(1262.50 \text{ lb}) + \frac{4}{5}F_{HK} = 0$$

$F_{HK} = 0$ ◀

$$\uparrow \Sigma F_y = 0: \quad F_{HI} - \frac{240}{1212}(1262.50 \text{ lb}) - 500 \text{ lb} - \frac{3}{5}(0) = 0$$

$F_{HI} = 750 \text{ lb C}$ ◀

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Joint I:

$\rightarrow \Sigma F_x = 0$: $\quad \dfrac{1188}{1212}(1262.50 \text{ lb}) - F_{IK} = 0$

$F_{IK} = 1237.50$ lb, $\qquad F_{IK} = 1238$ lb C ◀

$\uparrow \Sigma F_y = 0$: $\quad F_{IN} - \dfrac{240}{1212}(1262.50 \text{ lb}) - 750.00 \text{ lb} = 0$

$F_{IN} = 1000.00$ lb, $\qquad F_{IN} = 1000$ lb C ◀

Joint K:

$\rightarrow \Sigma F_x = 0$: $\quad 1237.50 \text{ lb} - \dfrac{1188}{1212}(1262.50 \text{ lb}) - \dfrac{4}{5}F_{KN} = 0$

$F_{KN} = 0$ ◀

$\uparrow \Sigma F_y = 0$: $\quad F_{KO} - \dfrac{240}{1212}(1262.50 \text{ lb}) - 750.00 \text{ lb} = 0$

$F_{KO} = 1000$ lb C ◀

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Chapter 6, Solution 23.

FBD Truss:

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

$\circlearrowleft \Sigma M_A = 0: \quad (12\text{ m})(M_y - 1\text{ kN})$

$- (2.4\text{ m} + 4.8\text{ m} + 6\text{ m} + 8.4\text{ m} + 10.8\text{ m})(1.5\text{ kN}) = 0$

$\mathbf{M}_y = 5.05\text{ kN} \uparrow$

$\uparrow \Sigma F_y = 0: \quad A_y - 2(1\text{ kN}) - 5(1.5\text{ kN}) + M_y = 0$

$\mathbf{A}_y = 4.45\text{ kN} \uparrow$

Joint FBDs:

$\uparrow \Sigma F_y = 0: \quad 4.45\text{ kN} - 1\text{ kN} - \frac{5}{13}F_{AB} = 0, \qquad F_{AB} = 8.97\text{ kN C} \blacktriangleleft$

Joint A:

$\rightarrow \Sigma F_x = 0: \quad F_{AC} - \frac{12}{13}(8.97\text{ kN}) = 0, \qquad F_{AC} = 8.28\text{ kN T} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \quad \frac{12}{13}F_{CE} - 8.28\text{ kN} = 0, \qquad F_{CE} = 8.97\text{ kN T} \blacktriangleleft$

Joint C:

$\uparrow \Sigma F_y = 0: \quad \frac{5}{13}(8.97\text{ kN}) - F_{BC} = 0, \qquad F_{BC} = 3.45\text{ kN C} \blacktriangleleft$

$\uparrow \Sigma F_y = 0: \quad \frac{5}{13}(8.97\text{ kN}) - 1.5\text{ kN} + 3.45\text{ kN} - \frac{5}{13}F_{BD} = 0$

$F_{BD} = 14.04\text{ kN} \qquad F_{BD} = 14.04\text{ kN C} \blacktriangleleft$

Joint B:

$\rightarrow \Sigma F_x = 0: \quad \frac{12}{13}(8.97\text{ kN}) - \frac{12}{13}(14.04\text{ kN}) + F_{BE} = 0$

$F_{BE} = 4.68\text{ kN} \qquad F_{BE} = 4.68\text{ kN T} \blacktriangleleft$

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Joint E:

$\rightarrow \Sigma F_x = 0$: $\quad \dfrac{6}{\sqrt{37}} F_{EH} - 4.68 \text{ kN} - \dfrac{12}{13}(8.97 \text{ kN}) = 0$

$F_{EH} = 13.1388 \text{ kN}$ or $F_{EH} = 13.14 \text{ kN T}$ ◀

$\uparrow \Sigma F_y = 0$: $\quad F_{DE} - \dfrac{5}{13}(8.97 \text{ kN}) - \dfrac{1}{\sqrt{37}}(13.1388) = 0$

$F_{DE} = 5.6100 \text{ kN}$ or $F_{DE} = 5.61 \text{ kN T}$ ◀

Joint D:

$\rightarrow \Sigma F_x = 0$: $\quad \dfrac{12}{13}(14.04 \text{ kN}) - \dfrac{12}{13} F_{DG} - \dfrac{1}{\sqrt{2}} F_{DH} = 0$

$\uparrow \Sigma F_y = 0$: $\quad \dfrac{5}{13}(14.04 \text{ kN}) - \dfrac{5}{13} F_{DG} - 1.5 \text{ kN} - 5.61 \text{ kN}$

$+ \dfrac{1}{\sqrt{2}} F_{DH} = 0$

Solving:

$F_{DG} = 8.60 \text{ kN C}$ ◀

$F_{DH} = 7.10 \text{ kN C}$ ◀

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Chapter 6, Solution 24.

FBD Truss:

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

$\circlearrowleft \Sigma M_A = 0: \quad (12\text{ m})(M_y - 1\text{ kN})$

$$-(2.4\text{ m} + 4.8\text{ m} + 6\text{ m} + 8.4\text{ m} + 10.8\text{ m})(1.5\text{ kN}) = 0$$

$$\mathbf{M}_y = 5.05\text{ kN} \uparrow$$

$\uparrow \Sigma F_y = 0: \quad A_y - 2(1\text{ kN}) - 5(1.5\text{ kN}) + M_y = 0$

$$\mathbf{A}_y = 4.45\text{ kN} \uparrow$$

Joint FBDs:

Joint M:

$\uparrow \Sigma F_y = 0: \quad 5.05\text{ kN} - 1\text{ kN} - \frac{5}{13}F_{KM} = 0, \qquad F_{KM} = 10.53\text{ kN C} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \quad \frac{12}{13}(10.53\text{ kN}) - F_{LM} = 0, \qquad F_{LM} = 9.72\text{ kN T} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \quad 9.72\text{ kN} - \frac{6}{\sqrt{37}}F_{JL} = 0, \qquad F_{JL} = 1.62\sqrt{37}$

$$F_{JL} = 9.85\text{ kN T} \blacktriangleleft$$

Joint L:

$\uparrow \Sigma F_y = 0: \quad \frac{1}{\sqrt{37}}(1.62\sqrt{37}\text{ kN}) - F_{KL} = 0, \qquad F_{KE} = 1.620\text{ kN C} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \quad \frac{12}{13}F_{IK} - \frac{24}{\sqrt{577}}F_{JK} - \frac{12}{13}(10.53\text{ kN}) = 0$

Joint K:

$\uparrow \Sigma F_y = 0: \quad \frac{5}{13}(10.53\text{ kN}) - \frac{5}{13}F_{IK} - \frac{1}{\sqrt{577}}F_{JK}$

$$-1.5\text{ kN} + 1.62\text{ kN} = 0$$

Solving: $\quad F_{IK} = 10.8136\text{ kN}, \qquad F_{IK} = 10.81\text{ kN C} \blacktriangleleft$

$\quad F_{JK} = 0.26205\text{ kN}, \qquad F_{JK} = 0.262\text{ kN T} \blacktriangleleft$

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Joint J:

$\rightarrow \Sigma F_x = 0$: $\quad \dfrac{24}{\sqrt{577}}(0.26205\text{ kN}) - \dfrac{6}{\sqrt{37}}(F_{HJ} - 9.85\text{ kN}) = 0$

$F_{HJ} = 10.1154\text{ kN}, \qquad F_{HJ} = 10.12\text{ kN T} \blacktriangleleft$

$\uparrow \Sigma F_y = 0$: $\quad \dfrac{1}{\sqrt{37}}(10.1154\text{ kN} \cdot 9.85\text{ kN}) - \dfrac{1}{\sqrt{577}}(0.26205\text{ kN}) - F_{IJ} = 0$

$F_{IJ} = 0.054541\text{ kN}, \qquad F_{IJ} = 54.5\text{ N C} \blacktriangleleft$

Joint I:

$\rightarrow \Sigma F_x = 0$: $\quad \dfrac{12}{13}\left(F_{GI} - 10.8136\text{ kN}\right) + \dfrac{24}{25}F_{HI} = 0$

$\uparrow \Sigma F_y = 0$: $\quad \dfrac{5}{13}\left(10.8136\text{ kN} - F_{GI}\right) + \dfrac{7}{25}F_{HI} - 1.5\text{ kN} + 0.05454\text{ kN} = 0$

Solving: $\quad F_{GI} = 8.6029\text{ kN}, \qquad F_{GI} = 8.60\text{ kN C} \blacktriangleleft$

$F_{HI} = 2.1257\text{ kN}, \qquad F_{HI} = 2.13\text{ kN C} \blacktriangleleft$

Joint G:

By symmetry: $\qquad F_{OG} = 8.60\text{ kN C} \blacktriangleleft$

$\uparrow \Sigma F_y = 0$: $\quad 2\left(\dfrac{5}{13}\right)(8.6029\text{ kN}) - 1.5\text{ kN} - F_{GH} = 0$

$F_{GH} = 5.12\text{ kN T} \blacktriangleleft$

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Chapter 6, Solution 25.

FBD Truss:

$\rightarrow \Sigma F_x = 0: \quad 180 \text{ lb} - A_x = 0$

$\mathbf{A}_x = 180 \text{ lb} \leftarrow$

$\circlearrowleft \Sigma M_A = (12 \text{ ft})G_y - (6 \text{ ft})(480 \text{ lb}) - (2 \text{ ft})(180 \text{ lb})$

$- (8 \text{ ft})(120 \text{ lb}) = 0, \qquad \mathbf{G}_y = 350 \text{ lb} \uparrow$

$\uparrow \Sigma F_y = 0: \quad A_y - 480 \text{ lb} - 120 \text{ lb} + 350 \text{ lb} = 0$

$\mathbf{A}_y = 250 \text{ lb} \uparrow$

Joint FBDs:

Joint A:

$\rightarrow \Sigma F_x = 0: \quad \frac{1}{\sqrt{2}} F_{AC} - 180 \text{ lb} = 0, \; F_{AC} = 180\sqrt{2} \text{ lb}$

$F_{AC} = 255 \text{ lb T} \blacktriangleleft$

$\uparrow \Sigma F_y = 0: \quad \frac{1}{\sqrt{2}}(180\sqrt{2} \text{ lb}) + 250 \text{ lb} - F_{AB} = 0, \qquad F_{AB} = 430 \text{ lb C} \blacktriangleleft$

Joint B:

$\rightarrow \Sigma F_x = 0: \quad 180 \text{ lb} - \frac{4}{5} F_{BD} + \frac{2}{\sqrt{5}} F_{BC} = 0$

$\uparrow \Sigma F_y = 0: \quad 430 \text{ lb} - \frac{3}{5} F_{BD} + \frac{1}{\sqrt{5}} F_{BC} = 0$

Solving: $\quad F_{BC} = 590\sqrt{5} \text{ lb}, \qquad F_{BC} = 1319 \text{ lb T} \blacktriangleleft$

$F_{BD} = 1700 \text{ lb C} \blacktriangleleft$

Joint C:

$\uparrow \Sigma F_y = 0: \quad \frac{5}{\sqrt{41}} F_{CD} - \frac{1}{\sqrt{5}}(590\sqrt{5} \text{ lb}) - \frac{1}{\sqrt{2}}(180\sqrt{2} \text{ lb}) = 0$

$F_{CD} = 154\sqrt{41} \text{ lb}, \qquad F_{CD} = 986 \text{ lb T} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \quad F_{CE} + \frac{4}{\sqrt{41}}(154\sqrt{41} \text{ lb}) - \frac{2}{\sqrt{5}}(590\sqrt{5} \text{ lb})$

$- \frac{1}{\sqrt{12}}(180\sqrt{2} \text{ lb}) = 0$

$F_{CE} = 744 \text{ lb T} \blacktriangleleft$

By inspection of joint G: $\qquad F_{FG} = 350 \text{ lb C and } F_{EG} = 0 \blacktriangleleft$

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Joint F:

$$\frac{F_{DF}}{5} = \frac{F_{EF}}{\sqrt{20}} = \frac{350}{1};$$

$$F_{EF} = 700\sqrt{5}\text{ lb},$$

$F_{DF} = 1750$ lb C ◀

$F_{EF} = 1565$ lb T ◀

Joint E:

$\uparrow \Sigma F_y = 0$: $\quad \frac{5}{\sqrt{41}} F_{DE} - 120\text{ lb} - \frac{1}{\sqrt{5}}(700\sqrt{5}\text{ lb}) = 0$

$$F_{DE} = 164\sqrt{41}\text{ lb},$$

$F_{DE} = 1050$ lb T ◀

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Chapter 6, Solution 26.

Joint FBDs:

Joint A:

$\uparrow \Sigma F_y = 0$: $\frac{9}{41}F_{AC} - 1.8 \text{ kips} = 0,$ $F_{AC} = 8.20 \text{ kips T}$ ◀

$\rightarrow \Sigma F_x = 0$: $\frac{40}{41}F_{AB} - 8.20 \text{ kips} = 0,$ $F_{AB} = 8.00 \text{ kips C}$ ◀

By inspection of joint B, $F_{BD} = F_{AB}$ $F_{BD} = 8.00 \text{ kips C}$ ◀

and then $F_{BC} = 0.6 \text{ kips},$ $F_{BC} = 0.600 \text{ kips C}$ ◀

Joint C:

Note: $\overline{DE} = \frac{9.2}{20}(4.5 \text{ ft}) = 2.07 \text{ ft},$ $\overline{CE} = 4.14 \text{ ft} = 2\overline{DE}$

$\uparrow \Sigma F_y = 0$: $\frac{1}{\sqrt{5}}F_{CD} - 0.6 \text{ kips} = 0,$ $F_{CD} = 0.6\sqrt{5} \text{ kips}$

$F_{CD} = 1.342 \text{ kips T}$ ◀

$\rightarrow \Sigma F_x = 0$: $8.2 \text{ kips} + \frac{2}{\sqrt{5}}\left(0.6\sqrt{5} \text{ kips}\right) - F_{CE} = 0$

$F_{CE} = 9.20 \text{ kips C}$ ◀

Joint D:

$\uparrow \Sigma F_y = 0$: $\frac{40}{41}\left(F_{DG} - 8.2 \text{ kips}\right) - \frac{2}{\sqrt{5}}\left(0.6\sqrt{5} \text{ kips}\right) = 0$

$F_{DG} = 9.43 \text{ kips T}$ ◀

$\uparrow \Sigma F_x = 0$: $F_{DE} - \frac{9}{41}\left(9.43 \text{ kips} - 8.2 \text{ kips}\right) - \frac{1}{\sqrt{5}}\left(0.6\sqrt{5} \text{ kips}\right) = 0$

$F_{DE} = 0.330 \text{ kips C}$ ◀

Joint E:

$\uparrow \Sigma F_y = 0$: $\frac{5}{13}F_{EG} - 0.33 \text{ kips} = 0,$ $F_{EG} = 0.858 \text{ kips T}$ ◀

$\rightarrow \Sigma F_x = 0$: $\frac{12}{13}\left(0.858 \text{ kips}\right) + 9.2 \text{ kips} - F_{EF} = 0$

$F_{EF} = 9.992 \text{ kips},$ $F_{EF} = 9.99 \text{ kips C}$ ◀

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Joint F:

By vertical symmetry $F_{FG} = F_{FH}$

$\rightarrow \Sigma F_x = 0$: $\quad 9.992 \text{ kips} - 2\left(\frac{4}{5}F_{FG}\right) = 0, \qquad F_{FG} = 5.995 \text{ kips}$

$F_{FG} = F_{FH} = 6.00 \text{ kips}$ C ◀

Vector Mechanics for Engineers: Statics and Dynamics, 8/e, Ferdinand P. Beer, E. Russell Johnston, Jr., Elliot R. Eisenberg, William E. Clausen, David Mazurek, Phillip J. Cornwell
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Chapter 6, Solution 27.

P6.14

Starting with △ *ABC*, add, in order, joints *E*, *D*, *F*, *G*, *H*

∴ simple truss ◀

P6.15

Starting with △ *DEF*, add, in order, *G*, *C*, *B*, *A*, *I*, *H*, *J*

∴ simple truss ◀

P6.23

Starting with △ *ABC*, add, in order, *E*, *F*, *D*, *H*, *G*, *I*, *J*, *K*, *L*, *M*

∴ simple truss ◀

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Chapter 6, Solution 28.

P6.21

Starting with △ *ABC*, add, in order, joints *E*, *D*, *F*, *H*, *J*, *K*, *L*, *I*, *G*, *N*, *P*, *Q*, *R*, *O*, *M*, *S*, *T*

∴ simple truss ◀

P6.25

Starting with △ *ABC*, add, in order, joints *D*, *E*, *F*, *G*

∴ simple truss ◀

P6.29

Starting with △ *ABD*, add, in order, joints *H*, *G*, *F*, *E*, *I*, *G*, *J*

∴ simple truss ◀

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Chapter 6, Solution 29.

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

Then, by inspection of joint F, $F_{FG} = 0$ ◀

Then, by inspection of joint G, $F_{GH} = 0$ ◀

By inspection of joint J, $F_{IJ} = 0$ ◀

Then, by inspection of joint I, $F_{HI} = 0$ ◀

$F_{EI} = 0$ ◀

Then, by inspection of joint E, $F_{BE} = 0$ ◀

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Chapter 6, Solution 30.

By inspection of joint D, $F_{DI} = 0$ ◀

By inspection of joint E, $F_{EI} = 0$ ◀

Then, by inspection of joint I, $F_{AI} = 0$ ◀

By inspection of joint F, $F_{FK} = 0$ ◀

By inspection of joint G, $F_{GK} = 0$ ◀

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Chapter 6, Solution 31.

By inspection of joint C: $F_{BC} = 0$ ◀

Then, by inspection of joint B: $F_{BE} = 0$ ◀

Then, by inspection of joint E: $F_{DE} = 0$ ◀

By inspection of joint H: $F_{FH} = 0$ ◀

and $F_{HI} = 0$ ◀

By inspection of joint Q: $F_{OQ} = 0$ ◀

and $F_{QR} = 0$ ◀

By inspection of joint J: $F_{LJ} = 0$ ◀

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Chapter 6, Solution 32.

By inspection of joint C: $F_{BC} = 0$ ◀

By inspection of joint G: $F_{FG} = 0$ ◀

Then, by inspection of joint F: $F_{FE} = 0$ ◀

By inspection of joint I: $F_{IJ} = 0$ ◀

By inspection of joint M: $F_{MN} = 0$ ◀

Then, by inspection of joint N: $F_{KN} = 0$ ◀

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Chapter 6, Solution 33.

By inspection of joint C: $F_{BC} = 0$ ◀

By inspection of joint M: $F_{LM} = 0$ ◀

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Chapter 6, Solution 34.

By inspection of joint A: $F_{AF} = 0$ ◀

By inspection of joint C: $F_{CH} = 0$ ◀

By inspection of joint E: $F_{DE} = F_{EI} = 0$ ◀

By inspection of joint L: $F_{GL} = 0$ ◀

By inspection of joint N: $F_{IN} = 0$ ◀

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Chapter 6, Solution 35.

(*a*)

By inspection of joint H: $F_{CH} = 0$ ◀

Then, by inspection of joint C: $F_{CG} = 0$ ◀

Then, by inspection of joint G: $F_{BG} = 0$ ◀

Then, by inspection of joint B: $F_{BF} = 0$ ◀

(*b*)

By inspection of joint J: $F_{IJ} = 0$ ◀

Then, by inspection of joint I: $F_{EI} = 0$ ◀

$F_{HI} = 0$ ◀

Then, by inspection of joint E: $F_{BE} = 0$ ◀

also, $\longrightarrow \Sigma F_x = 0$; $\mathbf{F}_x = 0$

So, by inspection of joint F: $F_{FG} = 0$ ◀

And by inspection of joint G: $F_{GH} = 0$ ◀

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Chapter 6, Solution 36.

FBD Truss:

$$\swarrow \Sigma F_z = 0: \quad \mathbf{B}_z = 0$$

$$\Sigma M_x = 0: \quad -(0.47\text{ m})C_y + (0.08\text{ m})(940\text{ N}) = 0$$

$$\mathbf{C}_y = 160\text{ N}\mathbf{j}$$

Joint FBDs:

Joint D:

where $\mathbf{F}_{AD} = F_{AD}\dfrac{-0.80\text{ m }\mathbf{i} - 0.08\text{ m }\mathbf{k}}{\sqrt{(0.8)^2 + (0.08)^2}\text{ m}} = F_{AD}\dfrac{-10\mathbf{i} - \mathbf{k}}{\sqrt{101}}$

$$\mathbf{F}_{BD} = F_{BD}\frac{-0.8\text{ m }\mathbf{i} - 0.16\text{ m }\mathbf{j} - 0.2\text{ m }\mathbf{k}}{\sqrt{(0.8\text{ m})^2 + (0.16\text{ m})^2 + (0.2\text{ m})^2}}$$

$$= F_{BD}\frac{-20\mathbf{i} + 4\mathbf{j} - 5\mathbf{k}}{21}$$

$$\mathbf{F}_{CD} = F_{CD}\frac{-0.8\text{ m }\mathbf{i} + 0.39\text{ m }\mathbf{k}}{\sqrt{(0.8\text{ m})^2 + (0.39\text{ m})^2}} = F_{CD}\frac{-80\mathbf{i} + 39\mathbf{k}}{89}$$

$$\uparrow \Sigma F_y = 0: \quad \frac{4}{21}F_{BD} - 940\text{ N} = 0, \quad F_{BD} = 4935\text{ N}, \qquad F_{BD} = 4.94\text{ kN T} \blacktriangleleft$$

$$\searrow \Sigma F_x = 0: \quad -\frac{10}{\sqrt{101}}F_{AD} - \frac{80}{89}F_{CD} - \frac{20}{21}(4935\text{ N}) = 0$$

$$\swarrow \Sigma F_z = 0: \quad -\frac{1}{\sqrt{101}}F_{AD} + \frac{39}{89}F_{CD} - \frac{5}{21}(4935\text{ N}) = 0$$

Solving: $F_{AD} = -590\sqrt{101}\text{ N}, \qquad F_{AD} = 5.93\text{ kN C} \blacktriangleleft$

$F_{CD} = 1335\text{ N}, \qquad F_{CD} = 1.335\text{ kN T} \blacktriangleleft$

continued

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Joint C:

$$\mathbf{F}_{BC} = F_{BC}\,\frac{0.16\text{ m }\mathbf{j} - 0.59\text{ m }\mathbf{k}}{\sqrt{(0.16\text{ m})^2 + (0.59\text{ m})^2}} = F_{BC}\,\frac{16\mathbf{j} - 59\mathbf{k}}{\sqrt{3737}}$$

$$\uparrow \Sigma F_y = 0: \quad \frac{16}{\sqrt{3737}}\,F_{BC} + 160\text{ N} = 0$$

$$F_{BC} = -10\sqrt{3737}\text{ N} \qquad F_{BC} = 611\text{ N C} \blacktriangleleft$$

$$\swarrow \Sigma F_z = 0: \quad -F_{AC} - \frac{59}{\sqrt{3737}}\left(-10\sqrt{3737}\text{ N}\right) - \frac{39}{89}\left(1335\text{ N}\right) = 0$$

$$F_{AC} = 5.00\text{ N T} \blacktriangleleft$$

Joint B:

$$\mathbf{F}_{AB} = F_{AB}\,\frac{-0.16\text{ m }\mathbf{j} + 0.12\text{ m }\mathbf{k}}{\sqrt{(0.16\text{ m})^2 + (0.12\text{ m})^2}} = F_{AB}\,\frac{-4\mathbf{j} + 3\mathbf{k}}{5}$$

$$\uparrow \Sigma F_y = 0: \quad -\frac{4}{5}\,F_{AB} + \frac{16}{\sqrt{3737}}\left(10\sqrt{3737}\text{ N}\right) - \frac{4}{21}\left(4935\text{ N}\right) = 0$$

$$F_{AB} = 975\text{ N C} \blacktriangleleft$$

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Chapter 6, Solution 37.

FBD Truss:

$\swarrow\ \Sigma F_z = 0: \qquad B_z + 987\text{ N} = 0$

$$\mathbf{B}_z = -987\text{ N}\,\mathbf{k}$$

$\circlearrowleft\ \Sigma M_x = 0: \qquad -(0.47\text{ m})\,C_y - (0.16\text{ m})(987\text{ N})$

$$+\,(0.08\text{ m})(940\text{ N}) = 0$$

$$\mathbf{C}_y = -176.0\text{ N}\,\mathbf{j}$$

Joint FBDs:

Joint D:

$$\mathbf{F}_{AD} = F_{AD}\,\frac{-0.8\text{ m}\,\mathbf{i} - 0.08\text{ m}\,\mathbf{k}}{\sqrt{(0.8\text{ m})^2 + (0.08\text{ m})^2}} = \frac{F_{AD}}{\sqrt{101}}\left(-10\mathbf{i} - \mathbf{k}\right)$$

$$\mathbf{F}_{BD} = F_{BD}\,\frac{-0.8\text{ m}\,\mathbf{i} - 0.16\text{ m}\,\mathbf{j} - 0.2\text{ m}\,\mathbf{k}}{\sqrt{(0.8\text{ m})^2 + (0.16\text{ m})^2 + (0.2\text{ m})^2}} = \frac{F_{BD}}{21}\left(-20\mathbf{i} + 4\mathbf{j} - 5\mathbf{k}\right)$$

$$\mathbf{F}_{CD} = F_{CD}\,\frac{-0.8\text{ m}\,\mathbf{i} + 0.39\text{ m}\,\mathbf{k}}{\sqrt{(0.8\text{ m})^2 + (0.39\text{ m})^2}} = \frac{F_{CD}}{89}\left(-80\mathbf{i} + 39\mathbf{k}\right)$$

$\uparrow\ \Sigma F_y = 0: \qquad \frac{4}{21}F_{BD} - 940\text{ N} = 0, \quad F_{BD} = 4935\text{ N}, \qquad F_{BD} = 4.94\text{ kN T} \blacktriangleleft$

$\searrow\ \Sigma F_x = 0: \qquad -\frac{10}{\sqrt{101}}F_{AD} - \frac{80}{89}F_{CD} - \frac{20}{21}(4935\text{ N}) = 0$

$\swarrow\ \Sigma F_z = 0: \qquad -\frac{1}{\sqrt{101}}F_{AD} + \frac{39}{89}F_{CD} - \frac{5}{21}(4935\text{ N}) + 987\text{ N} = 0$

Solving: $\qquad F_{CD} = -534\text{ N}, \qquad F_{CD} = 534\text{ N C} \blacktriangleleft$

$F_{AD} = -422\sqrt{101}\text{ N}, \qquad F_{AD} = 4.24\text{ kN C} \blacktriangleleft$

continued

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Joint C:

$$\mathbf{F}_{BC} = F_{BC}\,\frac{0.16\text{ m }\mathbf{j} - 0.59\text{ m }\mathbf{k}}{\sqrt{(0.16\text{ m})^2 + (0.59\text{ m})^2}} = \frac{F_{BC}}{\sqrt{3737}}\left(16\mathbf{j} - 59\mathbf{k}\right)$$

$$\uparrow \Sigma F_y = 0: \quad \frac{16}{\sqrt{3737}}\,F_{BC} - 176\text{ N} = 0, \quad F_{BC} = 11\sqrt{3737}\text{ N}$$

$$F_{BC} = 672\text{ N T} \blacktriangleleft$$

$$\swarrow \Sigma F_z = 0: \quad -F_{AC} - \frac{59}{\sqrt{3737}}\left(11\sqrt{3737}\text{ N}\right) + \frac{39}{89}\left(534\text{ N}\right) = 0$$

$$F_{AC} = -415\text{ N}, \qquad F_{AC} = 415\text{ N C} \blacktriangleleft$$

Joint B:

$$\mathbf{F}_{AB} = F_{AB}\,\frac{-0.16\text{ m }\mathbf{j} + 0.12\text{ m }\mathbf{k}}{\sqrt{(0.16\text{ m})^2 + (0.12\text{ m})^2}} = \frac{F_{AB}}{5}\left(-4\mathbf{j} + 3\mathbf{k}\right)$$

$$\uparrow \Sigma F_y = 0: \quad -\frac{4}{5}\,F_{AB} - \frac{16}{\sqrt{3737}}\left(11\sqrt{3737}\text{ N}\right) - \frac{4}{21}\left(4935\text{ N}\right) = 0$$

$$F_{AB} = -1395\text{ N}, \quad F_{AB} = 1.395\text{ kN C} \blacktriangleleft$$

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Chapter 6, Solution 38.

FBD Truss:

$$AB = AC = \sqrt{20}\ \text{ft}$$

$$AD = AE = 6\ \text{ft}$$

$$CD = 4\sqrt{2}\ \text{ft}$$

$\Sigma M_{BD} = 0$: $\quad (4\ \text{ft})(50\ \text{lb}) + (4\ \text{ft})(E_z) = 0$

$$\mathbf{E}_z = -(50\ \text{lb})\mathbf{k}$$

$\Sigma M_x = 0$: $\quad (4\ \text{ft})(300\ \text{lb}) + (4\ \text{ft})(-50\ \text{lb}) + (4\ \text{ft})(D_z) = 0$

$$\mathbf{D}_z = -(250\ \text{lb})\mathbf{k}$$

$\Sigma F_z = 0$: $\quad B_z - 50\ \text{lb} - 250\ \text{lb} = 0$

$$\mathbf{B}_z = (300\ \text{lb})\mathbf{k}$$

$\Sigma M_{Bz} = 0$: $\quad (2\ \text{ft})(300\ \text{lb}) - (4\ \text{ft})(C_y) = 0$

$$\mathbf{C}_y = (150\ \text{lb})\mathbf{j}$$

$\Sigma F_x = 0$: $\quad B_x + 50\ \text{lb} = 0 \qquad \mathbf{B}_x = -(50\ \text{lb})\mathbf{i}$

$\Sigma F_y = 0$: $\quad B_y + 150\ \text{lb} - 300\ \text{lb} = 0$

$$\mathbf{B}_y = (150\ \text{lb})\mathbf{j}$$

$$\mathbf{F}_{AE} = F_{AE}\frac{2\ \text{ft}\ \mathbf{i} - 4\ \text{ft}\ \mathbf{j} + 4\ \text{ft}\ \mathbf{k}}{\sqrt{(2\ \text{ft})^2 + (4\ \text{ft})^2 + (4\ \text{ft})^2}}$$

$$= \frac{\mathbf{F}_{AE}}{3}(2\mathbf{i} - 4\mathbf{j} + 4\mathbf{k})$$

Joint FBDs:

Joint E:

$\Sigma F_z = 0$: $\quad \frac{2}{3}F_{AE} - 50\ \text{lb} = 0, \qquad F_{AE} = 75.0\ \text{lb T}$ ◀

$\Sigma F_x = 0$: $\quad F_{DE} + \frac{1}{3}(75\ \text{lb}) = 0, \qquad F_{DE} = -25\ \text{lb}$

$$F_{DE} = 25.0\ \text{lb C}$$ ◀

$\Sigma F_y = 0$: $\quad -F_{CE} - \frac{2}{3}(75\ \text{lb}) = 0, \qquad F_{CE} = -50\ \text{lb}$

$$F_{CE} = 50.0\ \text{lb C}$$ ◀

continued

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Joint D:

$$\mathbf{F}_{AD} = F_{AD}\frac{-2\text{ ft }\mathbf{i} - 4\text{ ft }\mathbf{j} + 4\text{ ft }\mathbf{k}}{\sqrt{(2\text{ ft})^2 + (4\text{ ft})^2 + (4\text{ ft})^2}} = \frac{F_{AD}}{3}(-\mathbf{i} - 2\mathbf{j} + 2\mathbf{k})$$

$$\mathbf{F}_{CD} = F_{CD}\frac{-4\text{ ft }\mathbf{i} - 4\text{ ft }\mathbf{j}}{\sqrt{(4\text{ ft})^2 + (4\text{ ft})^2}} = \frac{F_{CD}}{\sqrt{2}}(-\mathbf{i} - \mathbf{j})$$

$\swarrow\ \Sigma F_z = 0$: $\quad \frac{2}{3}F_{AD} - 250\text{ lb} = 0,\ F_{AD} = 375\text{ lb},\quad F_{AD} = 375\text{ lb T}$ ◀

$\searrow\ \Sigma F_x = 0$: $\quad 25\text{ lb} - \frac{1}{\sqrt{2}}F_{CD} - \frac{1}{3}(375\text{ lb}) = 0,\quad F_{CD} = -100\sqrt{2}\text{ lb}$

$F_{CD} = 141.4\text{ lb C}$ ◀

$\uparrow\ \Sigma F_y = 0$: $\quad -F_{BD} - \frac{1}{\sqrt{2}}(-100\sqrt{2}\text{ lb}) - \frac{2}{3}(375\text{ lb}) = 0$

$F_{BD} = -150\text{ lb}\qquad F_{BD} = 150.0\text{ lb C}$ ◀

Joint C:

$$\mathbf{F}_{AC} = F_{AC}\frac{2\text{ ft }\mathbf{i} + 4\text{ ft }\mathbf{k}}{\sqrt{(2\text{ ft})^2 + (4\text{ ft})^2}} = \frac{F_{AC}}{\sqrt{5}}(\mathbf{i} + 2\mathbf{k})$$

$\swarrow\ \Sigma F_z = 0$: $\quad \frac{2}{\sqrt{5}}F_{AC} = 0,\qquad F_{AC} = 0$ ◀

$\searrow\ \Sigma F_x = 0$: $\quad F_{BC} - 100\text{ lb} = 0,\qquad F_{BC} = 100.0\text{ lb T}$ ◀

Joint B:

$$\mathbf{F}_{AB} = F_{AB}\frac{-2\text{ ft }\mathbf{i} + 4\text{ ft }\mathbf{k}}{\sqrt{(2\text{ ft})^2 + (4\text{ ft})^2}} = \frac{F_{AB}}{\sqrt{5}}(-\mathbf{i} + 2\mathbf{k})$$

$\swarrow\ \Sigma F_z = 0$: $\quad \frac{2}{\sqrt{5}}F_{AB} + 300\text{ lb} = 0$

$F_{AB} = -150\sqrt{5}\text{ lb},\qquad F_{AB} = 335\text{ lb C}$ ◀

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Chapter 6, Solution 39.

(*a*) **FBD Truss:**

$\Sigma M_y = 0$: $\quad B_x = 0 \qquad \mathbf{B}_x = 0$

$\Sigma M_x = 0$: $\quad (1.7\text{ m})\,A_z + (0.6\text{ m})(1700\text{ N}) = 0, \qquad A_z = -600\text{ N}$

$\Sigma M_z = 0$: $\quad -(1.7\text{ m})\,A_x - (1.125\text{ m})(1700\text{ N}) = 0 \qquad A_x = -1125\text{ N}$

$\Sigma F_x = 0$: $\quad C_x - 1125\text{ N} = 0 \qquad C_x = 1125\text{ N}$

$\Sigma F_y = 0$: $\quad C_y - 1700\text{ N} = 0 \qquad C_y = 1700\text{ N}$

$\Sigma F_z = 0$: $\quad B_z - 600\text{ N} = 0 \qquad B_z = 600\text{ N}$

so $\quad \mathbf{A} = -(1125\text{ N})\mathbf{i} - (600\text{ N})\mathbf{k}$

$\mathbf{B} = (600\text{ N})\mathbf{k}$

$\mathbf{C} = (1125\text{ N})\mathbf{i} + (1700\text{ N})\mathbf{j}$

(*b*)

Find zero force members: by inspection of joint B, $\quad F_{AB} = 0$ ◀

by inspection of joint D, $\quad F_{AD} = 0$ ◀

by inspection of joint C, $\quad F_{BC} = 0$ ◀

Joint FBDs:

Joint E:

$$\mathbf{F}_{AE} = F_{AE}\,\frac{-1.125\text{ m}\,\mathbf{i} + 1.7\text{ m}\,\mathbf{j} - 0.6\text{ m}\,\mathbf{k}}{\sqrt{(1.125\text{ m})^2 + (1.7\text{ m})^2 + (0.6\text{ m})^2}} = \frac{F_{AE}}{2.125}\left(-1.125\mathbf{i} + 1.7\mathbf{j} - 0.6\mathbf{k}\right)$$

$\Sigma F_y = 0$: $\quad \dfrac{1.7}{2.125}F_{AE} - 1700\text{ N} = 0, \quad F_{AE} = 2125\text{ N}$

$F_{AE} = 2.13\text{ kN T}$ ◀

$\Sigma F_x = 0$: $\quad -F_{BE} - \dfrac{1.125}{2.125}(2125\text{ N}), \quad F_{BE} = -1125\text{ N}$

$F_{BE} = 1.125\text{ kN C}$ ◀

$\Sigma F_z = 0$: $\quad -F_{DE} - \dfrac{0.6}{2.125}(2125\text{ N}) = 0, \quad F_{DE} = -600\text{ N}$

$F_{DE} = 600\text{ N C}$ ◀

continued

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Joint D:

$$\mathbf{F}_{BD} = F_{BD}\,\frac{-1.125\text{ m }\mathbf{i} + 0.6\text{ m }\mathbf{k}}{\sqrt{(1.125\text{ m})^2 + (0.6\text{ m})^2}} = \frac{F_{BD}}{1.275}\left(-1.125\mathbf{i} + 0.6\mathbf{k}\right)$$

$\swarrow\ \Sigma F_z = 0$: $\quad 600\text{ N} - \dfrac{0.6}{1.275}F_{BD} = 0, \quad F_{BD} = 1275\text{ N}$

$F_{BD} = 1.275\text{ kN T}$ ◀

$\searrow\ \Sigma F_x = 0$: $\quad -F_{CD} - \dfrac{1.125}{1.275}(1275\text{ N}) = 0, \quad F_{CD} = -1125\text{ N}$

$F_{CD} = 1.125\text{ kN C}$ ◀

Joint C:

By inspection: $\quad F_{AC} = -1700\text{ N}$ $\qquad F_{AC} = 1.700\text{ kN C}$ ◀

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Chapter 6, Solution 40.

(*a*) To check for simple truss, start with *ABDE* and add three members at a time which meet at a single new joint, successively adding joints *G*, *F*, *H* and *C*.

∴ This is a simple truss ◀

There are six reaction force components, A_x, A_y, A_z, B_y, B_z, and G_y, no two of which are colinear, so all can be determined with the six equilibrium equations. Motion is prevented by the constraints.

∴ Truss is completely constrained, and statically determinate. ◀

(*b*) **FBD Truss:**

$\Sigma M_{AB} = 0$: $(9.60 \text{ ft})\, G_y + (10.08 \text{ ft})(240 \text{ lb}) = 0$

$G_y = -252 \text{ lb}$ $\quad \mathbf{G}_y = -252 \text{ lb } \mathbf{j}$

$\Sigma M_z = 0$: $(11.00 \text{ ft})(B_y - 252 \text{ lb}) - (10.08 \text{ ft})(275 \text{ lb}) = 0$

$\mathbf{B}_y = 504 \text{ lb } \mathbf{j}$

$\Sigma F_x = 0$: $-A_x + 275 \text{ lb} = 0,$ $\quad \mathbf{A}_x = -275 \text{ lb } \mathbf{i}$

$\Sigma M_y = 0$: $-(9.6 \text{ ft})(275 \text{ lb}) - (11.0 \text{ ft})(B_z) = 0$

$B_z = -240 \text{ lb},$ $\quad \mathbf{B}_z = -240 \text{ lb } \mathbf{k}$

$\Sigma F_y = 0$: $-A_y + 504 \text{ lb} - 252 \text{ lb} = 0,$ $\quad \mathbf{A}_y = -252 \text{ lb } \mathbf{j}$

$\Sigma F_z = 0$: $A_z - 240 \text{ lb} + 240 \text{ lb} = 0$ $\quad \mathbf{A}_z = 0$

Determine zero force members:

By inspection of joint *C*: $F_{BC} = F_{CD} = F_{GC} = 0$

By inspection of joint *F*: $F_{BF} = F_{EF} = F_{FG} = 0$

By inspection of joint *A*: with $A_z = 0$, $F_{AD} = 0$

By inspection of joint *H*: $F_{DH} = 0$

And finally, considering joint *D* knowing that $F_{AD} = F_{CD} = F_{DH} = 0$, and recognizing that the three remaining members are not co-planar, they must also carry zero load, $F_{BD} = F_{DE} = F_{GH} = 0$.

The only load bearing members are thus *AB*, *AE*, *BE*, *BG*, *EG*, *EH*, *GH*.

continued

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Joint FBDs

Joint A:

Joint E:

By inspection: $F_{AB} = 275$ lb T, $F_{AE} = 252$ lb T ◀

from above: $F_{DE} = 0$ ◀

$F_{EF} = 0$ ◀

By inspection of joint H $F_{EH} = 240$ lb C ◀

$\uparrow \Sigma F_y = 0$: $-252 \text{ lb} - \dfrac{10.08}{1492} F_{BE} = 0$

$F_{BE} = -373$ lb, $F_{BE} = 373$ lb C ◀

$\swarrow \Sigma F_z = 0$: $240 \text{ lb} - \dfrac{9.6}{14.6} F_{EG} = 0$

$F_{EG} = 365$ lb T ◀

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Chapter 6, Solution 41.

(*a*) To check for simple truss, start with *ABDE* and add three members at a time which meet at a single new joint, successively adding joints *G*, *F*, *H* and *C*.

∴ This is a simple truss ◀

There are six reaction force components, A_x, A_y, A_z, B_y, B_z, and G_y, no two of which are colinear, so all can be determined with the six equilibrium equations. Motion is prevented by the constraints.

∴ Truss is completely constrained, and statically determinate. ◀

(*b*) **FBD Truss:**

$\Sigma M_{AB} = 0$: $(9.60 \text{ ft})\, G_y + (10.08 \text{ ft})(240 \text{ lb}) = 0$

$G_y = -252$ lb, $\mathbf{G}_y = -252 \text{ lb } \mathbf{j}$

$\Sigma M_z = 0$: $(11.00 \text{ ft})(B_y - 252 \text{ lb}) - (10.08 \text{ ft})(275 \text{ lb}) = 0$

$\mathbf{B}_y = 504 \text{ lb } \mathbf{j}$

$\Sigma F_x = 0$: $-A_x + 275 \text{ lb} = 0$, $\boldsymbol{A}_x = -275 \text{ lb } \mathbf{i}$

$\Sigma M_y = 0$: $-(9.6 \text{ ft})(275 \text{ lb}) - (11.0 \text{ ft})(B_z) = 0$

$B_z = -240$ lb, $\mathbf{B}_z = -240 \text{ lb } \mathbf{k}$

$\Sigma F_y = 0$: $-A_y + 504 \text{ lb} - 252 \text{ lb} = 0$, $\mathbf{A}_y = -252 \text{ lb } \mathbf{j}$

$\Sigma F_z = 0$: $A_z - 240 \text{ lb} + 240 \text{ lb} = 0$ $\mathbf{A}_z = 0$

Determine zero force members:

By inspection of joint *C*: $F_{BC} = F_{CD} = F_{GC} = 0$

By inspection of joint *F*: $F_{BF} = F_{EF} = F_{FG} = 0$

By inspection of joint *A*: with $A_z = 0$, $F_{AD} = 0$

By inspection of joint *H*: $F_{DH} = 0$

And finally, considering joint *D* knowing that $F_{AD} = F_{CD} = F_{DH} = 0$, and recognizing that the three remaining members are not co-planar, they must also carry zero load, $F_{BD} = F_{DE} = F_{GH} = 0$.

The only load bearing members are thus *AB*, *AE*, *BE*, *BG*, *EG*, *EH*, *GH*.

continued

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Now, by inspection of joint H, $F_{GH} = 275$ lb C ◀

from above, $F_{CG} = 0$ ◀

$F_{DG} = 0$ ◀

$F_{FG} = 0$ ◀

FBD Joint *G*:

$$\mathbf{F}_{BG} = F_{BG}\,\frac{-10.08\mathbf{j} + 9.6\mathbf{k}}{13.92}$$

$$\mathbf{F}_{EG} = F_{EG}\,\frac{-1\mathbf{i} + 9.6\mathbf{k}}{14.6}$$

$\searrow\ \Sigma F_x = 0$: $\quad 275\text{ lb} - \dfrac{11}{14.6}F_{EG} = 0,$ $\qquad F_{EG} = 365$ lb T ◀

$\uparrow\ \Sigma F_y = 0$: $\quad -\dfrac{10.08}{13.92}F_{BG} - 252\text{ lb} = 0,$ $\qquad F_{BG} = -348$ lb

$F_{BG} = 348$ lb C ◀

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Chapter 6, Solution 42.

FBD Truss:

$\rightarrow \Sigma F_x = 0: \qquad \mathbf{K}_x = 0$

$\circlearrowleft \Sigma M_A = 0: \quad 6a\left(K_y - 125 \text{ lb}\right) - 5a\left(250 \text{ lb}\right)$

$- 4a\left(250 \text{ lb}\right) - 3a\left(375 \text{ lb}\right)$

$-2a\left(500 \text{ lb}\right) - a\left(500 \text{ lb}\right) = 0$

$\mathbf{K}_y = 937.5 \text{ lb} \uparrow$

$\uparrow \Sigma F_y = 0: \quad A_y - 3\left(250 \text{ lb}\right) - 2\left(500 \text{ lb}\right)$

$-375 \text{ lb} - 125 \text{ lb} + 937.5 \text{ lb} = 0$

$\mathbf{A}_y = 1312.5 \text{ lb} \uparrow$

FBD Section *ABEC*:

$\circlearrowleft \Sigma M_E = 0: \quad \left(2 \text{ ft}\right) F_{CF} + \left(4 \text{ ft}\right)\left(500 \text{ lb}\right)$

$+ \left(8 \text{ ft}\right)\left(250 \text{ lb} - 1312.5 \text{ lb}\right) = 0$

$F_{CF} = 3250 \text{ lb}, \qquad F_{CF} = 3.25 \text{ kips T} \blacktriangleleft$

$\uparrow \Sigma F_y = 0: \quad 1312.5 \text{ lb} - 250 \text{ lb} - 2\left(500 \text{ lb}\right) - \dfrac{1}{\sqrt{5}} F_{EF} = 0$

$F_{EF} = 62.5\sqrt{5} \text{ lb}, \qquad F_{EF} = 139.8 \text{ lb T} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \quad 3250 \text{ lb} + \dfrac{2}{\sqrt{5}}\left(62.5\sqrt{5} \text{ lb}\right) - F_{EG} = 0$

$F_{EG} = 3375 \text{ lb}, \qquad F_{EG} = 3.38 \text{ kips C} \blacktriangleleft$

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Chapter 6, Solution 43.

FBD Truss:

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

$\circlearrowleft \Sigma M_A = 0: \quad 6a\left(K_y - 125 \text{ lb}\right) - 5a\left(250 \text{ lb}\right)$

$- 4a\left(250 \text{ lb}\right) - 3a\left(375 \text{ lb}\right)$

$- 2a\left(500 \text{ lb}\right) - a\left(500 \text{ lb}\right) = 0$

$\mathbf{K}_y = 937.5 \text{ lb} \uparrow$

$\uparrow \Sigma F_y = 0: \quad A_y - 3\left(250 \text{ lb}\right) - 2\left(500 \text{ lb}\right)$

$- 375 \text{ lb} - 125 \text{ lb} + 937.5 \text{ lb} = 0$

$\mathbf{A}_y = 1312.5 \text{ lb} \uparrow$

FBD Section *IJLK*:

$\circlearrowleft \Sigma M_z = 0: \quad \left(4 \text{ ft}\right)\left(937.5 \text{ lb} - 125 \text{ lb}\right) - \left(2 \text{ ft}\right) F_{HJ} = 0$

$F_{HJ} = 1625 \text{ lb}, \qquad F_{HJ} = 1.625 \text{ kips C} \blacktriangleleft$

$\uparrow \Sigma F_y = 0: \quad 937.5 \text{ lb} - 125 \text{ lb} - 250 \text{ lb} - \dfrac{1}{\sqrt{5}} F_{HI} = 0$

$F_{HI} = 562.5\sqrt{5} \text{ lbs}, \qquad F_{HI} = 1.258 \text{ kips C} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \quad 1.625 \text{ kips} + \dfrac{2}{\sqrt{5}}\left(0.5625\sqrt{5} \text{ kips}\right) - F_{FI} = 0$

$F_{FI} = 2.75 \text{ kips T} \blacktriangleleft$

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Chapter 6, Solution 44.

FBD Truss:

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

By load symmetry:

$$\mathbf{A}_y = \mathbf{L}_y = 840 \text{ N} \uparrow$$

$$\circlearrowleft \Sigma M_E = 0: \quad \frac{2}{3}(1.75 \text{ m})\frac{24}{25}F_{BD} + (2 \text{ m})(240 \text{ N}) - (4 \text{ m})(840 \text{ N} - 120 \text{ N}) = 0$$

$$F_{BD} = \frac{15000}{7} \text{ N}, \qquad F_{BD} = 2.14 \text{ kN C} \blacktriangleleft$$

FBD Section *ABC*:

$$\circlearrowleft \Sigma M_B = 0: \quad \left(\frac{1.75}{3} \text{ m}\right)F_{CE} - (2 \text{ m})(840 \text{ N} - 120 \text{ N}) = 0$$

$$F_{CE} = \frac{17280}{7} \text{ N}, \qquad F_{CE} = 2.47 \text{ kN T} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_A = 0: \quad (4 \text{ m})\left(\frac{7}{25}F_{BE}\right) - (2 \text{ m})(240 \text{ N}) = 0$$

$$F_{BE} = \frac{3000}{7} \text{ N}, \qquad F_{BE} = 429 \text{ N C} \blacktriangleleft$$

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Chapter 6, Solution 45.

FBD Truss:

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

By load symmetry

$$\mathbf{A}_y = \mathbf{L}_y = 840 \text{ N} \uparrow$$

slope: $GI = \dfrac{0.4}{3} = \dfrac{2}{15}$

$$IK = \frac{\frac{3.5}{3}}{4} = \frac{7}{24}$$

$$IJ = \frac{2.3}{3} = \frac{23}{30}$$

FBD Section *JKL*:

Resolve F_{IK} and F_{GJ} at L

$$\circlearrowleft \Sigma M_J = 0: \quad (3 \text{ m})\left(\frac{7}{25} F_{IK}\right) - (0.4 \text{ m})\left(\frac{24}{25} F_{IK}\right)$$

$$+ (3 \text{ m})(840 \text{ N} - 120 \text{ N}) - (1 \text{ m})(240 \text{ N}) = 0$$

$$F_{IK} = 4210.53 \text{ N}, \qquad F_{IK} = 4.21 \text{ kN C} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_I = 0: \quad (4 \text{ m})\left(\frac{2}{\sqrt{229}} F_{GJ}\right) - \left(\frac{3.5}{3} \text{ m}\right)\left(\frac{15}{\sqrt{229}} F_{GJ}\right)$$

$$+ (4 \text{ m})(840 \text{ N} - 120 \text{ N}) - (2 \text{ m})(240 \text{ N}) = 0$$

$$F_{GJ} = 3823.0 \text{ N}, \qquad F_{GJ} = 3.82 \text{ kN T} \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad \frac{7}{25}(4210.5 \text{ N}) - \frac{15}{\sqrt{229}}(3823.0 \text{ N}) - \frac{30}{\sqrt{1429}} F_{IJ} = 0$$

$$F_{IJ} = 318 \text{ N T} \blacktriangleleft$$

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Chapter 6, Solution 46.

FBD Truss:

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

By symmetry, $\qquad \mathbf{A}_y = \mathbf{M}_y = 8.5 \text{ kN} \uparrow$

FBD Section *ABDC*:

$$\circlearrowleft \Sigma M_D = 0: \quad (1 \text{ m})(1.5 \text{ kN} - 8.5 \text{ kN}) + (0.5 \text{ m})\frac{40}{41}F_{CE} = 0$$

$$F_{CE} = 14.35 \text{ kN T} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_E = 0: \quad (1 \text{ m})(1.5 \text{ kN}) + (2 \text{ m})(1.5 \text{ kN} - 8.5 \text{ kN})$$

$$+ (0.5 \text{ m})\frac{40}{41}F_{DF} = 0, \qquad F_{DF} = 25.625 \text{ kN}$$

$$F_{DF} = 25.6 \text{ kN C} \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad \frac{40}{41}(14.35 \text{ kN} - 25.625 \text{ kN}) + \frac{40}{\sqrt{1721}}F_{DE} = 0$$

$$F_{DE} = 11.4084 \text{ kN}, \qquad F_{DE} = 11.41 \text{ kN T} \blacktriangleleft$$

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Chapter 6, Solution 47.

FBD Truss:

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

By symmetry, $\mathbf{A}_y = \mathbf{M}_y = 8.5 \text{ kN} \uparrow$

FBD Section *IMNJ*:

$$\circlearrowleft \Sigma M_J = 0: \quad (2 \text{ m})(8.5 \text{ kN} - 1.5 \text{ kN}) - (1 \text{ m})(1.5 \text{ kN})$$

$$-(0.5 \text{ m})\frac{40}{41} F_{GI} = 0$$

$$F_{GI} = 25.625 \text{ kN}, \qquad F_{GI} = 25.6 \text{ kN T} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_G = 0: \quad (3 \text{ m})(8.5 \text{ kN} - 1.5 \text{ kN}) - (2 \text{ m})(1.5 \text{ kN})$$

$$-(1 \text{ m})(3 \text{ kN}) - (0.5 \text{ m})\frac{40}{41} F_{HJ} = 0$$

$$F_{HJ} = 30.75 \text{ kN}, \qquad F_{HJ} = 30.8 \text{ kN C} \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad \frac{40}{41}(30.75 \text{ kN} - 25.625 \text{ kN}) - \frac{40}{\sqrt{2441}} F_{GJ} = 0$$

$$F_{GJ} = 6.18 \text{ kN T} \blacktriangleleft$$

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Chapter 6, Solution 48.

FBD Truss:

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

By symmetry: $\mathbf{A}_y = \mathbf{L}_y = 6 \text{ kN} \uparrow$

FBD Section:

Notes:

$$y_F = \frac{15}{6} \text{ m}$$

$$y_D = \frac{2}{3} \cdot \frac{5}{2} = \frac{5}{3} \text{ m}$$

$$y_E = \frac{2}{3} \cdot 1 = \frac{2}{3} \text{ m}$$

$$y_F - y_D = \frac{5}{6} \text{ m}$$

$$y_G = 1 \text{ m}$$

$$y_D - y_G = \frac{2}{3} \text{ m}$$

continued

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$$\circlearrowleft \Sigma M_D = 0: (1\text{ m})\frac{6}{\sqrt{37}}F_{EG} + (2\text{ m})(2\text{ kN}) + (4\text{ m})(1\text{ kN} - 6\text{ kN}) = 0$$

$$F_{EG} = \frac{8}{3}\sqrt{37}\text{ kN} \qquad F_{EG} = 16.22\text{ kN T} \blacktriangleleft$$

$$\circlearrowright \Sigma M_A = 0: (2\text{ m})(2\text{ kN}) + (4\text{ m})(2\text{ kN}) - (6\text{ m})\left(\frac{1}{\sqrt{10}}F_{DG}\right) - (1\text{ m})\left(\frac{3}{\sqrt{10}}F_{DG}\right) = 0$$

$$F_{DG} = \frac{4}{3}\sqrt{10}\text{ kN} \qquad F_{DG} = 4.22\text{ kN C} \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \frac{6}{\sqrt{37}}F_{EG} - \frac{3}{\sqrt{10}}F_{DG} - \frac{12}{13}F_{DF} = 0 \qquad 16 - 4 - \frac{12}{13}F_{DF} = 0$$

$$F_{DF} = 13\text{ kN} \qquad F_{DF} = 13.00\text{ kN C} \blacktriangleleft$$

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Chapter 6, Solution 49.

FBD Truss:

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

By symmetry: $\mathbf{A}_y = \mathbf{L}_y = 6 \text{ kN} \uparrow$

FBD Section:

Notes: $y_I = \dfrac{2}{3}$ m

$$y_H = \frac{2}{3} \cdot \frac{5}{2} = \frac{5}{3} \text{ m}$$

so $y_H - y_I = 1$ m

continued

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$$\circlearrowleft \Sigma M_I = 0: \quad (4\text{ m})(6\text{ kN} - 1\text{ kN}) - (2\text{ m})(2\text{ kN}) - (1\text{ m})\left(\frac{12}{13}F_{HJ}\right) = 0$$

$$F_{HJ} = \frac{52}{3}\text{ kN} \qquad F_{HJ} = 17.33\text{ kN C} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_H = 0: \quad (4\text{ m})(6\text{ kN} - 1\text{ kN}) - (2\text{ m})(2\text{ kN}) - (1\text{ m})\left(\frac{6}{\sqrt{37}}F_{GI}\right) = 0$$

$$F_{GI} = \frac{8}{3}\sqrt{37}\text{ kN} \qquad F_{GI} = 16.22\text{ kN T} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_L = 0: \quad (2\text{ m})(2\text{ kN}) - (4\text{ m})F_{HI} = 0 \qquad F_{HI} = 1.000\text{ kN T} \blacktriangleleft$$

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Chapter 6, Solution 50.

FBD Truss:

Distance between loads = 1.5 m

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

By symmetry, $\qquad \mathbf{A}_y = \mathbf{K}_y = 18 \text{ kN} \uparrow$

FBD Section *ABC*:

$\circlearrowleft \Sigma M_D = 0: \quad (1.5 \text{ m})F_{CE} + (1.5 \text{ m})(6 \text{ kN}) - (3 \text{ m})(18 \text{ kN} - 3 \text{ kN}) = 0$

$F_{CE} = 22.5 \text{ kN T} \blacktriangleleft$

$\circlearrowleft \Sigma M_A = 0: \quad (1.8 \text{ m})\frac{4}{5}F_{CD} - (1.5 \text{ m})(6 \text{ kN}) = 0$

$F_{CD} = 6.25 \text{ kN T} \blacktriangleleft$

$\uparrow \Sigma F_y = 0: \quad 18 \text{ kN} - 3 \text{ kN} - 6 \text{ kN} - \frac{8}{17}F_{BD} + \frac{4}{5}(6.25 \text{ kN}) = 0$

$F_{BD} = 29.8 \text{ kN C} \blacktriangleleft$

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Chapter 6, Solution 51.

FBD Truss:

Distance between loads = 1.5 m

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

By symmetry, $\mathbf{A}_y = \mathbf{K}_y = 18 \text{ kN} \uparrow$

FBD section *GHK*:

$$\circlearrowleft \Sigma M_F = 0: \quad (4.5 \text{ m})(18 \text{ kN} - 3 \text{ kN}) - (3 \text{ m})(6 \text{ kN})$$

$$- (1.5 \text{ m})(6 \text{ kN}) - (2.4 \text{ m}) F_{EG} = 0$$

$$F_{EG} = 16.875 \text{ kN}, \qquad F_{EG} = 16.88 \text{ kN T} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_K = 0: \quad (1.5 \text{ m})(6 \text{ kN}) + (3 \text{ m})(6 \text{ kN}) - (3.6 \text{ m})\left(\frac{8}{\sqrt{73}} F_{FG}\right) = 0$$

$$F_{FG} = 8.0100 \text{ kN}, \qquad F_{FG} = 8.01 \text{ kN T} \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad \frac{15}{17} F_{FH} - \frac{3}{\sqrt{73}}(8.0100 \text{ kN}) - 16.875 \text{ kN} = 0$$

$$F_{FH} = 22.3 \text{ kN C} \blacktriangleleft$$

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Chapter 6, Solution 52.

FBD Truss:

$$\rightarrow \Sigma F_X = 0: \quad \mathbf{A}_x + 4 \text{ kips} - 4 \text{ kips} = 0$$

$$\mathbf{A}_x = 0$$

By symmetry, $\mathbf{A}_y = \mathbf{N}_y = 0$

FBD Section *ABDC*:

$$\circlearrowleft \Sigma M_D = 0: \quad (18 \text{ ft})(4 \text{ kips}) - (9 \text{ ft})\frac{4}{5}F_{CE} = 0$$

$$F_{CE} = 10.00 \text{ kips C} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_E = 0: \quad (18 \text{ ft})(4 \text{ kips}) - (12 \text{ ft})\frac{3}{5}F_{DF} = 0$$

$$F_{DF} = 10.00 \text{ kips C}$$

$$\rightarrow \Sigma F_x = 0: \quad 4 \text{ kips} + \frac{4}{5}(10 \text{ kips} - 10 \text{ kips}) - F_{DE} = 0$$

$$F_{DE} = 4.00 \text{ kips C} \blacktriangleleft$$

FBD Joint *E*:

$$\nwarrow \Sigma F_y = 0: \quad \frac{4}{5}F_{EF} - \frac{3}{5}(4 \text{ kips}) = 0$$

$$F_{EF} = 3.00 \text{ kips T} \blacktriangleleft$$

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Chapter 6, Solution 53.

FBD Truss:

$\rightarrow \Sigma F_x = 0: \quad \mathbf{A}_x + 4 \text{ kips} - 4 \text{ kips} = 0$

$\mathbf{A}_x = 0$

By symmetry, $\quad \mathbf{A}_y = \mathbf{N}_y = 0$

FBD Section *IJNM*:

$\circlearrowleft \Sigma M_G = 0: \quad -(27 \text{ ft})(4 \text{ kips}) + (9 \text{ ft})\frac{4}{5}F_{HI} = 0$

$F_{HI} = 15.00 \text{ kips T} \blacktriangleleft$

$\circlearrowleft \Sigma M_N = 0: \quad (9 \text{ ft})\frac{4}{5}(15 \text{ kips}) - (27 \text{ ft})F_{GI} = 0$

$F_{GI} = 4.00 \text{ kips C} \blacktriangleleft$

FBD Joint *I*:

$\nearrow \Sigma F_x = 0: \quad \frac{3}{5}(4 \text{ kips}) - \frac{4}{5}F_{IJ} = 0$

$F_{IJ} = 3.00 \text{ kips T} \blacktriangleleft$

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Chapter 6, Solution 54.

FBD Truss:

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

By symmetry, $\quad \mathbf{A}_y = \mathbf{M}_y = 7.5 \text{ kips} \uparrow$

FBD Section *IJNM*:

$\circlearrowleft \Sigma M_J = 0: \quad (9 \text{ ft})(7.5 \text{ kips} - 0.5 \text{ kips}) - (4.5 \text{ ft})(1 \text{ kip})$

$$-(5.25 \text{ ft})\left(\frac{4}{\sqrt{17}} F_{GI}\right) = 0, \qquad F_{GI} = 11.4858 \text{ kips.}$$

$F_{GI} = 11.49 \text{ kips T} \blacktriangleleft$

$\circlearrowleft \Sigma M_G = 0: \quad (12 \text{ ft})(7.5 \text{ kip} - 0.5 \text{ kips}) - (7.5 \text{ ft})(1 \text{ kip})$

$$-(3 \text{ ft})(3 \text{ kips}) + (4.5 \text{ ft}) F_{HJ} = 0$$

$F_{HJ} = 15 \text{ kips C}$

By inspection of joint H, $\quad F_{FH} = 15.00 \text{ kips C} \blacktriangleleft$

$\uparrow \Sigma F_y = 0: \quad \frac{1}{\sqrt{17}}(11.4858 \text{ kips}) + 7.5 \text{ kips} - 4.5 \text{ kips}$

$$-\frac{3}{\sqrt{13}} F_{GJ} = 0 \qquad F_{GJ} = 6.95 \text{ kips T} \blacktriangleleft$$

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Chapter 6, Solution 55.

FBD Truss:

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

By symmetry: $\quad \mathbf{A}_y = \mathbf{v}_y = 4.5 \text{ kips} \uparrow$

FBD Joint *K*:

$\rightarrow \Sigma F_x = 0: \quad \frac{1}{\sqrt{2}}\left(F_{IK} - F_{KN}\right) = 0 \qquad F_{IK} = F_{KN}$

$\uparrow \Sigma F_y = 0: \quad 2\left(\frac{1}{\sqrt{2}} F_{IK}\right) - 1 \text{ kip} = 0 \qquad F_{IK} = \frac{\sqrt{2}}{2} \text{ kip}$

so $\quad F_{IK} = 0.707 \text{ kip C} \blacktriangleleft$

FBD Section *ABEIJ*:

$\uparrow \Sigma F_y = 0: \quad 4.5 \text{ kips} - 1 \text{ kip} - 2(1.5 \text{ kips}) - \frac{1}{\sqrt{2}}\frac{\sqrt{2}}{2}\text{kips} + \frac{\sqrt{3}}{2} F_{JL} = 0,$

$F_{JL} = 0 \blacktriangleleft$

$\circlearrowleft \Sigma M_I = 0: \quad (3 \text{ ft})(1.5 \text{ kips}) + (6 \text{ ft})(1 \text{ kip} - 4.5 \text{ kips})$

$+\frac{\sqrt{3}}{2}(3 \text{ ft})(F_{JM}) = 0 \qquad F_{JM} = \frac{11}{\sqrt{3}} \text{ kips}$

$F_{JM} = 6.35 \text{ kips T} \blacktriangleleft$

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Chapter 6, Solution 56.

FBD Truss:

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

$\circlearrowleft \Sigma M_N = 0: \quad (4.8\text{ ft})(300\text{ lb}) + (7.2\text{ ft})(750\text{ lb})$

$+ (11.52\text{ ft})(750\text{ lb}) + (16.8\text{ ft})(1950\text{ lb})$

$+ (19.2\text{ ft})(900\text{ lb}) + (26.4\text{ ft})(1050\text{ lb})$

$+ (33.6\text{ ft})(150\text{ lb} - A_y) = 0$

$\mathbf{A}_y = 2925\text{ lb}\uparrow$

$\uparrow \Sigma F_y = 0: \quad 2925\text{ lb} - 2(150\text{ lb}) - 2(750\text{ lb}) - 1050\text{ lb}$

$- 900\text{ lb} - 1950\text{ lb} - 300\text{ lb} + N_y = 0$

$\mathbf{N}_y = 3075\text{ lb}$

FBD Section *ABC*:

$\circlearrowleft \Sigma M_B = 0: \quad (3.6\text{ ft})F_{CE} - (7.2\text{ ft})(2925\text{ lb} - 150\text{ lb}) = 0$

$F_{CE} = 5550\text{ lb}, \qquad F_{CE} = 5.55\text{ kips T} \blacktriangleleft$

$\circlearrowleft \Sigma M_A = 0: \quad (7.2\text{ ft})\frac{1}{\sqrt{5}}F_{BE} + (3.6\text{ ft})\frac{2}{\sqrt{5}}F_{BE} - (7.2\text{ ft})(1050\text{ lb}) = 0$

$F_{BE} = 525\sqrt{5}\text{ lb}, \qquad F_{BE} = 1.174\text{ kips C} \blacktriangleleft$

$\Sigma F_x = 0: \quad \frac{2}{\sqrt{5}}\left(F_{BD} - 525\sqrt{5}\text{ lb}\right) + 5550\text{ lb} = 0$

$F_{BD} = -5031.2\text{ lb}$

By inspection of joint D, $F_{DF} = F_{BD}$, so $\qquad F_{DF} = 5.03\text{ kips C} \blacktriangleleft$

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Chapter 6, Solution 57.

FBD Truss:

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

$\circlearrowleft \Sigma M_N = 0: \quad (4.8\text{ ft})(300\text{ lb}) + (7.2\text{ ft})(750\text{ lb})$
$+ (11.52\text{ ft})(750\text{ lb}) + (16.8\text{ ft})(1950\text{ lb})$
$+ (19.2\text{ ft})(900\text{ lb}) + (26.4\text{ ft})(1050\text{ lb})$
$+ (33.6\text{ ft})(150\text{ lb} - A_y) = 0$

$\mathbf{A}_y = 2925\text{ lb} \uparrow$

$\uparrow \Sigma F_y = 0: \quad 2925\text{ lb} - 2(150\text{ lb}) - 2(750\text{ lb}) - 1050\text{ lb}$
$- 900\text{ lb} - 1950\text{ lb} - 300\text{ lb} + N_y = 0$

$\mathbf{N}_y = 3075\text{ lb}$

FBD Section *KJMN*:

$\circlearrowleft \Sigma M_J = 0: \quad (7.2\text{ ft})(3075\text{ lb} - 150\text{ lb}) - (2.4\text{ ft})(300\text{ lb})$
$-(1.8\text{ ft})F_{IK} = 0$

$F_{IK} = 11300\text{ lb}, \qquad F_{IK} = 11.30\text{ kips T}$

$\circlearrowleft \Sigma M_I = 0: \quad (11.52\text{ ft})(3075\text{ lb} - 150\text{ lb}) - (6.72\text{ ft})(300\text{ lb})$
$-(4.32\text{ ft})(750\text{ lb}) + (3.96\text{ ft})\left(\frac{2}{\sqrt{5}}F_{HJ}\right) = 0$

$F_{HJ} = -3590.5\sqrt{5}\text{ lb}, \qquad F_{HJ} = 8.03\text{ kips C} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: \quad -\frac{2}{\sqrt{5}}\left(-3590.9\sqrt{5}\text{ lb}\right) - \frac{12}{13}F_{IJ} - 11300\text{ lb} = 0$

$F_{IJ} = -4461.4\text{ lb}, \qquad F_{IJ} = 4.46\text{ kip C} \blacktriangleleft$

FBD Joint *I*:

$\Sigma F_x = 0: \quad 11300\text{ lb} - \frac{12}{13}(4461.4\text{ lb}) - F_{GI} = 0$

$F_{GI} = 7181.8\text{ lb}, \qquad F_{GI} = 7.18\text{ kips T} \blacktriangleleft$

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Chapter 6, Solution 58.

FBD Truss:

Notes: $\alpha = 20°$, $\beta = 40°$, $\gamma = 60°$, $\delta = 80°$, $\phi = 22.5°$, $\theta = 45°$, $\psi = 60°$

outer members AC, CE, etc. are each 1.0 m
radial members AB, CD, etc. are each 0.4 m
By symmetry , $A_y = B_y = 2.6$ kN ↑
$\Sigma F_x = 0$: $\mathbf{A}_x = 0$

FBD Section *ABDC*:

$$\circlearrowleft \Sigma M_F = 0: \quad (\text{resolve } F_{CE} \text{ at } E)$$

$$\left[\frac{1}{\sqrt{2}}(0.4\text{ m})\right]F_{CE}\sin 40° + \left[\frac{1}{\sqrt{2}}(0.4\text{ m})\right](F_{CE}\cos 40°)$$

$$+\left[(1\text{ m})\sin 40° + \frac{1}{\sqrt{2}}(0.4\text{ m})\right](0.4\text{ kN})$$

$$-\left[(1\text{ m})\sin 20° + (1\text{ m})\sin 40° + \frac{1}{\sqrt{2}}(0.4\text{ m})\right](2.6\text{ kN}) = 0,$$

$F_{CE} = 7.3420$ kN, $\qquad F_{CE} = 7.34$ kN C ◀

$$\text{note } \sigma = \tan^{-1}\frac{(1\text{ m})\cos 40° - (0.4\text{ m})\sin 45° + (0.4\text{ m})\sin 22.5°}{(1\text{ m})\sin 40° + (0.4\text{ m})\cos 45° - (0.4\text{ m})\cos 22.5°} = 48.848°$$

$$\text{and } \varepsilon = \tan^{-1}\frac{(1\text{ m})\cos 40° - (0.4\text{ m})\sin 45°}{(1\text{ m})\sin 40° + (0.4\text{ m})\cos 45°} = 27.566°$$

Then, $\circlearrowleft \Sigma M_C = 0$: $\quad (0.4\text{ m})\left[F_{DF}\cos(90° - 22.5° - 48.848°)\right]$

$$-\left[(1\text{ m})\sin 20°\right](2.6\text{ kN}) = 0,$$

$F_{DF} = 2.3464$ kN, $\qquad F_{DF} = 2.35$ kN T ◀

and, $\rightarrow \Sigma F_x = 0$: $\quad F_{CF}(\cos 27.566°) + (2.3464\text{ kN})(\cos 48.848°)$

$$-(7.3420\text{ kN})\sin 40° = 0$$

$F_{CF} = 3.5819$ kN, $\qquad F_{CF} = 3.58$ kN T ◀

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Chapter 6, Solution 59.

FBD Truss:

Notes: $\alpha = 20°$, $\beta = 40°$, $\gamma = 60°$, $\delta = 80°$, $\phi = 22.5°$, $\theta = 45°$, $\psi = 60°$

outer members AC, CE, etc. are each 1.0 m

radial members AB, CD, etc. are each 0.4 m

By symmetry, $A_y = B_y = 2.6$ kN ↑

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

FBD Section *ABDFHGEC*:

$$\circlearrowleft \Sigma M_J = 0: \quad (\text{resolve } F_{GI} \text{ at } I)$$

$$(0.4\text{ m})F_{GI}\sin 80° + (1\text{ m})(\sin 80°)(1\text{ kN})$$
$$+\left[(1\text{ m})\sin 80° + (1\text{ m})\sin 60°\right](0.6\text{ kN})$$
$$+\left[(1\text{ m})\sin 80° + (1\text{ m})\sin 60° + (1\text{ m})\sin 40°\right](0.4\text{ kN})$$
$$-\left[(1\text{ m})\sin 80° + (1\text{ m})\sin 60° + (1\text{ m})\sin 40° + (1\text{ m})\sin 20°\right](2.6\text{ kN}) = 0$$

$F_{GI} = 10.8648$ kN, $\qquad F_{GI} = 10.86$ kN C ◀

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Note: $\sigma = \tan^{-1}\dfrac{0.4\text{ m} - (1\text{ m})\cos 80°}{(1\text{ m})\sin 80°} = 12.9443°$

so, $\circlearrowleft \Sigma M_H = 0$: $\left[(0.4\text{ m})\cos 60°\right](F_{GJ}\sin 12.9443°)$

$$-\left[(0.4\text{ m})\sin 60°\right](F_{GJ}\cos 12.9443°)$$

$$-\left[(0.4\text{ m})\sin 60°\right]\left[(10.8648\text{ kN})\sin 80°\right]$$

$$+\left[(0.4\text{ m})\cos 60°\right]\left[(10.8648\text{ kN})\cos 80°\right]$$

$$+\left[(0.4\text{ m})\cos 60°\right](1\text{ kN}) + \left[(1\text{ m})\sin 60° + (0.4\text{ m})\cos 60°\right](0.6\text{ kN})$$

$$+\left[(1\text{ m})\sin 60° + (1\text{ m})\sin 40° + (0.4\text{ m})\cos 60°\right](0.4\text{ kN})$$

$$-\left[(1\text{ m})(\sin 60° + \sin 40° + \sin 20°) + (0.4\text{ m})\cos 60°\right](2.6\text{ kN}) = 0$$

$F_{GJ} = 0.93851\text{ kN}$, $\qquad F_{GJ} = 939\text{ N T}$ ◀

FBD Joint I:

By symmetry: $\qquad F_{IK} = 10.8648\text{ kN}$

$\uparrow \Sigma F_y = 0$: $\quad -F_{IJ} - 1.2\text{ kN} + 2(10.8648\text{ kN})\cos 80° = 0$

$F_{IJ} = 2.5733\text{ kN}$, $\qquad F_{IJ} = 2.57\text{ kN T}$ ◀

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Chapter 6, Solution 60.

FBD Truss:

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

By symmetry, $\mathbf{A}_y = \mathbf{N}_y = 1.6$ kips $\uparrow$

FBD Section using cut a–a:

$\circlearrowleft \Sigma M_D = 0: \quad (9\text{ ft})F_{FH} + (6\text{ ft})(0.5\text{ kip}) - (12\text{ ft})(1.6\text{ kips}) = 0$

$F_{FH} = 1.800$ kips T ◀

$\circlearrowleft \Sigma F_x = 0: \quad 1.800\text{ kips} - F_{DG} = 0$

$F_{DG} = 1.800$ kips C ◀

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Chapter 6, Solution 61.

FBD Truss:

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

By symmetry $\mathbf{A}_y = \mathbf{N}_y = 1.6$ kips $\uparrow$

FBD Joint *J*:

$\rightarrow \Sigma F_x = 0: \quad -F_{GJ} - F_{HJ} = 0, \; F_{HJ} = -F_{GJ}$

By inspection of joint I, $F_{IJ} = 0.6$ kip C

FBD Section using cut b-b:

$\uparrow \Sigma F_y = 0: \quad \frac{3}{5}\left[F_{GJ} - \left(-F_{GJ}\right)\right] - 0.6 \text{ kip} - 0.5 \text{ kip} + 1.6 \text{ kips} = 0$

$F_{GJ} = -\frac{2.5}{6}$ kip, $\qquad F_{GJ} = 0.417$ kip C ◀

$\circlearrowleft \Sigma M_J = 0: \quad (12 \text{ ft})(1.6 \text{ kips}) - (6 \text{ ft})(0.5 \text{ kip}) - (4.5 \text{ ft})(F_{HK})$

$-(4.5 \text{ ft})(F_{IL}) = 0$

$\rightarrow \Sigma F_x = 0: \quad F_{IL} - F_{HK} = 0 \quad \text{so} \quad F_{IL} = F_{HK}$

and $\qquad F_{IL} = 1.800$ kips C ◀

$F_{HK} = 1.800$ kips T ◀

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Chapter 6, Solution 62.

FBD Section above a-a:

$$\circlearrowleft \Sigma M_G = 0: \quad (5.9\text{ m})\left(\frac{27}{\sqrt{793}}F_{IK}\right) - (2.7\text{ m})(40\text{ kN}) - (5.4\text{ m})(40\text{ kN}) = 0$$

$$F_{IK} = 57.275\text{ kN}, \qquad F_{IK} = 57.3\text{ kN C} \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad \frac{27}{\sqrt{793}}(57.275\text{ kN} - F_{GJ}) = 0$$

$$F_{GJ} = 57.275\text{ kN T}$$

FBD Section *ACIG*:

$$\uparrow \Sigma F_y = 0: \quad \frac{27}{\sqrt{793}}(57.275\text{ kN} - 57.275\text{ kN})$$

$$+ \frac{18}{\sqrt{949}}(F_{HK} - F_{HJ}) = 0, \quad F_{HJ} = F_{HK}$$

$$\rightarrow \Sigma F_x = 0: \quad 3(40\text{ kN}) - 2\frac{25}{\sqrt{949}}F_{HK} = 0$$

$$F_{HK} = 53.884\text{ kN} \qquad F_{HK} = 53.9\text{ kN C} \blacktriangleleft$$

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Chapter 6, Solution 63.

FBD Section *ACFBD*:

$$\circlearrowleft \Sigma M_D = 0: \quad (4.3\text{ m})\frac{27}{\sqrt{793}}F_{FI} - (2.7\text{ m})(40\text{ kN}) = 0$$

$$F_{FI} = 26.196\text{ kN}, \qquad F_{FI} = 26.2\text{ kN C} \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad \frac{27}{\sqrt{793}}(26.196\text{ kN} - F_{DG}) = 0$$

$$F_{DG} = 26.196\text{ kN T}$$

FBD Section *ACFD*:

$$\uparrow \Sigma F_y = 0: \quad \frac{27}{\sqrt{793}}(26.196\text{ kN} - 26.196\text{ kN})$$

$$+\frac{54}{\sqrt{6397}}(F_{EI} - F_{EG}) = 0, \quad F_{EI} = F_{EG}$$

$$\rightarrow \Sigma F_x = 0: \quad -2\frac{59}{\sqrt{6397}}(F_{EG}) + 2(40\text{ kN})$$

$$-\frac{8}{\sqrt{793}}(26.196\text{ kN} + 26.196\text{ kN}) = 0$$

$$F_{EG} = 44.136\text{ kN}, \qquad F_{EG} = 44.1\text{ kN T} \blacktriangleleft$$

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Chapter 6, Solution 64.

FBD Truss:

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

$$\circlearrowleft \Sigma M_F = 0: \quad (2.4\text{ m})(8\text{ kN}) + (5.1\text{ m})(12\text{ kN})$$

$$-(7.5\text{ m})A_y = 0, \qquad \mathbf{A}_y = 10.72\text{ kN} \uparrow$$

Since only *CD* can provide an upward force necessary for equilibrium, it must be in tension, and $F_{BE} = 0$

FBD Section *ABC*:

$$\uparrow \Sigma F_y = 0: \quad 10.72\text{ kN} - 12\text{ kN} + \frac{1.68}{3.18}F_{CD} = 0$$

$$F_{CD} = 2.4229\text{ kN}, \qquad F_{CD} = 2.42\text{ kN T} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_C = 0: \quad (1.68\text{ m})F_{BD} - (2.4\text{ m})(10.72\text{ kN}) = 0$$

$$F_{BD} = 15.3143\text{ kN}, \qquad F_{BD} = 15.31\text{ kN C} \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad F_{CE} + \frac{2.7}{3.18}(2.4229\text{ kN}) - 15.3143\text{ kN} = 0$$

$$F_{CE} = 13.26\text{ kN T} \blacktriangleleft$$

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Chapter 6, Solution 65.

FBD Truss:

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

$$\circlearrowleft \Sigma M_F = 0: \quad (2.4\text{ m})(8\text{ kN}) + (5.1\text{ m})(6\text{ kN}) - (7.5\text{ m})A_y = 0$$

$$\mathbf{A}_y = 6.64\text{ kN} \uparrow$$

Since only *BE* can provide the downward force necessary for equilibrium,
it must be in tension, so $F_{CD} = 0$

FBD Section *ABC*:

$$\uparrow \Sigma F_y = 0: \quad 6.64\text{ kN} - 6\text{ kN} - \frac{1.68}{3.18}F_{BE} = 0$$

$$F_{BE} = 1.21143\text{ kN}, \qquad F_{BE} = 1.211\text{ kN T} \blacktriangleleft$$

$$\circlearrowleft \Sigma M = 0: \quad (1.68\text{ m})F_{CE} - (2.4\text{ m})(6.64\text{ kN}) = 0$$

$$F_{CE} = 9.4857\text{ kN}, \qquad F_{CE} = 9.49\text{ kN T} \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad 9.4857\text{ kN} + \frac{2.7}{3.18}(1.21143\text{ kN}) - F_{BD} = 0$$

$$F_{BD} = 10.51\text{ kN C} \blacktriangleleft$$

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Chapter 6, Solution 66.

FBD Truss:

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

$$\circlearrowleft \Sigma M_C = 0: \quad (8\text{ ft})(6\text{ kips}) - (8\text{ ft})(9\text{ kips}) + (16\text{ ft})G_y$$

$$-(24\text{ ft})(12\text{ kips}) = 0$$

$$\mathbf{G}_y = 19.5\text{ kips} \uparrow$$

FBD Section *ABC*:

$$\uparrow \Sigma F_y = 0: \quad 19.5\text{ kips} + C_y - 6\text{ kips} - 9\text{ kips} - 12\text{ kips} = 0$$

$$C_y = 7.5\text{ kips} \uparrow$$

Since only *BE* can provide the downward force necessary for equilibrium, it must be in tension, so *CD* is slack, $F_{CD} = 0$

$$\uparrow \Sigma F_y = 0: \quad -6\text{ kips} + 7.5\text{ kips} - \frac{3}{5}F_{BE} = 0$$

$$F_{BE} = 2.50\text{ kips T} \blacktriangleleft$$

FBD Section *FGH*:

Since only *EF* can provide the downward force necessary for equilibrium, it must be in tension, so *DG* is slack, $F_{DG} = 0$

$$\uparrow \Sigma F_y = 0: \quad 19.5\text{ kips} - 12\text{ kips} - \frac{3}{5}F_{EF} = 0$$

$$F_{EF} = 12.00\text{ kips T} \blacktriangleleft$$

Knowing that $F_{CD} = F_{DG} = 0$, inspection of joint *D* gives

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

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Chapter 6, Solution 67

FBD Truss:

$$\circlearrowleft \Sigma M_A = 0: \quad (32\text{ ft})H_y - (24\text{ ft})(12\text{ kips}) - (16\text{ ft})(9\text{ kips})$$

$$-(8\text{ ft})(6\text{ kips}) = 0, \qquad \mathbf{H}_y = 15\text{ kips}\uparrow$$

$$\uparrow \Sigma F_y = 0: \quad A_y - 6\text{ kips} - 9\text{ kips} - 12\text{ kips} + 15\text{ kips} = 0$$

$$\mathbf{A}_y = 12\text{ kips}\uparrow$$

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

FBD Section *ABC*:

Since only *BE* can provide the downward force necessary for equilibrium, it must be in tension, so *CD* is slack, $F_{CD} = 0$

$$\uparrow \Sigma F_y = 0: \quad 12\text{ kips} - 6\text{ kips} - \frac{3}{5}F_{BE} = 0$$

$$F_{BE} = 10.00\text{ kips T} \blacktriangleleft$$

Since only *EF* can provide the downward force necessary for equilibrium, it must be in tension, so *DG* is slack, $F_{DG} = 0$

$$\uparrow \Sigma F_y = 0: \quad 15\text{ kips} - 12\text{ kips} - \frac{3}{5}F_{EF} = 0$$

$$F_{EF} = 5.00\text{ kips T} \blacktriangleleft$$

FBD Section *FGH*:

Knowing that $F_{CD} = F_{DF} = 0$, inspection of joint *D* gives

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

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Chapter 6, Solution 68

FBD Section *ABDC*:

Since only *DE* can provide the leftward force necessary for equilibrium, it must be in tension, and *CF* must be slack, $F_{CF} = 0$

$$\rightarrow \Sigma F_x = 0: \quad 20 \text{ kN} - \frac{4}{5} F_{DE} = 0, \qquad F_{DE} = 25.0 \text{ kN C} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_D = 0: \quad (3.2 \text{ m}) F_{CE} - (2.4 \text{ m})(20 \text{ kN}) = 0$$

$$F_{CE} = 15.00 \text{ kN T} \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad F_{DF} - 15.00 \text{ kN} - \frac{3}{5}(25 \text{ kN}) = 0$$

$$F_{DE} = 30.0 \text{ kN C} \blacktriangleleft$$

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Chapter 6, Solution 69.

FBD Section *ABFE*:

It is not apparent which counter is active, so we guess that $F_{EH} = 0$;

$$\circlearrowleft \Sigma M_F = 0: \quad (3.2\text{ m})\left(\frac{24}{\sqrt{745}}F_{EG} + 40\text{ kN}\right) - (4.8\text{ m})(20\text{ kN}) = 0$$

$$F_{EG} = -11.3728\text{ kN}$$

$$F_{EG} = 11.37\text{ kN C} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_G = 0: \quad (5.8\text{ m})\left(\frac{24}{\sqrt{745}}F_{FH}\right) - (7.2\text{ m})(20\text{ kN}) - (1.3\text{ m})(40\text{ kN}) = 0$$

$$F_{FH} = 38.432\text{ kN}, \qquad F_{FH} = 38.4\text{ kN C} \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad 20\text{ kN} - \frac{13}{\sqrt{745}}(38.432\text{ kN} - 11.3728\text{ kN}) - \frac{15}{17}F_{FG} = 0$$

$$F_{FG} = 8.0604\text{ kN}, \qquad F_{FG} = 8.06\text{ kN T} \blacktriangleleft$$

Since F_{EG} is in tension, our guess was correct. A negative answer would be impossible, indicating an incorrect guess.

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Chapter 6, Solution 70.

Structure (a): Non-simple truss with $r = 3$, $m = 16$, $N = 10$, so $2N > m + r$

$\therefore$ partially constrained ◀

Structure (b): Non-simple truss with $r = 3$, $m = 15$, $N = 10$, so $2N > m + r$

$\therefore$ partially constrained ◀

Structure (c): Non-simple truss with $r = 4$, $m = 16$, $N = 10$, so $N = 2m + r$

Examine Forces:

By inspection of joint J, $F_{HJ} = 0$, $F_{IJ} = P$ C

Then, by inspection of joint H, $F_{FH} = 0$, $F_{GH} = P$ C

By inspection of joint I, $F_{GI} = 0$, $\mathbf{I}_y = 0$

Although several members carry no load with the given truss loading, they do constrain the motion of GH and IJ. Truss $ABFG$ is a simple truss with $r = 3$, $m = 11$, $N = 7$ ($2N = r + m$)

so the structure is completely constrained, and determinate. ◀

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Chapter 6, Solution 71.

Structure (a):

Simple truss with $r = 4,\ m = 16,\ n = 10$

So $m + r = 20 = 2n$ so completely constrained and determinate ◀

Structure (b):

Compound truss with $r = 3,\ m = 16,\ n = 10$

So $m + r = 19 < 2n = 20$ so partially constrained ◀

Structure (c):

Non-simple truss with $r = 4,\ m = 12,\ n = 8$

So $m + r = 16 = 2n$ but must examine further, note that reaction forces $\mathbf{A}_x$ and $\mathbf{H}_x$ are aligned, so no equilibrium equation will resolve them.

$\therefore$ Statically indeterminate ◀

Also consider

For $\Sigma F_y = 0$: $H_y = 0$, but then $\circlearrowleft\ \Sigma M_A \neq 0$ in FBD Truss,

$\therefore$ Improperly constrained ◀

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Chapter 6, Solution 72.

Structure (a):

Simple truss (start with ABC and add joints alphabetical to complete truss), with

$$r = 4,\ m = 13,\ n = 8 \qquad \text{so} \qquad r + m = 17 > 2n = 16$$

Structure is completely constrained but indeterminate. ◀

Structure (b):

From FBD II: $\Sigma M_G = 0 \Rightarrow J_y$

$\Sigma F_x = 0 \Rightarrow F_x$

FBD I: $\Sigma M_A = 0 \Rightarrow F_y$

$\Sigma F_y = 0 \Rightarrow A_y$

$\Sigma F_x = 0 \Rightarrow A_x$

FBD II: $\Sigma F_y = 0 \Rightarrow G_y$

Thus have two simple trusses with all reactions known,

so structure is completely constrained and determinate. ◀

Structure (c):

Structure has $r = 4,\ m = 13,\ n = 9$

so $r + m = 17 < 2n = 18$, structure is partially constrained ◀

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Chapter 6, Solution 73.

Structure (a):

Non-Simple truss with $r = 4$, $m = 12$, $N = 8$, so $2N = r + m$, but we must examine further:

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

By symmetry, $F_{BD} = F_{DF}$ and $F_{CD} = F_{DG}$

FBD joint *D*:

Vertical equilibrium cannot be satisfied with $F_{CD} = F_{DG}$,

Improperly constrained ◀

Structure (b):

Non-simple truss with $r = 3$, $m = 10$, $N = 7$, so $2N = m + r$

$\therefore$ Partially constrained ◀

Structure (c):

Non-simple truss with $r = 3$, $m = 13$, $N = 8$, so $2N = r + m$, but we must examine further

$\circlearrowleft \Sigma M_A = 0: \quad 3a\,G_y - (a + 3a + 4a)P = 0$

$$\mathbf{G}_y = \frac{8}{3}P \uparrow$$

Joint *H*:

$\uparrow \Sigma F_y = 0: \quad \frac{1}{\sqrt{2}}F_{FH} - P = 0$

$F_{FH} = P\sqrt{2}$ T

Joint *F*:

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

$F_{FG} = 2P$ C

Joint *G*:

$\Sigma F_y \neq 0$

Improperly constrained ◀

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Chapter 6, Solution 74.

Structure (a):

No. of members $m = 12$

No. of joints $n = 8$ $\quad m + r = 16 = 2n$

No. of react. comps. $r = 4$ $\quad$ unks = eqns

FBD of *EH*:

$$\Sigma M_H = 0 \rightarrow F_{DE};\ \Sigma F_x = 0 \rightarrow F_{GH};\ \Sigma F_y = 0 \rightarrow H_y$$

Then *ABCDGF* is a simple truss and all forces can be determined.

This example is completely constrained and determinate. ◀

Structure (b):

No. of members $m = 12$

No. of joints $n = 8$ $\quad m + r = 15 < 2n = 16$

No. of react. comps. $r = 3$ $\quad$ unks < eqns

partially constrained ◀

Note: Quadrilateral *DEHG* can collapse with joint *D* moving downward: in (a) the roller at *F* prevents this action.

Structure (c):

No. of members $m = 13$

No. of joints $n = 8$ $\quad m + r = 17 > 2n = 16$

No. of react. comps. $r = 4$ $\quad$ unks > eqns

completely constrained but indeterminate ◀

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Chapter 6, Solution 75.

Structure (a):

Rigid truss with $r = 3,\ m = 14,\ n = 8$

so $r + m = 17 > 2n = 16$

so completely constrained but indeterminate ◀

Structure (b):

Simple truss (start with ABC and add joints alphabetically), with

$r = 3,\ m = 13,\ n = 8$ so $r + m = 16 = 2n$

so completely constrained and determinate ◀

Structure (c):

Simple truss with $r = 3,\ m = 13,\ n = 8$ so $r + m = 16 = 2n$, but horizontal reactions (A_x and D_x) are collinear so cannot be resolved by any equilibrium equation.

$\therefore$ structure is improperly constrained ◀

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Chapter 6, Solution 76.

FBD member *AE*:

$\rightarrow \Sigma F_x = 0: \quad -A_x + 120 \text{ lb} = 0,$ $\qquad A_x = 120 \text{ lb}$

on *ABCD* $\qquad \mathbf{A}_x = 120.0 \text{ lb} \rightarrow$ ◀

$\circlearrowleft \Sigma M_A = 0: \quad (8 \text{ in.})(C) - (2 \text{ in.})(120 \text{ lb}) = 0$

$C = 30 \text{ lb}$

$\uparrow \Sigma F_y = 0: \quad 30 \text{ lb} - A_y = 0,$ $\qquad A_y = 30 \text{ lb}$

on *ABCD* $\qquad \mathbf{A}_y = 30.0 \text{ lb} \uparrow$ ◀

FBD member *ABCD*:

$\rightarrow \Sigma F_x = 0: \quad 120 \text{ lb} - B_x = 0,$ $\qquad \mathbf{B}_x = 120.0 \text{ lb} \leftarrow$ ◀

$\circlearrowleft \Sigma M_B = 0: \quad (6 \text{ in.})D - (4 \text{ in.})(30 \text{ lb}) - (4 \text{ in.})(30 \text{ lb})$

$-(2 \text{ in.})(120 \text{ lb}) = 0$

$\mathbf{D} = 80.0 \text{ lb} \uparrow$ ◀

$\uparrow \Sigma F_y = 0: \quad 30 \text{ lb} - B_y - 30 \text{ lb} + 80 \text{ lb} = 0$

$\mathbf{B}_y = 80.0 \text{ lb} \downarrow$ ◀

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Chapter 6, Solution 77.

FBD member *ABC*:

Note that *BD* is a two-force member

(a) $\circlearrowleft \Sigma M_C = 0$: $(16 \text{ in.})\left(\frac{4}{5}F_{BD}\right) - (24 \text{ in.})(80 \text{ lb}) = 0$

$F_{BD} = 150$ lb, $\mathbf{F}_{BD} = 150.0 \text{ lb} \angle 36.9°$ ◀

(b) $\uparrow \Sigma F_y = 0$: $C_y - \frac{3}{5}(150 \text{ lb}) = 0$, $C_y = 90$ lb

$\rightarrow \Sigma F_x = 0$: $C_x - \frac{4}{5}(150 \text{ lb}) + 80 \text{ lb} = 0$, $C_x = 40$ lb

$\mathbf{C} = 98.5 \text{ lb} \angle 66.0°$ ◀

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Chapter 6, Solution 78.

FBD Frame:

$$\circlearrowleft \Sigma M_A = 0: \quad (0.25\text{ m})D_x - (0.95\text{ m})(480\text{ N}) = 0$$

$$\mathbf{D}_x = 1824\text{ N} \leftarrow \blacktriangleleft$$

FBD member *DF*:

Note that *BE* is a two-force member, $E_x = E_y$

$$\rightarrow \Sigma F_x = 0: \quad -1824\text{ N} + E_x = 0, \qquad \mathbf{E}_x = 1824\text{ N} \rightarrow \blacktriangleleft$$

so $\quad \mathbf{E}_y = 1824\text{ N} \uparrow \blacktriangleleft$

$$\circlearrowleft \Sigma M_D = 0: \quad (0.50\text{ m})(1824\text{ N}) - (0.75\text{ m})C + (0.95\text{ m})(480\text{ N}) = 0$$

$$\mathbf{C} = 1824\text{ N} \downarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad -D_y + 1824\text{ N} - 1824\text{ N} + 480\text{ N} = 0$$

$$\mathbf{D}_y = 480\text{ N} \downarrow \blacktriangleleft$$

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Chapter 6, Solution 79.

FBD Frame:

$$\circlearrowleft \Sigma M_A = 0: \quad (0.25\text{ m})D_x - 400\text{ N}\cdot\text{m} = 0$$

$$\mathbf{D}_x = 1600\text{ N} \rightarrow \blacktriangleleft$$

FBD member *DF*:

Note *BE* is a two-force member, so $E_x = E_y$

$$\rightarrow \Sigma F_x = 0: \quad 1600\text{ N} - E_x = 0, \qquad \mathbf{E}_x = 1600\text{ N} \leftarrow \blacktriangleleft$$

$$\therefore\ \mathbf{E}_y = 1600\text{ N} \downarrow \blacktriangleleft$$

$$\circlearrowleft \Sigma M_D = 0: \quad -(0.50\text{ m})(1600\text{ N}) + (0.75\text{ m})C - 400\text{ N}\cdot\text{m} = 0$$

$$\mathbf{C} = 1600\text{ N} \uparrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad D_y - 1600\text{ N} + 1600\text{ N} = 0$$

$$\mathbf{D}_y = 0 \blacktriangleleft$$

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Chapter 6, Solution 80.

FBD Ring:

(*a*) $\circlearrowleft \Sigma M_A = 0: \quad (8 \text{ in.})(F_{BC}\cos 35°) - (8 \text{ in.})(6 \text{ lb}) = 0$

$F_{BC} = 7.3246 \text{ lb},$ $\qquad F_{BC} = 7.32 \text{ lb C}$ ◀

(*b*) $\rightarrow \Sigma F_x = 0: \quad A_x - (7.3246 \text{ lb})\cos 35° = 0$

$A_x = 6 \text{ lb}$

$\uparrow \Sigma F_y = 0: \quad A_y + (7.3246 \text{ lb})\sin 35° - 6 \text{ lb} = 0$

$A_y = 1.79876 \text{ lb}$

$\mathbf{A} = 6.26 \text{ lb} \measuredangle 16.69°$ ◀

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Chapter 6, Solution 81.

FBD Ring:

(a) $\circlearrowleft \Sigma M_A = 0$: $(8 \text{ in.})(F_{BC}\cos 20° - 6 \text{ lb}) = 0$

$$F_{BC} = \frac{6 \text{ lb}}{\cos 20°}, \qquad F_{BC} = 6.39 \text{ lb C} \blacktriangleleft$$

(b) $\rightarrow \Sigma F_x = 0$: $A_x - \dfrac{6 \text{ lb}}{\cos 20°}\cos 20° = 0,$ $\qquad A_x = 6 \text{ lb}$

$\uparrow \Sigma F_y = 0$: $A_y - \dfrac{6}{\cos 20°}\sin 20° - 6 \text{ lb} = 0,$ $\qquad A_y = 8.1838 \text{ lb}$

$\mathbf{A} = 10.15 \text{ lb} \measuredangle 53.8° \blacktriangleleft$

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Chapter 6, Solution 82.

FBD Frame:

$$\circlearrowleft \Sigma M_A = 0: \quad (0.2\text{ m})B_x - (0.36\text{ m})\left(\frac{\sqrt{2}}{2}180\text{ N}\right) = 0$$

$$B_x = 162\sqrt{2}\text{ N}, \qquad \mathbf{B}_x = 229\text{ N} \leftarrow \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad -162\sqrt{2}\text{ N} + A_x - \frac{\sqrt{2}}{2}(180\text{ N}) = 0$$

$$A_x = 252\sqrt{2}\text{ N}, \qquad \mathbf{A}_x = 356\text{ N} \rightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad B_y - \frac{\sqrt{2}}{2}(180\text{ N}) = 0$$

$$B_y = 90\sqrt{2}\text{ N}, \qquad \mathbf{B}_y = 127.3\text{ N} \uparrow \blacktriangleleft$$

FBD member *ABD*:

$$\circlearrowleft \Sigma M_C = 0: \quad (0.20\text{ m})\left(252\sqrt{2}\text{ N}\right) - (0.08\text{ m})\left(90\sqrt{2}\text{ N}\right)$$

$$-(0.20\text{ m})D = 0, \qquad D = 216\sqrt{2}\text{ N}$$

$$\mathbf{D} = 305\text{ N} \downarrow \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad 252\sqrt{2}\text{ N} - 162\sqrt{2}\text{ N} - C_x = 0$$

$$C_x = 90\sqrt{2}\text{ N}, \qquad \mathbf{C}_x = 127.3\text{ N} \leftarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad 90\sqrt{2}\text{ N} + C_y - 216\sqrt{2}\text{ N} = 0$$

$$C_y = 126\sqrt{2}\text{ N}, \qquad \mathbf{C}_y = 178.2\text{ N} \uparrow \blacktriangleleft$$

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Chapter 6, Solution 83.

FBD Frame:

$\circlearrowleft \Sigma M_B = 0: \quad (0.2\text{ m})A_x - 60\text{ N}\cdot\text{m} = 0$

$\mathbf{A}_x = 300\text{ N} \rightarrow$ ◀

$\rightarrow \Sigma F_x = 0: \quad 300\text{ N} - B_x = 0,$ $\quad \mathbf{B}_x = 300\text{ N} \leftarrow$ ◀

$\uparrow \Sigma F_y = 0: \quad B_y = 0,$ $\quad \mathbf{B}_y = 0$ ◀

FBD member *ABD*:

$\circlearrowleft \Sigma M_C = 0: \quad (0.20\text{ m})(300\text{ N}) - (0.20\text{ m})D_y = 0$

$\mathbf{D}_y = 300\text{ N} \downarrow$ ◀

$\uparrow \Sigma F_y = 0: \quad C_y - 300\text{ N} = 0$ $\quad \mathbf{C}_y = 300\text{ N} \uparrow$ ◀

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

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Chapter 6, Solution 84.

(*a*) **FBD *AC*:**

Note: *CE* is a two-force member

$$\circlearrowleft \Sigma M_A = 0: \quad (8\text{ in.})\left(\frac{F_{CE}}{\sqrt{2}}\right) + (2\text{ in.})\left(\frac{F_{CE}}{\sqrt{2}}\right) - (6\text{ in.})(24\text{ lb}) = 0$$

$F_{CE} = 14.4\sqrt{2}$ lb, so $\mathbf{E}_x = 14.40$ lb $\rightarrow$ ◀

$\mathbf{E}_y = 14.40$ lb $\uparrow$ ◀

$$\rightarrow \Sigma F_x = 0: \quad -A_x + 14.4\text{ lb} = 0$$

$\mathbf{A}_x = 14.40$ lb $\leftarrow$ ◀

$$\uparrow \Sigma F_y = 0: \quad A_y - 24\text{ lb} + 14.40\text{ lb} = 0$$

$\mathbf{A}_y = 9.60$ lb $\uparrow$ ◀

(*b*) **FBD *CE*:**

Note *AC* is a two-force member

$$\circlearrowleft \Sigma M_E = 0: \quad (3\text{ in.})\left(\frac{4}{\sqrt{17}}F_{AC} + \frac{1}{\sqrt{17}}F_{AC}\right) - (1\text{ in.})(24\text{ lb}) = 0$$

$F_{AC} = 1.6\sqrt{17}$ lb, $\mathbf{A}_x = 6.40$ lb $\leftarrow$ ◀

$\mathbf{A}_y = 1.600$ lb $\uparrow$ ◀

$$\rightarrow \Sigma F_x = 0: \quad E_x - \frac{4}{\sqrt{17}}\left(1.6\sqrt{17}\text{ lb}\right) = 0,$$

$\mathbf{E}_x = 6.40$ lb $\rightarrow$ ◀

$$\uparrow \Sigma F_y = 0: \quad E_y + \frac{1}{\sqrt{17}}\left(1.6\sqrt{17}\text{ lb}\right) - 24\text{ lb} = 0$$

$\mathbf{E}_y = 22.4$ lb $\uparrow$ ◀

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Chapter 6, Solution 85.

(*a*) **FBD *AC*:**

Note: *CE* is a two-force member

$$\circlearrowleft \Sigma M_A = 0: \quad (0.4\text{ m})\left(\frac{1}{\sqrt{2}}F_{CE} + \frac{1}{\sqrt{2}}F_{CE}\right) - (0.3\text{ m})(320\text{ lb})$$

$F_{CE} = 120\sqrt{2}$ N, $\qquad \mathbf{E}_x = 120.0\text{ N} \rightarrow$ ◀

$\mathbf{E}_y = 120.0\text{ N} \uparrow$ ◀

$$\rightarrow \Sigma F_x = 0: \quad -A_x + \frac{1}{\sqrt{2}}\left(120\sqrt{2}\text{ N}\right) = 0, \qquad \mathbf{A}_x = 120.0\text{ N} \leftarrow$$ ◀

$$\uparrow \Sigma F_y = 0: \quad A_y - 320\text{ N} + \frac{1}{\sqrt{2}}\left(120\sqrt{2}\text{ N}\right) = 0 \qquad \mathbf{A}_y = 200\text{ N} \uparrow$$ ◀

(*b*) **FBD *CE*:**

Note: *AC* is a two-force member

$$\circlearrowleft \Sigma M_E = 0: \quad (0.25\text{ m})\left(\frac{1}{\sqrt{2}}F_{AC} + \frac{1}{\sqrt{2}}F_{AC}\right) - (0.15\text{ m})(320\text{ N}) = 0$$

$F_{AC} = 96\sqrt{2}$ N, $\qquad \mathbf{A}_x = 96.0\text{ N} \leftarrow$ ◀

$\mathbf{A}_y = 96.0\text{ N} \uparrow$ ◀

$$\rightarrow \Sigma F_x = 0: \quad E_x - 96.0\text{ N} = 0 \qquad \mathbf{E}_x = 96.0\text{ N} \rightarrow$$ ◀

$$\uparrow \Sigma F_y = 0: \quad E_y - 320\text{ N} + 96.0\text{ N} = 0 \qquad \mathbf{E}_y = 224\text{ N} \uparrow$$ ◀

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Chapter 6, Solution 86.

(*a*) **FBD *AC*:**

Note: *CE* is a two-force member

$$\circlearrowleft \Sigma M_A = 0: \quad -(8\text{ in.})\left(\frac{1}{\sqrt{2}}F_{CE}\right) - (2\text{ in.})\left(\frac{1}{\sqrt{2}}F_{CE}\right) + 192\text{ lb}\cdot\text{in.} = 0$$

$F_{CE} = 19.2\sqrt{2}$ lb, $\qquad \mathbf{E}_x = 19.20$ lb ← ◀

$\mathbf{E}_y = 19.20$ lb ↓ ◀

$\rightarrow \Sigma F_x = 0: \quad A_x - 19.2\text{ lb} = 0, \qquad \mathbf{A}_x = 19.20$ lb → ◀

$\uparrow \Sigma F_y = 0: \quad A_y - 19.2\text{ lb} = 0, \qquad \mathbf{A}_y = 19.20$ lb ↑ ◀

(*b*) **FBD *CE*:**

Note: *AC* is a two-force member

$$\circlearrowleft \Sigma M_E = 0: \quad (3\text{ in.})\left(\frac{1}{\sqrt{17}}F_{AE} + \frac{4}{\sqrt{17}}F_{AE}\right) + 192\text{ lb}\cdot\text{in.} = 0$$

$F_{AE} = -12.8\sqrt{17}$ lb, $\qquad A_x = \dfrac{4}{\sqrt{17}}F_{AE}, \qquad \mathbf{A}_x = 51.2$ lb → ◀

$A_y = \dfrac{1}{\sqrt{17}}F_{AE}, \qquad \mathbf{A}_y = 12.80$ lb ↓ ◀

$\rightarrow \Sigma F_x = 0: \quad E_x - 51.2\text{ lb} = 0, \qquad \mathbf{E}_x = 51.2$ lb → ◀

$\uparrow \Sigma F_y = 0: \quad E_y - 12.80\text{ lb} = 0, \qquad \mathbf{E}_y = 12.80$ lb ↑ ◀

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Chapter 6, Solution 87.

(*a*) **FBD *AC*:**

Note: *CE* is a two-force member

$$\circlearrowleft \Sigma M_A = 0: \quad 120 \text{ N}\cdot\text{m} - (0.4 \text{ m})\left(\frac{2}{\sqrt{2}} F_{CE}\right) = 0,$$

$$F_{CE} = 150\sqrt{2} \text{ N}$$

$$\mathbf{E}_x = 150.0 \text{ N} \leftarrow \blacktriangleleft$$

$$\mathbf{E}_y = 150.0 \text{ N} \downarrow \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad A_x - 150.0 \text{ N} = 0, \qquad \mathbf{A}_x = 150.0 \text{ N} \rightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad A_y - 150.0 \text{ N} = 0, \qquad \mathbf{A}_y = 150.0 \text{ N} \uparrow \blacktriangleleft$$

(*b*) **FBD *CE*:**

Note: *AC* is a two-force member

$$\circlearrowleft \Sigma M_E = 0: \quad -(0.25 \text{ m})\left(\frac{2}{\sqrt{2}} F_{AC}\right) + 120 \text{ N}\cdot\text{m} = 0$$

$$F_{AC} = 240\sqrt{2} \text{ N}, \qquad \mathbf{A}_x = 240 \text{ N} \rightarrow \blacktriangleleft$$

$$\mathbf{A}_y = 240 \text{ N} \downarrow \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad 240 \text{ N} - E_x = 0, \qquad \mathbf{E}_x = 240 \text{ N} \leftarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad E_y - 240 \text{ N} = 0, \qquad \mathbf{E}_y = 240 \text{ N} \uparrow \blacktriangleleft$$

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Chapter 6, Solution 88.

FBD Frame:

Note: In analysis of entire frame, location of **M** is immaterial. Note also that *AB*, *BC*, and *FG* are two force members.

$\circlearrowleft \Sigma M_H = 0: \quad (6\text{ ft})I_y - 180\text{ lb}\cdot\text{ft} = 0, \qquad \mathbf{I}_y = 30.0\text{ lb} \uparrow$ ◀

(*a*) **FBD *AI*:**

$\uparrow \Sigma F_y = 0: \quad 30\text{ lb} - \frac{5}{13}F_{AB} = 0, \qquad \mathbf{F}_{AB} = 78.0\text{ lb} \measuredangle 22.6°$ ◀

$\circlearrowleft \Sigma M_C = 0: \quad (2.5\text{ ft})\left(\frac{12}{13}78\text{ lb} - F_{FG}\right) = 0, \qquad \mathbf{F}_{GH} = 72.0\text{ lb} \rightarrow$ ◀

$\rightarrow \Sigma F_x = 0: \quad F_{BC} - \frac{12}{13}78\text{ lb} - 72\text{ lb} = 0, \qquad \mathbf{F}_{BC} = 144.0\text{ lb} \rightarrow$ ◀

(*b*) **FBD *AI*:**

As above, $\Sigma F_y = 0$ yields $\qquad \mathbf{F}_{AB} = 78.0\text{ lb} \measuredangle 22.6°$ ◀

Then:

$\circlearrowleft \Sigma M_C = 0: \quad (2.5\text{ ft})\left(\frac{12}{13}78.0\text{ lb} - F_{FG}\right) - 180\text{ lb}\cdot\text{ft} = 0$

$\mathbf{F}_{FG} = 0$ ◀

$\rightarrow \Sigma F_x = 0: \quad F_{BC} - \frac{12}{13}(78.0\text{ lb}) = 0, \qquad \mathbf{F}_{BC} = 72.0\text{ lb} \rightarrow$ ◀

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Chapter 6, Solution 89.

(*a*) **FBD *ACF*:**

Note: *BC* is a two-force member

$$\circlearrowleft \Sigma M_F = 0: \quad (0.1\text{ m})(120\text{ N}) - (0.3\text{ m})\left(\frac{1}{\sqrt{26}}F_{BC}\right) = 0,$$

$$F_{BC} = 40\sqrt{26}\text{ N}, \qquad \mathbf{B}_x = 200\text{ N} \rightarrow \blacktriangleleft$$

$$\mathbf{B}_y = 40.0\text{ N} \downarrow \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad \frac{5}{\sqrt{26}}\left(40\sqrt{26}\text{ N}\right) - F_x = 0, \qquad \mathbf{F}_x = 200\text{ N} \leftarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad F_y - 120\text{ N} - \frac{1}{\sqrt{26}}\left(40\sqrt{26}\text{ N}\right) = 0, \qquad \mathbf{F}_y = 160.0\text{ N} \uparrow \blacktriangleleft$$

(*b*) **FBD *BCE*:**

Note *ACF* is a two-force member

$$\circlearrowleft \Sigma M_B = 0: \quad (0.4\text{ m})(120\text{ N}) - (0.3\text{ m})\left(\frac{1}{\sqrt{5}}F_{CF}\right) = 0,$$

$$F_{CF} = 160\sqrt{5}\text{ N}, \qquad \mathbf{F}_x = 320\text{ N} \leftarrow \blacktriangleleft$$

$$\mathbf{F}_y = 160.0\text{ N} \uparrow \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad B_x - \frac{2}{\sqrt{5}}\left(160\sqrt{5}\text{ N}\right) = 0, \qquad \mathbf{B}_x = 320\text{ N} \rightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad \frac{1}{\sqrt{5}}\left(160\sqrt{5}\text{ N}\right) - 120\text{ N} - B_y = 0$$

$$\mathbf{B}_y = 40.0\text{ N} \downarrow \blacktriangleleft$$

(*c*) Moving the 120 N force from *D* to *E* does not affect the reactions. The answers are the same as in part (*b*). ◀

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Chapter 6, Solution 90.

(*a*) **FBD *AF*:**

Note: *BC* is a two-force member

$$\circlearrowleft \Sigma M_F = 0: \quad (0.3\text{ m})\left(\frac{1}{\sqrt{26}}F_{BC}\right) - 48\text{ N}\cdot\text{m} = 0,$$

$$F_{BC} = 160\sqrt{26}\text{ N}$$

so $\mathbf{B}_x = 800\text{ N} \leftarrow$ ◀

$\mathbf{B}_y = 160.0\text{ N} \uparrow$ ◀

$$\rightarrow \Sigma F_x = 0: \quad F_x - 800\text{ N} = 0, \qquad \mathbf{F}_x = 800\text{ N} \rightarrow ◀$$

$$\uparrow \Sigma F_y = 0: \quad -F_y + 160\text{ N} = 0, \qquad \mathbf{F}_y = 160.0\text{ N} \downarrow ◀$$

(*b* & *c*) **FBD *BCE*:**

Note: *ACF* is a two-force member, and that the application point of the couple is immaterial.

$$\circlearrowleft \Sigma M_B = 0: \quad (0.3\text{ m})\left(\frac{1}{\sqrt{5}}F_{CF}\right) - 48\text{ N}\cdot\text{m} = 0$$

$$F_{CF} = 160\sqrt{5}\text{ N}, \qquad \mathbf{F}_x = 320\text{ N} \rightarrow ◀$$

$\mathbf{F}_y = 160.0\text{ N} \downarrow$ ◀

$$\rightarrow \Sigma F_x = 0: \quad 320\text{ N} - B_x = 0, \qquad \mathbf{B}_x = 320\text{ N} \leftarrow ◀$$

$$\uparrow \Sigma F_y = 0: \quad -160\text{ N} + B_y = 0, \qquad \mathbf{B}_y = 160.0\text{ N} \uparrow ◀$$

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Chapter 6, Solution 91.

First note that, when a cable or cord passes over a *frictionless*, *motionless* pulley, the tension is unchanged.

$$\circlearrowleft \Sigma M_C = 0: \quad rT_1 - rT_2 = 0 \qquad T_1 = T_2$$

(*a*) Replace each force with an equivalent force-couple.

(*b*) Cut cable and replace forces on pulley with equivalent pair of forces at *A* as above.

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Chapter 6, Solution 92.

FBD Pipe 2:

$$\nearrow \Sigma F_{x'} = 0: \quad N_G - \frac{3}{5}(220 \text{ lb}) = 0, \qquad N_G = 132 \text{ lb}$$

$$\nwarrow \Sigma F_{y'} = 0: \quad N_D - \frac{4}{5}(220 \text{ lb}) = 0, \qquad N_D = 176 \text{ lb}$$

FBD Pipe 1:

$$\theta = 90° - 2\tan^{-1}\frac{3}{4} = 16.2602°$$

$$\nearrow \Sigma F_{x'} = 0: \quad N_F \cos(16.2602°) - 132 \text{ lb} - \frac{3}{5}(220 \text{ lb}) = 0$$

$$N_F = 275.00 \text{ lb}$$

$$\nwarrow \Sigma F_{y'} = 0: \quad N_C + (275 \text{ lb})\cos(16.2602°) - \frac{4}{5}(220 \text{ lb}) = 0$$

$$N_C = 99.00 \text{ lb}$$

FBD Frame & Pipes:

$$\circlearrowleft \Sigma M_A = 0: \quad (48 \text{ in.})\, E_y - \left\{24 \text{ in.} + \left[24 \text{ in.} + \frac{4}{5}(10 \text{ in.})\right]\right\}(220 \text{ lb}) = 0$$

$$E_y = 256\frac{2}{3} \text{ lb}, \qquad \mathbf{E}_y = 257 \text{ lb} \uparrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad A_y - 2(220 \text{ lb}) + 256\frac{2}{3} \text{ lb} = 0$$

$$A_y = 183\frac{1}{3} \text{ lb} \qquad \mathbf{A}_y = 183.3 \text{ lb} \uparrow \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad A_x - E_x = 0, \qquad A_x = E_x$$

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FBD *BE*:

$$\circlearrowleft \Sigma M_B = 0: \quad (24 \text{ in.})\left(256\,\frac{2}{3} \text{ lb}\right) - (18 \text{ in.})\,E_x + \left(\frac{15}{4} \text{ in.}\right)(275 \text{ lb}) = 0$$

$E_x = 399.5$ lb, $\qquad \mathbf{E}_x = 400 \text{ lb} \longleftarrow$ ◀

From above, $\qquad \mathbf{A}_x = 400 \text{ lb} \longrightarrow$ ◀

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Chapter 6, Solution 93.

FBD Pipe 2:

$$\nearrow \Sigma F_{x'} = 0: \quad N_G - \frac{3}{5}(220 \text{ lb}) = 0, \qquad N_G = 132 \text{ lb}$$

$$\nwarrow \Sigma F_{y'} = 0: \quad N_D - \frac{4}{5}(220 \text{ lb}) = 0, \qquad N_D = 176 \text{ lb}$$

FBD Pipe 1:

$$\nearrow \Sigma F_{x'} = 0: \quad N_F - \frac{3}{5}(220 \text{ lb}) - 132 \text{ lb} = 0, \qquad N_F = 264 \text{ lb}$$

$$\nwarrow \Sigma F_{y'} = 0: \quad N_C - \frac{4}{5}(220 \text{ lb}) = 0, \qquad N_C = 176 \text{ lb}$$

FBD *BE*:

$$\circlearrowleft \Sigma M_B = 0: \quad (24 \text{ in.})\, E_y - (32 \text{ in.})\, E_x + (5 \text{ in.})(264 \text{ lb}) = 0$$

$$4E_x - 3E_y = 165 \qquad (1)$$

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FBD Frame with Pipes:

$$\circlearrowleft \Sigma M_A = 0: (48 \text{ in.})\, E_y - (14 \text{ in.})\, E_x + (5 \text{ in.})(264 \text{ lb})$$

$$- (35 \text{ in.} + 45 \text{ in.})(176 \text{ lb}) = 0 \qquad (2)$$

solving with (1) above:

$$E_y = 355\,\frac{2}{3} \text{ lb}, \qquad \mathbf{E}_y = 356 \text{ lb} \uparrow \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad A_x - 308 \text{ lb} - \frac{4}{5}(264 \text{ lb}) + \frac{3}{5} \cdot 2\,(176 \text{ lb}) = 0$$

$$\mathbf{A}_x = 308 \text{ lb} \rightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad A_y + 355\,\frac{2}{3} \text{ lb} - \frac{3}{5}(264 \text{ lb}) - \frac{4}{5} \cdot 2\,(176 \text{ lb}) = 0$$

$$\mathbf{A}_y = 84.3 \text{ lb} \uparrow \blacktriangleleft$$

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Chapter 6, Solution 94.

FBD *AC*:

$$\circlearrowleft \Sigma M_c = 0: \quad (0.6\text{ m})\,A_x - (0.06\text{ m})(170\text{ N}) = 0,$$

$$\mathbf{A}_x = 17.00\text{ N} \leftarrow \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad -17\text{ N} + \frac{15}{17}(170\text{ N}) - C_x = 0, \qquad C_x = 133\text{ N}$$

FBD *CE*:

$$\rightarrow \Sigma F_x = 0: \quad 133\text{ N} - \frac{15}{17}(170\text{ N}) + E_x = 0,$$

$$\mathbf{E}_x = 17.00\text{ N} \rightarrow \blacktriangleleft$$

$$\circlearrowleft \Sigma M_C = 0: \quad (0.48\text{ m})(17.00\text{ N}) + (0.90\text{ m})\,E_y - (0.45\text{ m})(170\text{ N}) = 0,$$

$$\mathbf{E}_y = 75.9\text{ N} \uparrow \blacktriangleleft$$

FBD Frame:

$$\uparrow \Sigma F_y = 0: \quad A_y - 170\text{ N} + 75.9\text{ N} = 0,$$

$$\mathbf{A}_y = 94.1\text{ N} \uparrow \blacktriangleleft$$

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Chapter 6, Solution 95.

FBD Frame & pulley:

$\circlearrowleft \Sigma M_B = 0: \quad (0.6\text{ m})\, A_y - (0.075\text{ m})(240\text{ N}) = 0,$

$\mathbf{A}_y = 30.0\text{ N} \downarrow$ ◀

$\uparrow \Sigma F_y = 0: \quad -30.0\text{ N} + B_y - 240\text{ N} = 0,$

$\mathbf{B}_y = 270\text{ N} \uparrow$ ◀

$\rightarrow \Sigma F_x = 0: \quad -A_x + B_x = 0, \qquad A_x = B_x$

FBD *AD*:

$\circlearrowleft \Sigma M_D = 0: \quad (0.200\text{ m})\, A_x - (0.075\text{ m})(240\text{ N})$
$+ (0.30\text{ m})(30\text{ N}) = 0$

$\mathbf{A}_x = 45.0\text{ N} \leftarrow$ ◀

From above $\quad A_x = B_x, \qquad \mathbf{B}_x = 45.0\text{ N} \rightarrow$ ◀

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Chapter 6, Solution 96.

(*a*)

FBD Entire machine:

$\circlearrowleft \Sigma M_A = 0$: $(95 \text{ in.})(16 \text{ kips}) - (35 \text{ in.})(18 \text{ kips}) + (145 \text{ in.})(2B)$

$-(170 \text{ in.})(50 \text{ kips}) = 0,$

$B = 26.241 \text{ kips}$ $\qquad$ $\mathbf{B} = 26.2 \text{ kips} \uparrow$ ◀

$\uparrow \Sigma F_y = 0$: $-16 \text{ kips} + 2A - 18 \text{ kips} + 2(26.241 \text{ kips}) - 50 \text{ kips} = 0,$

$\mathbf{A} = 15.76 \text{ kips} \uparrow$ ◀

(*b*)

FBD Motor unit:

$\circlearrowleft \Sigma M_D = 0$: $(30 \text{ in.})C_x + (85 \text{ in.})(52.482 \text{ kips}) - (110 \text{ in.})(50 \text{ kips}) = 0$

$C_x = 34.634 \text{ kips},$ $\qquad$ $\mathbf{C}_x = 34.6 \text{ kips} \leftarrow$ ◀

$\rightarrow \Sigma F_x = 0$: $D_x - 34.634 \text{ kips} = 0,$ $\qquad$ $\mathbf{D}_x = 34.6 \text{ kips} \rightarrow$ ◀

$\uparrow \Sigma F_y = 0$: $52.482 \text{ kips} - 50 \text{ kips} - D_y = 0,$

$\mathbf{D}_y = 2.48 \text{ kips} \downarrow$ ◀

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Chapter 6, Solution 97.

(*a*)

FBD Entire Machine:

where **A** and **B** are single wheel forces

$\circlearrowleft \Sigma M_A = 0$: $(145 \text{ in.})(2B) - (35 \text{ in.})(18 \text{ kips})$

$- (170 \text{ in.})(50 \text{ kips}) = 0$

$2B = 62.966 \text{ kips}$, $\mathbf{B} = 31.5 \text{ kips} \uparrow$ ◀

$\uparrow \Sigma F_y = 0$: $2A + 62.966 \text{ kips} - 18 \text{ kips} - 50 \text{ kips} = 0$

$2A = 5.034 \text{ kips}$, $\mathbf{A} = 2.52 \text{ kips} \uparrow$ ◀

(*b*)

FBD Motor unit:

$\circlearrowleft \Sigma M_D = 0$: $(85 \text{ in.})(62.966 \text{ kips}) - (110 \text{ in.})(50 \text{ kips})$

$+ (30 \text{ in.})\, C_x = 0$, $C_x = 4.9297 \text{ kips}$

$\mathbf{C}_x = 4.93 \text{ kips} \rightarrow$ ◀

$\uparrow \Sigma F_y = 0$: $-D_y - 50 \text{ kips} + 62.966 \text{ kips} = 0$

$\mathbf{D}_y = 12.97 \text{ kips} \downarrow$ ◀

$\rightarrow \Sigma F_x = 0$: $D_x - C_x = 0$, $D_x = C_x$,

$\mathbf{D}_x = 4.93 \text{ kips} \rightarrow$ ◀

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Chapter 6, Solution 98.

FBD Frame:

$\circlearrowleft \Sigma M_A = 0$: $(0.625\text{ m})\,F - (0.75\text{ m})(4\text{ kN}) - (1.25\text{ m})(3\text{ kN}) = 0$

$\mathbf{F}_x = 10.8\text{ kN} \rightarrow$

$\rightarrow \Sigma F_x = 0$: $A_x - 10.8\text{ kN} = 0,$ $\mathbf{A}_x = 10.80\text{ kN} \leftarrow$ ◀

$\uparrow \Sigma F_y = 0$: $A_y - 4\text{ kN} - 3\text{ kN} = 0,$ $\mathbf{A}_y = 7.00\text{ kN} \uparrow$ ◀

FBD *BF*: (I)

FBD *ABD*: (II)

I: $\circlearrowleft \Sigma M_C = 0$: $(0.375\text{ m})(10.8\text{ kN}) - (0.25\text{ m})\,B_x = 0,\ B_x = 16.2\text{ kN},$ $\mathbf{B}_x = 16.20\text{ kN} \leftarrow$ ◀

II: $\circlearrowleft \Sigma M_D = 0$: $(0.25\text{ m})(10.8\text{ kN} + 16.2\text{ kN}) + (0.5\text{ m})\,B_y - (1.00\text{ m})(7.0\text{ kN}) = 0,$

$B_y = 0.5\text{ kN},$ $\mathbf{B}_y = 500\text{ N} \downarrow$ ◀

$\rightarrow \Sigma F_x = 0$: $-10.8\text{ kN} - 16.20\text{ kN} + D_x = 0,$ $D_x = 27\text{ kN},$ $\mathbf{D}_x = 27.0\text{ kN} \rightarrow$ ◀

$\uparrow \Sigma F_y = 0$: $7.0\text{ kN} - 0.5\text{ kN} - D_y = 0,$ $D_y = 6.5\text{ kN},$ $\mathbf{D}_y = 6.50\text{ kN} \downarrow$ ◀

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Chapter 6, Solution 99.

FBD Frame:

$\circlearrowleft \Sigma M_A = 0$: $\quad (0.3\text{ m})\, D_x = -(0.4\text{ m})(900\text{ N}) = 0, \qquad D_x = 1200\text{ N}$

$\mathbf{D}_x = 1.200\text{ kN} \rightarrow$

$\rightarrow \Sigma F_x = 0$: $\quad 1.200\text{ kN} - A_x = 0, \quad A_x = 1.200\text{ kN}, \quad \mathbf{A}_x = 1.200\text{ kN} \leftarrow$

$\uparrow \Sigma F_y = 0$: $\quad A_y - 900\text{ N} = 0 \qquad \mathbf{A}_y = 900\text{ N} \uparrow$

Note: AG is a two-force member.

$\circlearrowleft \Sigma M_A = 0$: $\quad (0.2\text{ m})\left[B_y - (0.4\text{ m})(900\text{ N})\right] = 0, \qquad B_y = 1800\text{ N}$

FBD *AC*:

$\uparrow \Sigma F_y = 0$: $\quad 900\text{ N} + 1800\text{ N} - 900\text{ N} - \frac{3}{5} F_{AG} = 0$

$F_{AG} = 3000\text{ N} \quad \left(F_{AGx} = 2400\text{ N},\ F_{AGy} = 1800\text{ N}\right)$

$\rightarrow \Sigma F_x = 0$: $\quad -\frac{4}{5}(3000\text{ N}) - 1200\text{ N} + B_x = 0, \quad B_x = 3600\text{ N}$

On *GBEH*: $\quad \mathbf{G}_x = 2.40\text{ kN} \rightarrow, \qquad \mathbf{G}_y = 1.800\text{ kN} \uparrow \blacktriangleleft$

$\mathbf{B}_x = 3.60\text{ kN} \leftarrow, \qquad \mathbf{B}_y = 1.800\text{ kN} \downarrow \blacktriangleleft$

FBD *DF*:

$\circlearrowleft \Sigma M_E = 0$: $\quad -(0.2\text{ m})\frac{3}{5} F_{DH} = 0, \qquad F_{DH} = 0$

$\rightarrow \Sigma F_x = 0$: $\quad 1200\text{ N} - E_x = 0 \qquad E_x = 1200\text{ N}$

$\uparrow \Sigma F_y = 0$: $\quad E_y = 0$

On *GBEH*: $\quad \mathbf{E}_x = 1.200\text{ kN} \rightarrow, \qquad \mathbf{E}_y = 0 \blacktriangleleft$

$\mathbf{H}_x = 0, \qquad \mathbf{H}_y = 0 \blacktriangleleft$

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Chapter 6, Solution 100.

FBD Frame:

$\circlearrowleft \Sigma M_A = 0$: $(6 \text{ in.})\, D_x - (13.5 \text{ in.})(48 \text{ lb}) - (16.5 \text{ in.})(20 \text{ lb}) = 0$

$D_x = 163 \text{ lb}$

$\rightarrow \Sigma F_x = 0$: $-A_x + 20 \text{ lb} + 48 \text{ lb} + 163 \text{ lb} = 0$

$A_x = 231 \text{ lb}$

$\uparrow \Sigma F_y = 0$: $A_y = 0$

FBD *DE*:

$\circlearrowleft \Sigma M_E = 0$: $(19.5 \text{ in.})(163 \text{ lb}) - (6 \text{ in.})\, B_x = 0$

$B_x = 529.75 \text{ lb}$

$\circlearrowleft \Sigma M_C = 0$: $(4.5 \text{ in.})\, B_y - (7.5 \text{ in.})(231 \text{ lb}) = 0, \quad B_y = 385 \text{ lb}$

On *ABC*: $\mathbf{B}_x = 530 \text{ lb} \rightarrow, \quad \mathbf{B}_y = 385 \text{ lb} \downarrow$

$\rightarrow \Sigma F_x = 0$: $-231 \text{ lb} + 529.75 \text{ lb} - C_x = 0, \quad C_x = 298.75 \text{ lb}$

$\uparrow \Sigma F_y = 0$: $C_y - 385 \text{ lb} = 0, \quad C_y = 385 \text{ lb}$

On *ABC*: $\mathbf{C}_x = 299 \text{ lb} \leftarrow, \quad \mathbf{C}_y = 385 \text{ lb} \uparrow$

FBD *ABC*:

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Chapter 6, Solution 101.

FBD Frame:

$\circlearrowleft \Sigma M_E = 0: \quad (6 \text{ in.})(84 \text{ lb}) - (42 \text{ in.})\, A_y = 0$

$A_y = 12.00 \text{ lb}$

FBD *CF*: (I)

FBD *ABC*: (II)

I: $\circlearrowleft \Sigma M_D = 0: \quad (3.5 \text{ in.})\, C_x + (7 \text{ in.})\, C_y - (5 \text{ in.})(84 \text{ lb}) = 0, \qquad C_x + 2C_y = 120 \text{ lb}$

II: $\circlearrowleft \Sigma M_B = 0: \quad (12 \text{ in.})\, C_y - (3.5 \text{ in.})\, C_x - (12 \text{ in.})(12 \text{ lb}) = 0, \qquad 3.5\, C_x - 12\, C_y = 144 \text{ lb}$

Solving: $\quad C_x = 60.632 \text{ lb}, \qquad C_y = 29.684 \text{ lb}$

On *ABC*: $\quad \mathbf{C}_x = 60.6 \text{ lb} \rightarrow \qquad \mathbf{C}_y = 29.7 \text{ lb} \uparrow$ ◀

II: $\rightarrow \Sigma F_x = 0: \quad -B_x + 60.632 \text{ lb} = 0, \qquad B_x = 60.632 \text{ lb}, \qquad \mathbf{B}_x = 60.6 \text{ lb} \leftarrow$ ◀

$\uparrow \Sigma F_y = 0: \quad 12 \text{ lb} + B_y + 29.684 \text{ lb} = 0, \qquad B_y = -41.684 \text{ lb}, \qquad \mathbf{B}_y = 41.7 \text{ lb} \downarrow$ ◀

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Chapter 6, Solution 102.

FBD Stool:

$$\frac{w}{2} = \frac{1}{2}(56\text{ kg})\left(9.81\ \frac{\text{N}}{\text{kg}}\right) = 274.68\text{ N}$$

$$\circlearrowleft \Sigma M_A = 0: \quad (0.350\text{ m})\,B_y - (0.150\text{ m})(274.68\text{ N}) = 0,$$

$$B_y = 117.72\text{ N}$$

FBD *BE*:

$$\circlearrowleft \Sigma M_E = 0: \quad (1.25\text{ m})(117.72\text{ N}) - (0.15\text{ m})\left(\frac{1}{\sqrt{2}}\,F_{FG}\right) = 0$$

$$F_{FG} = 98.1\sqrt{2}\text{ N}$$

$$\rightarrow \Sigma F_x = 0: \quad E_x - \frac{1}{\sqrt{2}}(98.1\sqrt{2})\text{ N} = 0, \qquad \mathbf{E}_x = 98.1\text{ N} \rightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad -E_y + \frac{1}{\sqrt{2}}(98.1\sqrt{2}\text{ N}) + 117.72\text{ N} = 0$$

$$E_y = 215.82\text{ N}, \qquad \mathbf{E}_y = 216\text{ N} \downarrow \blacktriangleleft$$

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Chapter 6, Solution 103.

FBD *BC*:

Note that only **one** of the forces $\mathbf{B}_y$, $\mathbf{B}'_y$ exists.

$$\circlearrowleft \Sigma M_C = 0: \quad M_C\left(B_y \text{ or } B'_y\right) - \left(0.15 \text{ m}\right)\frac{1}{\sqrt{2}} F_{FG} = 0$$

$$F_{FG} = \left(\frac{\sqrt{2}}{0.15 \text{ m}}\right) M_C\left(B_y \text{ or } B'_y\right) \qquad (1)$$

So we seek a maximum of $M_C\left(B_y \text{ or } B'_y\right)$

where $\quad M_C\left(B_y\right) = \left(0.125 \text{ m}\right) B_y$

$$M_C\left(B'_y\right) = \left(0.175 \text{ m}\right) B'_y$$

$$w = \left(56 \text{ kg}\right)\left(9.81 \text{ N/kg}\right) = 549.36 \text{ N}$$

FBD stool:

consider contact at A', $\mathbf{A}_y = 0$, either

$$\circlearrowleft \Sigma M_{A'} = \left(0.425 \text{ m}\right) B_y - \left(0.225 \text{ m}\right)\frac{w}{2} = 0$$

$$B_y = 0.26471\, w, \qquad M_C\left(B_y\right) = \left(0.03309 \text{ m}\right) w \qquad \text{(i)}$$

or $\left(M_{A'}\right) = \left(0.475 \text{ m}\right) B'_y - \left(0.225 \text{ m}\right)\dfrac{w}{2} = 0$

$$B'_y = \left(0.23684\right) w, \quad M_C\left(B'_y\right) = \left(0.04145 \text{ m}\right) w \qquad \text{(ii)}$$

consider contact at A, $\mathbf{A}'_y = 0$, either

$$\circlearrowleft \Sigma M_A = 0: \quad \left(0.35 \text{ m}\right) B_y - \left(0.15 \text{ m}\right)\frac{w}{2} = 0$$

$$B_y = 0.21429\, w, \quad M_C\left(B_y\right) = \left(0.02678 \text{ m}\right) w \qquad \text{(iii)}$$

or $\circlearrowleft \Sigma M_A = 0: \quad \left(0.40 \text{ m}\right) B'_y - \left(0.15 \text{ m}\right)\dfrac{w}{2} = 0$

$$B'_y = 0.1875\, w, \quad M_C\left(B'_y\right) = \left(0.03281 \text{ m}\right) w \qquad \text{(iv)}$$

(*a*) The maximum is (ii), with contact at A' and B', and ◀

(*b*) $F_{FG\,\max} = \left(\dfrac{\sqrt{2}}{0.15 \text{ m}}\right)\left(0.04145 \text{ m}\right)\left(549.36 \text{ N}\right) = 214.69 \text{ N},$

$F_{FG\,\max} = 215 \text{ N T}$ ◀

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Chapter 6, Solution 104.

Members FBDs:

I: $\circlearrowleft \Sigma M_A = 0$: $(12.8\text{ ft})B_x - (32\text{ ft})B_y - (20\text{ ft})(14\text{ kips}) = 0$

II: $\circlearrowright \Sigma M_C = 0$: $(7.2\text{ ft})B_x + (24\text{ ft})B_y - (12\text{ ft})(21\text{ kips}) = 0$

Solving: $B_x = 27.5$ kips, $B_y = 2.25$ kips,

I: $\rightarrow \Sigma F_x = 0$: $A_x - 27.5\text{ kips} = 0$, $A_x = 27.5$ kips, (*a*)

$\mathbf{A}_x = 27.5$ kips $\rightarrow$ ◀

$\uparrow \Sigma F_y = 0$: $A_y - 14\text{ kips} - 2.25\text{ kips} = 0$, $A_y = 16.25$ kips, $\mathbf{A}_y = 16.25$ kips $\uparrow$ ◀

(*b*) $\mathbf{B}_x = 27.5$ kips $\leftarrow$ ◀

$\mathbf{B}_y = 2.25$ kips $\downarrow$ ◀

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Chapter 6, Solution 105.

Member FBDs:

II: $\circlearrowleft\ \Sigma M_C = 0$: $(7.2\text{ ft})\,B_x - (24\text{ ft})\,B_y - (12\text{ ft})(14\text{ kips}) = 0$

I: $\circlearrowright\ \Sigma M_A = 0$: $(12.8\text{ ft})\,B_x + (32\text{ ft})\,B_y - (20\text{ ft})(21\text{ kips}) = 0$

Solving: $B_x = 28.75$ kips, $B_y = 1.675$ kips,

I: $\rightarrow\ \Sigma F_x = 0$: $A_x - 28.75\text{ kips} = 0$, $A_x = 28.75$ kips, (*a*)

$\mathbf{A}_x = 28.8$ kips $\rightarrow$ ◀

$\uparrow\ \Sigma F_y = 0$: $A_y - 21\text{ kips} + 1.625\text{ kips}$, $A_y = 19.375$ kips , $\mathbf{A}_y = 19.38$ kips $\uparrow$ ◀

(*b*) $\mathbf{B}_x = 28.8$ kips $\leftarrow$ ◀

$\mathbf{B}_y = 1.625$ kips $\uparrow$ ◀

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Chapter 6, Solution 106.

FBD Frame:

$\circlearrowleft \Sigma M_A = 0$: $\quad (12 \text{ in.})\, D_x - (28 \text{ in.})(411 \text{ lb}) = 0$

$$\mathbf{D}_x = 959 \text{ lb} \rightarrow$$

FBD *DF*:

Note that *BF* and *CE* are two-force members.

$\rightarrow \Sigma F_x = 0$: $\quad 959 \text{ lb} + \frac{4}{5} F_{CE} - \frac{15}{17} F_{BF} = 0$

$\circlearrowleft \Sigma M_D = 0$: $\quad (12 \text{ in.})\left(\frac{3}{5} F_{CE}\right) + (34.5 \text{ in.})\left(\frac{8}{17} F_{BF}\right) = 0$

Solving: $\quad F_{BF} = 357 \text{ lb},$

$\circlearrowleft \Sigma M_E = 01$: $\quad (22.5 \text{ in.})\left[\frac{8}{17}(357 \text{ lb})\right] - (12 \text{ in.})\, D_y = 0$

$\mathbf{D}_y = 315 \text{ lb} \uparrow$, so (a) $\mathbf{D} = 1009 \text{ lb} \measuredangle 18.18° \blacktriangleleft$

(b) $F_{BF} = 357 \text{ lb T} \blacktriangleleft$

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Chapter 6, Solution 107.

FBD Frame:

$$\circlearrowleft \Sigma M_A = 0: \quad (12 \text{ in.})\, D_x - (34.5 \text{ in.})(274 \text{ lb}) = 0$$

$$D_x = 787.75 \text{ lb}$$

FBD *DF*:

$$\circlearrowleft \Sigma M_D = 0: \quad (12 \text{ in.})\left(\frac{3}{5} F_{CE}\right) + (34.5 \text{ in.})\left(\frac{8}{17} F_{BF} - 274 \text{ lb}\right) = 0$$

$$\rightarrow \Sigma F_x = 0: \quad 787.75 \text{ lb} + \frac{4}{5} F_{CE} - \frac{15}{17} F_{BF} = 0$$

Solving: $\quad F_{BF} = 684.25 \text{ lb},$

$$\circlearrowleft \Sigma M_E = 0: \quad (22.5 \text{ in.})\left[\frac{8}{17}(684.25 \text{ lb}) - 274 \text{ lb}\right] - (12 \text{ in.})\, D_y = 0$$

$D_y = 90$ lb, so (a) $\mathbf{D} = 793 \text{ lb} \measuredangle 6.52°$ ◀

(b) $F_{BF} = 684 \text{ lb T}$ ◀

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Chapter 6, Solution 108.

FBD *AC*:

Note that *BE* is a two force member

$$\uparrow \Sigma F_y = 0: \quad \frac{1}{\sqrt{5}} F_{BE} - P = 0$$

$$F_{BE} = \sqrt{5}\, P$$

$$\circlearrowleft \Sigma M_A = 0: \quad (0.4\text{ m})\left[\frac{1}{\sqrt{5}}\left(\sqrt{5}\,P\right)\right] + (0.1\text{ m})\left[\frac{2}{\sqrt{5}}\left(\sqrt{5}\,P\right)\right]$$

$$-aP + (0.3\text{ m})C = 0$$

so $\quad (a - 0.6\text{ m})P = (0.3\text{ m})C$

since $P > 0$ and $C \geq 0$, $a - 0.6\text{ m} \geq 0$

$a \geq 0.6\text{ m}$ ◀

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Chapter 6, Solution 109.

Member FBDs:

$$\circlearrowleft \Sigma M_A = 0: \quad (0.6\text{ m})\frac{4}{5}F_{CF} - (0.9\text{ m})\left(\frac{4}{5}F_{DG}\right) = 0$$

$$\circlearrowleft \Sigma M_E = 0: \quad -(0.3\text{ m})\frac{4}{5}F_{CF} + (0.6\text{ m})\frac{4}{5}F_{DG} - (0.9\text{ m})(800\text{ N}) = 0$$

Solving: $F_{CF} = 9000$ N, $F_{DG} = 6000$ N

$F_{CF} = 9.00$ kN C ◀

$F_{DG} = 6.00$ kN T ◀

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Chapter 6, Solution 110.

Member FBDs:

$$\circlearrowleft \Sigma M_A = 0: \quad (0.3\text{ m})F_{BF} - (0.9\text{ m})\frac{4}{5}F_{DG} = 0$$

$$\circlearrowleft \Sigma M_E = 0: \quad -(0.3\text{ m})F_{BF} + (0.6\text{ m})\frac{4}{5}F_{DG} - (0.9\text{ m})(0.8\text{ kN}) = 0$$

Solving: $F_{BE} = -3$ kN, $F_{BF} = -7.2$ kN

so $F_{BF} = 7.20$ kN T ◀

$F_{DG} = 3.00$ kN C ◀

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Chapter 6, Solution 111.

Member FBDs:

$$\circlearrowleft \Sigma M_A = 0: \quad (0.6\text{ m})\frac{4}{5}F_{CH} - (0.3\text{ m})\frac{4}{5}F_{BG} = 0$$

$$\circlearrowleft \Sigma M_E = 0: \quad -(0.9\text{ m})\frac{4}{5}F_{CH} + (0.6\text{ m})\frac{4}{5}F_{BG} - (0.9\text{ m})(0.8\text{ kN}) = 0$$

Solving: $F_{BG} = 6$ kN, $F_{CH} = 3$ kN

so $F_{BG} = 6.00$ kN T ◀

$F_{CH} = 3.00$ kN C ◀

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Chapter 6, Solution 112.

Member FBDs:

I: $\circlearrowleft \Sigma M_J = 0$: $\quad 2a\,C_y + a\,C_x - a\,P = 0$ $\qquad$ II: $\circlearrowleft \Sigma M_K = 0$: $\quad 2a\,C_y - a\,C_x = 0$

Solving: $\quad C_x = \dfrac{P}{2}, \quad C_y = \dfrac{P}{4}$

I: $\rightarrow \Sigma F_x = 0$: $\quad \dfrac{1}{\sqrt{2}} F_{BG} - C_x = 0, \quad F_{BG} = \sqrt{2} C_x = \dfrac{\sqrt{2}}{2} P,$ $\qquad F_{BG} = 0.707\ P$ T ◀

$\uparrow \Sigma F_y = 0$: $\quad F_{AF} + \dfrac{1}{\sqrt{2}}\left(\dfrac{\sqrt{2}}{2} P\right) - P + \dfrac{P}{4} = 0, \quad F_{AF} = \dfrac{P}{4},$ $\qquad F_{AF} = 0.250\ P$ T ◀

II: $\rightarrow \Sigma F_x = 0$: $\quad C_x - \dfrac{1}{\sqrt{2}} F_{DG} = 0, \quad F_{DG} = \sqrt{2} C_x = \dfrac{\sqrt{2}}{2} P,$ $\qquad F_{DG} = 0.707\ P$ T ◀

$\uparrow \Sigma F_y = 0$: $\quad -\dfrac{P}{4} + \dfrac{1}{\sqrt{2}}\left(\dfrac{\sqrt{2}}{2} P\right) + F_{EH} = 0, \quad F_{EH} = -\dfrac{P}{4}$ $\qquad F_{EH} = 0.250\ P$ C ◀

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Chapter 6, Solution 113.

Note that, if we assume P is applied to BF, each individual member FBD looks like:

so $$F_{\text{short}} = 2F_{\text{long}} = \frac{2}{3}F_{\text{load}}$$

(by moment equations about S and L).

Labeling each interaction force with the letter corresponding to the joint of application, we have:

$$F = \frac{2(P+E)}{3} = 2B$$

$$E = \frac{C}{3} = \frac{D}{2}$$

$$C = \frac{B}{3} = \frac{A}{2}$$

so $$\frac{2(P+E)}{3} = 2B = 6C = 18E \qquad P + E = 27E \qquad \mathbf{E} = \frac{P}{26}\uparrow$$

so $$\mathbf{D} = 2\mathbf{E} = \frac{P}{13}\uparrow \quad ◀$$

$$A = 2C = 3E \qquad \mathbf{A} = \frac{3P}{13}\uparrow \quad ◀$$

$$F = \frac{2}{3}\left(P + \frac{P}{26}\right) \qquad \mathbf{F} = \frac{9P}{13}\uparrow \quad ◀$$

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Chapter 6, Solution 114.

Note that, if we assume P is applied to EG, each individual member FBD looks like

so $$2F_{\text{left}} = 2F_{\text{right}} = F_{\text{middle}}$$

Labeling each interaction force with the letter corresponding to the joint of its application, we see that

$$B = 2A = 2F$$

$$C = 2B = 2D$$

$$G = 2C = 2H$$

$$P + F = 2G\left(=4C = 8B = 16F\right) = 2E$$

From $$P + F = 16F, \quad F = \frac{P}{15}$$ so $$\mathbf{A} = \frac{P}{15}\uparrow \quad ◀$$

$$\mathbf{D} = \frac{2P}{15}\uparrow \quad ◀$$

$$\mathbf{H} = \frac{4P}{15}\uparrow \quad ◀$$

$$\mathbf{E} = \frac{8P}{15}\uparrow \quad ◀$$

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Chapter 6, Solution 115.

(*a*) **Member FBDs:**

FBD II: $\uparrow \Sigma F_y = 0$: $B_y = 0$ $\circlearrowleft \Sigma M_B = 0$: $aF_2 = 0$ $F_2 = 0$

FBD I: $\circlearrowleft \Sigma M_A = 0$: $aF_2 - 2aP = 0$ but $F_2 = 0$

so $P = 0$ not rigid for $P \neq 0$ ◀

(*b*) **Member FBDs:**

Note: 7 unknowns $\left(A_x, A_y, B_x, B_y, F_1, F_2, C\right)$ but only 6 independent equations.

System is statically indeterminate ◀

System is, however, rigid ◀

(*c*) **FBD whole:**

FBD right:

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FBD I: $\circlearrowright\ \Sigma M_A = 0: 5aB_y - 2aP = 0 \qquad \mathbf{B}_y = \frac{2}{5}P\uparrow$

$\uparrow\ \Sigma F_y = 0: A_y - P + \frac{2}{5}P = 0 \qquad \mathbf{A}_y = \frac{3}{5}P\uparrow$

FBD II: $\circlearrowleft\ \Sigma M_c = 0: \frac{a}{2}B_x - \frac{5a}{2}B_y = 0 \qquad B_x = 5B_y \qquad \mathbf{B}_x = 2P \rightarrow$

FBD I: $\rightarrow\ \Sigma F_x = 0: A_x + B_x = 0 \qquad A_x = -B_x \qquad \mathbf{A}_x = 2P \leftarrow$

$\mathbf{A} = 2.09P \searrow 16.70°$ ◀

$\mathbf{B} = 2.04P \nearrow 11.31°$ ◀

System is rigid ◀

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Chapter 6, Solution 116.

Note: In all three cases, the right member has only three forces acting, two of which are parallel. Thus the third force, at B, must be parallel to the link forces.

(a) **FBD whole:**

$\circlearrowleft \Sigma M_A = 0$: $\quad -2aP - \dfrac{a}{4}\dfrac{4}{\sqrt{17}}B + 5a\dfrac{1}{\sqrt{17}}B = 0 \qquad B = 2.06P \qquad \mathbf{B} = 2.06P \searrow 14.04°$ ◀

$\rightarrow \Sigma F_x = 0$: $\quad A_x - \dfrac{4}{\sqrt{17}}B = 0 \qquad \mathbf{A}_x = 2P \leftarrow$

$\uparrow \Sigma F_y = 0$: $\quad A_y - P + \dfrac{1}{\sqrt{17}}B = 0 \qquad \mathbf{A}_y = \dfrac{P}{2} \uparrow \qquad \mathbf{A} = 2.06P \nearrow 14.04°$ ◀

rigid ◀

(b) **FBD whole:**

Since **B** passes through A, $\circlearrowleft \Sigma M_A = 2aP = 0$ only if $P = 0$

$\therefore$ no equilibrium if $P \neq 0$ not rigid ◀

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(*c*) **FBD whole:**

$$\circlearrowleft \Sigma M_A = 0: \; 5a\frac{1}{\sqrt{17}}B + \frac{3a}{4}\frac{4}{\sqrt{17}}B - 2aP = 0 \qquad B = \frac{\sqrt{17}}{4}P \qquad \mathbf{B} = 1.031P \angle 14.04° \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \; A_x + \frac{4}{\sqrt{17}}B = 0 \qquad A_x = -P$$

$$\uparrow \Sigma F_y = 0: \; A_y - P + \frac{1}{\sqrt{17}}B = 0 \qquad A_y = P - \frac{P}{4} = \frac{3P}{4} \qquad \mathbf{A} = 1.250P \angle 36.9° \blacktriangleleft$$

System is rigid ◀

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Chapter 6, Solution 117.

(*a*) **Member FBDs:**

FBD I: $\circlearrowleft \Sigma M_A = 0$: $aF_1 - 2aP = 0$ $\quad F_1 = 2P$; $\uparrow \Sigma F_y = 0$: $A_y - P = 0$ $\quad \mathbf{A}_y = P \uparrow$

FBD II: $\circlearrowleft \Sigma M_B = 0$: $-aF_2 = 0$ $\quad F_2 = 0$

$\rightarrow \Sigma F_x = 0$: $B_x + F_1 = 0$, $B_x = -F_1 = -2P$ $\quad \mathbf{B}_x = 2P \rightarrow$

$\uparrow \Sigma F_y = 0$: $B_y = 0$ $\quad$ so $\mathbf{B} = 2P \rightarrow$ ◀

FBD I: $\rightarrow \Sigma F_x = 0$: $-A_x - F_1 + F_2 = 0$ $\quad A_x = F_2 - F_1 = 0 - 2P$ $\quad \mathbf{A}_x = 2P \rightarrow$

so $\mathbf{A} = 2.24P \measuredangle 26.6°$ ◀

Frame is rigid ◀

(*b*) **FBD left:** **FBD whole:**

FBD I: $\circlearrowleft \Sigma M_E = 0$: $\frac{a}{2}P + \frac{a}{2}A_x - \frac{5a}{2}A_y = 0$ $\quad A_x - 5A_y = -P$

FBD II: $\circlearrowleft \Sigma M_B = 0$: $3aP + aA_x - 5aA_y = 0$ $\quad A_x - 5A_y = -3P$

This is impossible unless $P = 0$ $\therefore$ not rigid ◀

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(*c*) **Member FBDs:**

FBD I: $\Sigma F_y = 0: A - P = 0$ $\qquad$ $\mathbf{A} = P \uparrow$ ◀

$\circlearrowleft \Sigma M_D = 0: aF_1 - 2aA = 0 \qquad F_1 = 2P$

$\rightarrow \Sigma F_x = 0: F_2 - F_1 = 0 \qquad F_2 = 2P$

FBD II: $\circlearrowleft \Sigma M_B = 0: 2aC - aF_1 = 0 \qquad C = \dfrac{F_1}{2} = P$ $\qquad$ $\mathbf{C} = P \uparrow$ ◀

$\rightarrow \Sigma F_x = 0: F_1 - F_2 + B_x = 0 \qquad B_x = P - P = 0$

$\uparrow \Sigma F_x = 0: B_y + C = 0 \qquad B_y = -C = -P$ $\qquad$ $\mathbf{B} = P$ ◀

Frame is rigid ◀

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Chapter 6, Solution 118.

FBD *ABC*:

$$\circlearrowleft \Sigma M_C = 0: \quad \left[0.045\text{ m} + (0.30\text{ m})\sin 30°\right]\left[(400\text{ N})\sin 30°\right]$$

$$+\left[0.030\text{ m} + (0.30\text{ m})\cos 30°\right]\left[(400\text{ N})\cos 30°\right]$$

$$-(0.03\text{ m})\left(\frac{12}{13}F_{BD}\right) - (0.045\text{ m})\left(\frac{5}{13}F_{BD}\right) = 0$$

$$F_{BD} = 3097.64\text{ N}$$

$$\rightarrow \Sigma F_x = 0: \quad \frac{5}{13}(3097.64\text{ N}) - (400\text{ N})\sin 30° - C_x = 0$$

$$\mathbf{C}_x = 991.39\text{ N} \leftarrow$$

$$\uparrow \Sigma F_y = 0: \quad \frac{12}{13}(3097.64\text{ N}) - (400\text{ N})\cos 30° - C_y = 0$$

$$\mathbf{C}_y = 2512.9\text{ N} \downarrow$$

FBD Blade:

(*a*) Vertical component at $D = \frac{12}{13}(3097.64\text{ N})$

$= 2.86\text{ kN}$ ◀

(*b*) $\mathbf{C} = 2.70\text{ kN} \measuredangle 68.5°$ ◀

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Chapter 6, Solution 119.

FBD Blade:

$$\uparrow \Sigma F_y = 0: \quad 3\text{ kN} - \frac{12}{13}F_{BD} = 0: \quad F_{BD} = 3.25\text{ kN C}$$

FBD *ABC*:

$$\circlearrowleft \Sigma M_C = 0: \quad \left[0.045\text{ m} + (0.3\text{ m})\sin 30°\right]P\sin 30°$$

$$+\left[0.030\text{ m} + (0.3\text{ m})\cos 30°\right]P\cos 30°$$

$$-(0.045\text{ m})\frac{5}{13}(3.25\text{ kN})$$

$$-(0.03\text{ m})\frac{12}{13}(3.25\text{ kN}) = 0$$

$$P = 0.41968\text{ kN}$$

so (*a*) $P = 420\text{ N}$ ◀

$$\rightarrow \Sigma F_x = 0: \quad -(0.41968\text{ kN})\sin 30° + \frac{5}{13}(3.25\text{ kN}) - C_x = 0$$

$$\mathbf{C}_x = 1.04016\text{ kN} \leftarrow$$

$$\uparrow \Sigma F_y = 0: \quad -(0.41968\text{ kN})\cos 30° + \frac{12}{13}(3.25\text{ kN}) - C_y = 0$$

$$\mathbf{C}_y = 2.6365\text{ kN} \downarrow$$

so (*b*) $\mathbf{C} = 2.83\text{ kN} \measuredangle 68.5°$ ◀

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Chapter 6, Solution 120.

FBD Stamp *D*:

$\uparrow \Sigma F_y = 0: \quad E - F_{BD}\cos 20° = 0, \quad E = F_{BD}\cos 20°$

FBD *ABC*:

$\circlearrowleft \Sigma M_A = 0: \quad (0.2\text{ m})(\sin 30°)(F_{BD}\cos 20°)$

$+ (0.2\text{ m})(\cos 30°)(F_{BD}\sin 20°)$

$- \left[(0.2\text{ m})\sin 30° + (0.4\text{ m})\cos 15°\right](250\text{ N}) = 0$

$F_{BD} = 793.64\text{ N C}$

and, from above, $E = (793.64\text{ N})\cos 20°$

(*a*) $E = 746\text{ N} \downarrow$ ◀

$\rightarrow \Sigma F_x = 0: \quad A_x - (793.64\text{ N})\sin 20° = 0$

$\mathbf{A}_x = 271.44\text{ N} \rightarrow$

$\uparrow \Sigma F_y = 0: \quad A_y + (793.64\text{ N})\cos 20° - 250\text{ N} = 0$

$\mathbf{A}_y = 495.78\text{ N} \downarrow$

so (*b*) $\mathbf{A} = 565\text{ N} \measuredangle 61.3°$ ◀

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Chapter 6, Solution 121.

FBD Stamp *D*:

$\uparrow \Sigma F_y = 0: \quad 900 \text{ N} - F_{BD}\cos 20° = 0, \qquad F_{BD} = 957.76 \text{ N C}$

(*a*)

FBD *ABC*:

(*b*)

$\circlearrowleft \Sigma M_A = 0: \quad \left[(0.2 \text{ m})(\sin 30°)\right](957.76 \text{ N})\cos 20°$

$+\left[(0.2 \text{ m})(\cos 30°)\right](957.76 \text{ N})\sin 20°$

$-\left[(0.2 \text{ m})\sin 30° + (0.4 \text{ m})\cos 15°\right]P = 0$

$P = 301.70 \text{ N}, \qquad \mathbf{P} = 302 \text{ N} \downarrow$ ◀

$\rightarrow \Sigma F_x = 0: \quad A_x - (957.76 \text{ N})\sin 20° = 0$

$\mathbf{A}_x = 327.57 \text{ N} \rightarrow$

$\uparrow \Sigma F_y = 0: \quad -A_y + (957.76 \text{ N})\cos 20° - 301.70 \text{ N} = 0$

$\mathbf{A}_y = 598.30 \text{ N} \downarrow$

so $\qquad \mathbf{A} = 682 \text{ N} \measuredangle 61.3°$ ◀

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Chapter 6, Solution 122.

FBD *ABC*:

$$\theta = \sin^{-1}\frac{\left[(45\text{ mm})\sin 25° - 10\text{ mm}\right]}{100\text{ mm}} = 5.1739°$$

$$\circlearrowleft \Sigma M_C = 0: \quad (70\text{ mm})(110\text{ N}) - \left[(45\text{ mm})\sin 25°\right]F_{BD}\cos 5.1739°$$

$$+\left[(45\text{ mm})\cos 25°\right]F_{BD}\sin 5.1739° = 0$$

$$F_{BD} = 504.50\text{ N}$$

$$\rightarrow \Sigma F_x = 0: \quad (504.50\text{ N})\cos 5.1739° - (110\text{ N})\sin 25° - C_x = 0, \qquad C_x = 455.96\text{ N}$$

FBD *CE*:

$$\rightarrow \Sigma F_x = 0: \quad 455.96\text{ N} - Q = 0$$

$$Q = 455.96\text{ N}, \qquad (a) \quad \mathbf{Q} = 456\text{ N} \leftarrow \blacktriangleleft$$

$$(b) \quad F_{BD} = 540\text{ N T} \blacktriangleleft$$

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Chapter 6, Solution 123.

Member FBDs:

$$\theta = \tan^{-1}\frac{\left(\overline{BC} + \overline{CD}\right)\sin 60°}{\overline{AF} + \left(\overline{AB} + \overline{BC} - \overline{CD}\right)\cos 60°}$$

$$= \tan^{-1}\frac{(2.5 \text{ in.} + 1 \text{ in.})\sin 60°}{4.5 \text{ in.} + (1.5 \text{ in.} + 2.5 \text{ in.} - 1 \text{ in.})\cos 60°}$$

$$\theta = 26.802°$$

From FBD *CDE*:

$$\circlearrowleft \Sigma M_C = 0: \quad (7.5 \text{ in.})(20 \text{ lb}) - (1 \text{ in.})F_{DF}\cos(30° - 26.802°) = 0,$$

$$F_{DF} = 150.234 \text{ lb C}$$

$$\rightarrow \Sigma F_x = 0: \quad (150.234 \text{ lb})\cos(26.802°) - (20 \text{ lb})\sin 60° - C_x = 0,$$

$$C_x = 116.774 \text{ lb}$$

$$\uparrow \Sigma F_y = 0: \quad (150.234 \text{ lb})\sin 26.802° - (20 \text{ lb})\cos 60° - C_y = 0$$

$$C_y = 57.742 \text{ lb}$$

From FBD *ABC*:

$$\circlearrowleft \Sigma M_A = 0: \quad \left[(1.5 \text{ in.})\sin 60°\right]B_x + \left[(1.5 \text{ in.})\cos 60°\right]B_y - \left[(4 \text{ in.})\sin 60°\right](116.774 \text{ lb})$$

$$+\left[(4 \text{ in.})\cos 60°\right](57.742 \text{ lb}) = 0, \qquad \sqrt{3}B_x + B_y = 385.37 \text{ lb} \qquad (1)$$

continued

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From FBD *BFG*:

$$\circlearrowleft \Sigma M_G = 0: \quad -(1.5\text{ in.})\left[(150.234\text{ lb})\sin 26.802°\right] + \left[(1.5\text{ in.})\cos 30°\right]\left[(150.234\text{ lb})\cos 26.802°\right]$$
$$-\left[(1.5\text{ in.})\cos 30°\right]B_x - \left[6\text{ in.} + (1.5\text{ in.})\sin 30°\right]B_y = 0, \qquad \sqrt{3}B_x - 9B_y = 96.775\text{ lb} \qquad (2)$$

Solving (1) and (2): $B_x = 243.32$ lb, $B_y = -36.075$ lb

$$\rightarrow \Sigma F_x = 0: \quad 243.32\text{ lb} - (150.234\text{ lb})\cos 26.802° - G_x = 0, \qquad \mathbf{G}_x = 109.226\text{ lb} \leftarrow$$

$$\uparrow \Sigma F_y = 0: \quad G_y - (150.234\text{ lb})\sin 26.802° + 36.075\text{ lb} = 0, \qquad \mathbf{G}_y = 31.667\text{ lb} \uparrow$$

On G, $\mathbf{G} = 113.7\text{ lb} \searrow 16.17° \blacktriangleleft$

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Chapter 6, Solution 124.

Member FBDs:

$$\theta = \tan^{-1}\frac{\left(\overline{BC} + \overline{CD}\right)\sin 60°}{\overline{AF} + \overline{AB}\cos 75° + \left(\overline{BC} - \overline{CD}\right)\cos 60°}$$

$$= \tan^{-1}\frac{(2.5\text{ in.} + 1\text{ in.})\sin 60°}{4.5\text{ in.} + (1.5\text{ in.})\cos 75° + \left[(2.5\text{ in.} - 1\text{ in.})\right]\cos 60°}$$

$$\theta = 28.262°$$

From FBD *CDE*:

$$\circlearrowleft \Sigma M_C = 0: \quad (7.5\text{ in.})(20\text{ lb}) - (1\text{ in.})F_{DF}\cos(30° - 28.262°) = 0$$

$$F_{DF} = 150.069\text{ lb}$$

$$\rightarrow \Sigma F_x = 0: \quad (150.069\text{ lb})\cos 28.262° - (20\text{ lb})\sin 60° - C_x = 0$$

$$C_x = 114.859\text{ lb}$$

$$\uparrow \Sigma F_y = 0: \quad (150.069\text{ lb})\sin 28.262° - (20\text{ lb})\cos 60° - C_y = 0$$

$$C_y = 61.058\text{ lb}$$

From FBD *ABC*:

$$\circlearrowleft \Sigma M_A = 0: \quad \left[(1.5\text{ in.})\sin 75°\right]B_x - \left[(1.5\text{ in.})\cos 75°\right]B_y - \left[(1.5\text{ in.})\sin 75° + (2.5\text{ in.})\sin 60°\right](114.859\text{ lb})$$

$$+ \left[(1.5\text{ in.})\cos 75° + (2.5\text{ in.})\cos 60°\right](61.058\text{ lb}) = 0$$

$$\text{or} \quad 1.44889\,B_x - 0.38823\,B_y = 315.07\text{ lb} \qquad (1)$$

continued

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From FBD *BFG*:

$$\circlearrowleft \Sigma M_G = 0: \quad -(1.5\text{ in.})\left[(150.069\text{ lb})\sin 28.262°\right] + \left[(1.5\text{ in.})\cos 15°\right]\left[(150.069\text{ lb})\cos 28.262°\right]$$

$$-\left[(1.5\text{ in.})\cos 15°\right]B_x + \left[(6\text{ in.}) + (1.5\text{ in.})\sin 15°\right]B_y = 0$$

$$\text{or} \quad 1.44889\,B_x - 6.3882\,B_y = 84.926\text{ lb} \qquad (2)$$

Solving (1) and (2): $B_x = 227.74$ lb, $B_y = 38.358$ lb

$$\rightarrow \Sigma F_x = 0: \quad 227.74\text{ lb} - (150.069\text{ lb})\cos 28.262° - G_x = 0, \qquad \mathbf{G}_x = 95.560\text{ lb} \leftarrow$$

$$\uparrow \Sigma F_y = 0: \quad G_y - (150.069\text{ lb})\sin 28.262° + 38.358\text{ lb} = 0, \qquad \mathbf{G}_y = 32.700\text{ lb} \uparrow$$

So force on G is $\mathbf{G} = 101.8\text{ lb} \searrow 18.89°$ ◀

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Chapter 6, Solution 125.

FBD Piston:

$\uparrow \Sigma F_y = 0: \quad 180 \text{ lb} - F_{CE}\cos 20° = 0, \qquad F_{CE} = 191.552 \text{ lb C}$

FBD Joint *C*:

$$\frac{F_{BC}}{\sin 40°} = \frac{191.552°}{\sin 40°}$$

$$F_{BC} = 191.552 \text{ lb}$$

FBD *AB*:

$\circlearrowleft \Sigma M_A = 0: \quad (6 \text{ in.})(191.552 \text{ lb})\cos 30° - M = 0$

$\mathbf{M} = 995 \text{ lb}\cdot\text{in.} \circlearrowright$ ◀

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Chapter 6, Solution 126.

FBD *AB*:

$$\circlearrowleft \Sigma M_A = 0: \quad (6 \text{ in.}) F_{BC} \cos 30° - 660 \text{ lb}\cdot\text{in.} = 0,$$

$$F_{BC} = 127.017 \text{ lb T}$$

FBD Piston:

$$\uparrow \Sigma F_y = 0: \quad 180 \text{ lb} - F_{CE} \cos\phi = 0, \qquad F_{CE} = \frac{180 \text{ lb}}{\cos\phi} \text{ C}$$

FBD Joint *C*:

$$\uparrow \Sigma F_y = 0: \quad \frac{180 \text{ lb}}{\cos\phi} \cos\phi + (127.017 \text{ lb}) \sin 30° \quad - F_{CD} \cos\phi = 0,$$

$$F_{CD} \cos\phi = 243.51 \text{ lb} \qquad (1)$$

$$\rightarrow \Sigma F_x = 0: \quad (127.017 \text{ lb}) \cos 30° - \frac{180 \text{ lb}}{\cos\phi} \sin\phi \quad - F_{CD} \sin\phi = 0$$

$$F_{CD} \sin\phi = 110.000 \text{ lb} - (180 \text{ lb}) \tan\phi \qquad (2)$$

divide (2) by (1) $\qquad \tan\phi = 0.45173 - 0.73919 \tan\phi$

$$\tan\phi = 0.25974, \qquad \phi = 14.56° \blacktriangleleft$$

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Chapter 6, Solution 127.

(*a*) **FBD *E*:**

$\rightarrow \Sigma F_x = 0: \quad F_{DE}\cos\alpha - 160 \text{ N} = 0, \qquad F_{DE} = \dfrac{160 \text{ N}}{\cos\alpha}$

where $\alpha = \tan^{-1}\dfrac{38.8 \text{ mm}}{92.2 \text{ mm}} = 22.823°$, so $F_{DE} = 173.59 \text{ N C}$

FBD Joint *D*:

$$\beta = \tan^{-1}\frac{37.5 \text{ mm} - 18.8 \text{ mm}}{38.8 \text{ mm}} = 25.732°$$

$\nearrow \Sigma F_x = 0: \quad F_{CD}\cos(45° - 25.732°)$

$$-(173.59 \text{ N})\cos(25.732° + 22.823°) = 0$$

$$F_{CD} = 121.717 \text{ N C}$$

FBD *BC*:

$\circlearrowleft \Sigma M_B = 0: \quad (0.045 \text{ m})(121.717 \text{ N})\sin 45° - M = 0,$

$M = 3.873 \text{ N}\cdot\text{m}, \qquad \mathbf{M} = 3.87 \text{ N}\cdot\text{m} \circlearrowright$ ◀

(*b*) **FBD *E*:**

$\rightarrow \Sigma F_x = 0: \quad F_{DE}\cos\alpha - 160 \text{ N} = 0, \qquad F_{DE} = \dfrac{160 \text{ N}}{\cos\alpha}$

where $\alpha = \tan^{-1}\dfrac{20 \text{ mm} + 35.4 \text{ mm} - 26.4 \text{ mm}}{92.2 \text{ mm} + 27.8 \text{ mm} - 24.3 \text{ mm}} = 16.8584°$

so $F_{DE} = 167.185 \text{ N C}$

continued

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FBD Joint *D*:

$$\beta = \tan^{-1}\frac{27.8\text{ mm} - 24.3\text{ mm}}{26.4\text{ mm}} = 7.5520°$$

$$\gamma = \tan^{-1}\frac{20\text{ mm} + 35.4\text{ mm} - 26.4\text{ mm}}{24.3\text{ mm} + 7.5\text{ mm}} = 42.363°$$

$$\nearrow \Sigma F_{y'} = 0: \quad (167.185\text{ N})\sin(16.8584° + 42.363°)$$

$$-F_{CD}\sin(90° - 7.5520° - 42.363°) = 0,$$

$$F_{CD} = 223.07\text{ N C}$$

FBD *BC*:

$$\delta = \tan^{-1}\frac{35.4\text{ mm}}{27.8\text{ mm}} = 51.857°$$

$$\circlearrowleft \Sigma M_B = 0: \quad M - (0.045\text{ m})(223.07\text{ N})\sin(90° - 51.857° - 7.5520°) = 0$$

$$\mathbf{M} = 5.12\text{ N}\cdot\text{m} \blacktriangleleft$$

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Chapter 6, Solution 128.

(*a*) **FBD *BC*:**

$$\circlearrowleft \Sigma M_B = 0: \quad (0.045\text{ m})F_{CD}\sin 45° - 6.00\text{ N}\cdot\text{m} = 0$$

$$F_{CD} = 188.562\text{ N C}$$

FBD Joint *D*:

$$\alpha = \tan^{-1}\frac{38.8\text{ mm}}{92.2\text{ mm}} = 22.823°$$

$$\beta = \tan^{-1}\frac{37.5\text{ mm} - 18.8\text{ mm}}{38.8\text{ mm}} = 25.732°$$

$$\nearrow \Sigma F_{x'} = 0: \quad (188.562\text{ N})\cos(45° - 25.732°)$$

$$-F_{DE}\cos(22.823° + 25.732°) = 0, \quad F_{DE} = 268.92\text{ N C}$$

FBD *E*:

$$\Sigma F_x = 0: \quad (268.92\text{ N})\cos(22.823°) - P = 0,$$

$$\mathbf{P} = 248\text{ N} \longleftarrow ◀$$

(*b*) **FBD *BC*:**

$$\delta = \tan^{-1}\frac{35.4\text{ mm}}{27.8\text{ mm}} = 51.857°$$

$$\beta = \tan^{-1}\frac{27.8\text{ mm} - 24.3\text{ mm}}{26.4\text{ mm}} = 7.5520°$$

$$\circlearrowleft \Sigma M_B = 0: \quad (0.045\text{ m})F_{CD}\sin(90° - 51.857° - 7.5510°) - 6.00\text{ N}\cdot\text{m} = 0$$

$$F_{CD} = 262.00\text{ N C}$$

continued

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FBD Joint *D*:

$$\beta = 7.5520°, \quad \gamma = \tan^{-1}\frac{20\text{ mm} + 35.4\text{ mm} - 26.4\text{ mm}}{24.3\text{ mm} + 7.5\text{ mm}} = 42.363°$$

$$\alpha = \tan^{-1}\frac{20\text{ mm} + 35.4\text{ mm} - 26.4\text{ mm}}{92.2\text{ mm} + 27.8\text{ mm} - 24.3\text{ mm}} = 16.8584°$$

$$\nearrow \Sigma F_{y'} = 0: \quad F_{DE}\sin(16.8584° + 42.363°)$$

$$-(262.00\text{ N})\sin(90° - 7.5520° - 42.363°) = 0,$$

$$F_{DE} = 196.366\text{ N C}$$

FBD *E*:

$$\rightarrow \Sigma F_x = 0: \quad (196.366\text{ N})(\cos 16.8584°) - P = 0,$$

$$\mathbf{P} = 187.9\text{ N} \leftarrow \blacktriangleleft$$

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Chapter 6, Solution 129.

Member FBDs:

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

$\circlearrowleft \Sigma M_C = 0: \quad (0.128\text{ m})B_x - (0.10\text{ m})(80\text{ N}) = 0, \qquad B_x = 62.5\text{ N}$

***AB*:** $\circlearrowleft \Sigma M_A = 0: \quad (0.15\text{ m})(62.5\text{ N}) - M = 0, \qquad \mathbf{M} = 9.38\text{ N}\cdot\text{m} \circlearrowright$ ◀

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Chapter 6, Solution 130.

FBD *BCD*:

$$d = 0.24\text{ m}\frac{0.100\text{ m}}{0.128\text{ m}} = 0.1875\text{ m}$$

$$\uparrow \Sigma F_y = 0: \quad (80\text{ N})\sin 45° - B_y = 0$$

$$B_y = 40\sqrt{2}\text{ N}$$

$$\circlearrowleft \Sigma M_C = 0: \quad (0.100\text{ m})(80\text{ N})\cos 45°$$

$$+(0.1875\text{ m})(80\text{ N})\sin 45°$$

$$+(0.24\text{ m})(40\sqrt{2}\text{ N})$$

$$-(0.128\text{ m})B_x = 0$$

$$B_x = 233.13\text{ N}$$

FBD *AB*:

$$\circlearrowleft \Sigma M_A = 0: \quad (0.2\text{ m})(40\sqrt{2}\text{ N}) - (0.15\text{ m})(233.13\text{ N}) = 0$$

$$\mathbf{M} = 46.3\text{ N}\cdot\text{m}. \circlearrowright \quad ◀$$

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Chapter 6, Solution 131.

FBD *BD*:

$$\theta = 90° - 25° = 65°$$

$$\circlearrowleft \Sigma M_B = 0: \quad \left[2(0.2\text{ m})\cos 25°\right] D \sin 65° - 15\text{ N}\cdot\text{m} = 0$$

$$D = 45.654\text{ N}$$

FBD *AC*:

$$\circlearrowleft \Sigma M_A = 0: \quad M_A = (0.2\text{ m})(45.654\text{ N}) = 0$$

$$\mathbf{M}_A = 9.13\text{ N}\cdot\text{m} \circlearrowright \blacktriangleleft$$

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Chapter 6, Solution 132.

FBD *BD*:

$$\circlearrowleft \Sigma M_B = 0: \quad \left[2(0.2\text{ m})\cos 25°\right]C - 15\text{ N}\cdot\text{m} = 0$$

$$C = 41.377\text{ N}$$

FBD *AC*:

$$\circlearrowleft \Sigma M_A = 0: \quad M_A - (0.2\text{ m})(41.377\text{ N})\sin 65° = 0$$

$$\mathbf{M}_A = 7.50\text{ N}\cdot\text{m} \circlearrowright \quad ◀$$

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Chapter 6, Solution 133.

FBD Member *CD*:

Noting that **B** is Perpendicular to *CD*,

$$\nearrow \Sigma F_{x'} = 0: \quad D_y \sin 30° - (80 \text{ lb}) \cos 30° = 0,$$

$$D_y = 138.564 \text{ lb}$$

FBD Machine:

$$\circlearrowleft \Sigma M_A = 0: \quad \frac{10 \text{ in.}}{\sin 30°}(138.564 \text{ lb}) - M = 0,$$

$$M = 2771.3 \text{ lb}\cdot\text{in.}$$

$$\mathbf{M} = 2.77 \text{ kip}\cdot\text{in.} \circlearrowright \quad ◀$$

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Chapter 6, Solution 134.

FBD *CD*:

Since **B** is $\perp$ to CD

$$\nearrow \Sigma F_{x'} = 0: \quad D_y \sin 30° - (80 \text{ lb})\cos 30° = 0$$

$$D_y = 138.564 \text{ lb}$$

FBD Whole:

$$a = 10 \text{ in.} - (8 \text{ in.})\cos 30° = 3.07180 \text{ in.}$$

$$b = \frac{a}{\tan 30°} = 5.32051 \text{ in.}$$

$$d = b - 4 \text{ in.} = 1.32051 \text{ in.}$$

$$\circlearrowleft \Sigma M_A = 0: \quad (10 \text{ in.})(80 \text{ lb}) + (1.32051 \text{ in.})(138.564 \text{ lb}) - M = 0$$

$$\mathbf{M} = 983 \text{ lb}\cdot\text{in.} \circlearrowright \quad ◀$$

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Chapter 6, Solution 135.

FBD *ABD*:

First note, by inspection, that $P = W = 250$ lb.

Note: that BC is a two-force member

$$\circlearrowleft \Sigma M_D = 0: \quad (5\text{ in.})\frac{3}{\sqrt{10}}F_{BC} + (3\text{ in.})\frac{1}{\sqrt{10}}F_{BC} - (9\text{ in.})(250\text{ lb}) = 0$$

$$F_{BC} = 125\sqrt{10}\text{ lb T}$$

$$\rightarrow \Sigma F_x = 0: \quad D_x - \frac{3}{\sqrt{10}}\left(125\sqrt{10}\text{ lb}\right) = 0$$

$$\mathbf{D}_x = 375\text{ lb} \rightarrow$$

$$\uparrow \Sigma F_y = 0: \quad 250\text{ lb} - \frac{1}{\sqrt{10}}\left(125\sqrt{10}\text{ lb}\right) - D_y = 0$$

$$\mathbf{D}_y = 125\text{ lb} \downarrow$$

(note, that $D_y = 125$ lb is evident by symmetry of the barrel)

so $\mathbf{D} = 395$ lb $\searrow 18.43°$ ◀

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Chapter 6, Solution 136.

FBD whole:

By symmetry $\mathbf{A} = \mathbf{B} = 22.5 \text{ kN} \uparrow$

FBD *ADF*:

$\circlearrowleft \Sigma M_F = 0: \quad (75 \text{ mm})CD - (100 \text{ mm})(22.5 \text{ kN}) = 0$

$\mathbf{CD} = 30 \text{ kN} \leftarrow$ ◀

$\rightarrow \Sigma F_x = 0: \quad F_x - CD = 0 \qquad F_x = CD = 30 \text{ kN}$

$\uparrow \Sigma F_y = 0: \quad 22.5 \text{ kN} - F_y = 0 \qquad F_y = 22.5 \text{ kN}$

so $\mathbf{F} = 37.5 \text{ kN} \searrow 36.9°$ ◀

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Chapter 6, Solution 137.

FBD Joint *A*:

$$\frac{T_B}{17} = \frac{T_C}{17} = \frac{2.1\text{ kN}}{30}$$

$$T_B = T_C = 1.19\text{ kN}$$

FBD *BF* and *CF* w/cables to *A*:

By symmetry $\quad E_x = F_x = 1.05\text{ kN}$

and $\quad E_y = F_y$

FBD Machine:

By symmetry $\quad H_x = I_x = 1.05\text{ kN}$

and $\quad H_y = I_y$

FBD *BF*:

$$\circlearrowleft \Sigma M_D = 0: \quad (0.075\text{ m})F_y - (0.08\text{ m})(1.05\text{ kN}) - (0.15\text{ m})\frac{15}{17}(1.19\text{ kN}) - (0.16\text{ m})\frac{8}{16}(1.19\text{ kN}) = 0$$

$$F_y = 4.48\text{ kN}$$

$$\circlearrowleft \Sigma M_G = 0: \quad (0.075\text{ m})(4.48\text{ kN}) + (0.08\text{ m})(1.05\text{ kN}) + (0.02\text{ m})(1.05\text{ kN}) - (0.15\text{ m})H_y = 0$$

$$H_y = 2.94\text{ kN}$$

FBD *FGH*:

$\uparrow \Sigma F_y = 0: \quad 2.94\text{ kN} - G_y + 4.48\text{ kN} = 0\,, \qquad G_y = 7.42\text{ kN}$

$\rightarrow \Sigma F_x = 0: \quad -1.05\text{ kN} + G_x + 1.05\text{ kN} = 0\,, \qquad G_x = 0$

so $\quad \mathbf{H} = 3.12\text{ kN} \measuredangle 70.3° \blacktriangleleft$

$\mathbf{G} = 7.42\text{ kN} \downarrow \blacktriangleleft$

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Chapter 6, Solution 138.

FBD Machine:

By inspection, $P = W = 110$ lb,

By symmetry: $H_x = I_x$, $H_y = I_y$

$\uparrow \Sigma F_y = 0$: $110 \text{ lb} - 2H_y = 0$, $H_y = I_y = 55$ lb,

FBD *ABC*:

By symmetry: $F_{CE} = F_{BD}$

$\uparrow \Sigma F_y = 0$: $110 \text{ lb} - 2\left(\frac{4}{5} F_{CE}\right) = 0$, $F_{CE} = F_{BD} = \frac{550}{8}$ lb C

$\circlearrowleft \Sigma M_H = 0$: $(2.5 \text{ in.})\left[\frac{4}{5}\left(\frac{550}{8} \text{ lb}\right)\right] + (17 \text{ in.})\left[\frac{3}{5}\left(\frac{550}{8} \text{ lb}\right)\right]$

$- (4 \text{ in.})\, F_{FG} = 0$

$F_{FG} = 209.69$ lb, $\mathbf{F}_{FG} = 210 \text{ lb} \rightarrow$ ◀

FBD *DFH*:

$\rightarrow \Sigma F_x = 0$: $209.69 \text{ lb} - \frac{3}{5}\left(\frac{550}{8} \text{ lb}\right) - H_x = 0$

$H_x = 168.440$ lb

so $\mathbf{H} = 177.2 \text{ lb} \measuredangle 18.08°$ ◀

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Chapter 6, Solution 139.

FBD top handle:

Note *CD* and *DE* are two-force members

$$\circlearrowleft \Sigma M_A = 0: \quad (4 \text{ in.})\frac{6}{\sqrt{61}}F_{CD} - (1.5 \text{ in.})\frac{5}{\sqrt{61}}F_{CD} - (13.2 \text{ in.})(90 \text{ lb}) = 0$$

$$F_{CD} = 72\sqrt{61} \text{ lb}$$

By symmetry: $F_{DE} = F_{CD} = 72\sqrt{61}$ lb

FBD Joint *D*:

$$\rightarrow \Sigma F_x = 0: \quad D - 2\frac{5}{\sqrt{61}}\left(72\sqrt{61} \text{ lb}\right) = 0, \qquad D = 720 \text{ lb} \blacktriangleleft$$

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Chapter 6, Solution 140.

FBD top handle:

By symmetry the horizontal force at F must be zero

$$\rightarrow \Sigma F_x = 0: \quad D_x = 0$$

$$\circlearrowleft \Sigma M_F = 0: \quad (0.015 \text{ m})\, F_y - (0.185 \text{ m})(135 \text{ N}) = 0$$

$$D_y = 1665 \text{ N}$$

FBD *ABD*:

$$\circlearrowleft \Sigma M_B = 0: \quad (40 \text{ mm})(1665 \text{ N}) - (30 \text{ mm})\, A = 0$$

$$A = 2220 \text{ N}$$

$$A = 2.22 \text{ kN} \blacktriangleleft$$

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Chapter 6, Solution 141.

FBD cutter *AC*:

$$\circlearrowleft \Sigma M_C = 0: \quad (32\text{ mm})1.5\text{ KN} - (28\text{ mm})A_y - (10\text{ mm})A_x = 0$$

$$10A_x + 28\left(\frac{11}{13}A_x\right) = 48\text{ kN}$$

$$A_x = 1.42466\text{ kN}$$

$$A_y = 1.20548\text{ kN}$$

FBD handle *AD*:

$$\circlearrowleft \Sigma M_D = 0: \quad (15\text{ mm})(1.20548\text{ kN}) - (5\text{ mm})(1.42466\text{ kN})$$

$$-(70\text{ mm})P = 0$$

$$P = 0.1566\text{ kN} = 156.6\text{ N} \blacktriangleleft$$

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Chapter 6, Solution 142.

FBD *CD*:

$$\theta = \tan^{-1}\frac{0.85 \text{ in.} - 0.3 \text{ in.}}{2.6 \text{ in.} - 1.3 \text{ in.}} = 22.932°$$

$$\circlearrowleft \Sigma M_D = 0: \quad (3.4 \text{ in.})(30 \text{ lb}) - (0.8 \text{ in.})F_{AC}\sin 22.932° + (0.3 \text{ in.})F_{AC}\cos 22.932° = 0$$

$$F_{AC} = 2879.6 \text{ lb}$$

$$\rightarrow \Sigma F_x = 0: \quad D_x - (2879.6 \text{ lb})\cos 22.932° = 0, \qquad D_x = 2652.0 \text{ lb}$$

$$\uparrow \Sigma F_y = 0: \quad D_y - (2879.6 \text{ lb})\sin 22.932° + 30 \text{ lb} = 0,$$

$$D_y = 1092.00 \text{ lb}$$

FBD *BD*:

$$\circlearrowleft \Sigma M_B = 0: \quad (2.6 \text{ in.})F + (0.2 \text{ in.})(1092.00 \text{ lb}) - (0.85 \text{ in.})(2652.0 \text{ lb}) = 0$$

$$F = 783 \text{ lb} \blacktriangleleft$$

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Chapter 6, Solution 143.

FBD Joint *B*:

$$\alpha = \tan^{-1}\frac{1}{10} = 5.7106°$$

$$\searrow \Sigma F_{x'} = 0: \quad F_{BC}\cos(30° + 5.7106°) - (54 \text{ lb})\cos 30° = 0$$

$$F_{BC} = 57.595 \text{ lb T}$$

By symmetry: $F_{CD} = 57.595$ lb

FBD Joint *C*:

$$\nearrow \Sigma F_{x''} = 0: \quad 2(57.595 \text{ lb})\sin(5.7106°) - P = 0$$

$$P = 11.4618 \text{ lb}$$

so $\mathbf{P} = 11.46 \text{ lb} \measuredangle 30.0°$ ◀

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Chapter 6, Solution 144.

FBD *BC*:

$$\circlearrowleft \Sigma M_B = 0: \quad (1 \text{ in.})\, C_x - (2.65 \text{ in.})(270 \text{ lb}) = 0$$

$$C_x = 715.5 \text{ lb}$$

FBD *CF*:

$$\circlearrowleft \Sigma M_C = 0: \quad (3.5 \text{ in.})\, P - (0.75 \text{ in.})\, F_{DE} \cos 40° + (0.65 \text{ in.})\, F_{DE} \sin 40° = 0$$

$$F_{DE} = 22.333\, P$$

$$\rightarrow \Sigma F_x = 0: \quad C_x - (22.333\, P) \cos 40° + P \sin 30° = 0$$

$$P = 43.081 \text{ lb}$$

$$\mathbf{P} = 43.1 \text{ lb} \measuredangle 60.0° \blacktriangleleft$$

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Chapter 6, Solution 145.

FBD Handles:

$$\circlearrowleft \Sigma M_C = 0: \quad -aB_x + b\left(100\text{ N} - 100\text{ N}\right) = 0$$

$$B_x = 0$$

FBD top handle:

$$\circlearrowleft \Sigma M_A = 0: \quad \left(28\text{ mm}\right) B_y - \left(110\text{ mm}\right)\left(100\text{ N}\right) = 0$$

$$B_y = 392.86\text{ N}$$

FBD top blade:

$$\circlearrowleft \Sigma M_D = 0: \quad \left(40\text{ mm}\right)\left(392.86\text{ N}\right) - \left(30\text{ mm}\right) E = 0$$

$$E = 523.81\text{ N} \qquad E = 524\text{ N} \blacktriangleleft$$

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Chapter 6, Solution 146.

FBD *BE*:

$$\circlearrowleft \Sigma M_B = 0: \quad \left(\sqrt{746}\text{ mm}\right) C - \left(640\text{ mm}\right)\left(0.25\text{ kN}\right) = 0$$

$$C = \frac{160}{\sqrt{746}}\text{ kN}$$

FBD Blade:

$$\circlearrowleft \Sigma M_A = 0: \quad \left(38\text{ mm}\right) F - \left(47\text{ mm}\right)\left[\frac{2}{\sqrt{5}}\left(\frac{160}{\sqrt{746}}\text{ kN}\right)\right]$$

$$- \left(23\text{ mm}\right)\left[\frac{1}{\sqrt{5}}\left(\frac{160}{\sqrt{746}}\text{ kN}\right)\right] = 0$$

$$F = 8.82\text{ kN} \blacktriangleleft$$

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Chapter 6, Solution 147.

FBD Boom with bucket and man:

$$\theta = \tan^{-1}\frac{3\text{ ft} + (6\text{ ft})\sin 35°}{(6\text{ ft})\cos 35° - 1.5\text{ ft}} = 62.070°$$

$$\circlearrowleft \Sigma M_A = 0:\ \left[(6\text{ ft})\cos 35°\right]\left(F_{BD}\sin 62.070°\right)$$

$$-\left[(6\text{ ft})\sin 35°\right]\left(F_{BD}\cos 62.070°\right)$$

$$-\left[(9\text{ft})\cos 35°\right](1400\text{ lb}) - \left[(20\text{ ft})\cos 35°\right](450\text{ lb}) = 0$$

$F_{BD} = 17693$ lb, $\qquad \mathbf{F}_{BD} = 6.48\text{ kips} \measuredangle 62.1°$ ◀

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Chapter 6, Solution 148.

FBD *AED*:

(*a*) $\circlearrowleft \Sigma M_A = 0$: $(36 \text{ in.})(1500 \text{ lb}) - (25 \text{ in.})\,F = 0,$

$F = 2160 \text{ lb}$

$\uparrow \Sigma F_y = 0$: $A_y - 1500 \text{ lb} = 0, \qquad A_y = 1500 \text{ lb}$

$\rightarrow \Sigma F_y = 0$: $A_x - 2160 \text{ lb} = 0, \qquad A_x = 2160 \text{ lb}$

FBD Entire machine:

$\circlearrowleft \Sigma M_B = 0$: $(84 \text{ in.})(1500 \text{ lb}) - (25 \text{ in.})\,G_x = 0,$

$G_x = 5040 \text{ lb}$

$\circlearrowleft \Sigma M_C = 0$: $(24 \text{ in.})(G_y + 1500 \text{ lb})$

$- (12.5 \text{ in.})(5040 \text{ lb} - 2160 \text{ lb}) = 0,$

$\mathbf{G}_y = 0$ ◀

FBD *AG*:

(*b*) $\uparrow \Sigma F_y = 0$: $C_y - 1500 \text{ lb} + 0 = 0,$

$C_y = 1500 \text{ lb}$

$\rightarrow \Sigma F_x = 0$: $C_x - 2160 \text{ lb} - 5040 \text{ lb} = 0,$

$C_x = 7200 \text{ lb}$

so on *BCF*, $\mathbf{C}_x = 7.20 \text{ kips} \leftarrow$, $\mathbf{C}_y = 1.500 \text{ kips} \downarrow$ ◀

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Chapter 6, Solution 149.

FBD boom:

Note: $\theta = \tan^{-1}\dfrac{(3.2\sin 24° - 1)\text{ m}}{(3.2\cos 24° - 0.6)\text{ m}}$

$\theta = 44.73°$

(*a*)

$$\circlearrowleft \Sigma M_A = 0: \quad [(6.4\text{ m})\cos 24°](2.3544\text{ kN})$$

$$-[(3.2\text{ m})\cos 24°]B\sin 44.73°$$

$$+[(3.2\text{ m})\sin 24°]B\cos 44.73° = 0$$

$B = 12.153$ kN $\qquad$ $\mathbf{B} = 12.15$ kN $\measuredangle$ 44.7° ◀

$$\rightarrow \Sigma F_x = 0: A_x - (12.153\text{ kN})\cos 44.73° = 0$$

$\mathbf{A}_x = 8.633$ kN $\rightarrow$

(*b*)

$$\uparrow \Sigma F_y = 0: \quad -2.3544\text{ kN} + (12.153\text{ kN})\sin 44.73° - A_y = 0$$

$\mathbf{A}_y = 6.198$ kN $\downarrow$

On boom: $\mathbf{A} = 10.63$ kN $\searrow$ 35.7°

On carriage: $\mathbf{A} = 10.63$ kN $\measuredangle$ 35.7° ◀

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Chapter 6, Solution 150.

FBD Bucket (one side):

(*a*)

$$\circlearrowleft \Sigma M_D = 0: \quad (0.8\text{ m})(2.4525\text{ kN}) - (0.5\text{ m})\,F_{AB} = 0$$

$$F_{AB} = 3.924\text{ kN}$$

$$\mathbf{w} = (250\text{ kg})(9.81\text{ N/kg}) = 2452.5\text{ N} = 2.4525\text{ kN}$$

FBD link *BE*:

$$\Sigma M_E = 0: \quad (0.68\text{ m})(3.924\text{ kN}) - (0.54\text{ m})\left(\frac{80}{89}F_{CD}\right) + (0.35\text{ m})\left(\frac{39}{89}F_{CD}\right) = 0, \qquad F_{CD} = 7.682\text{ kN}$$

$$F_{CD} = 7.68\text{ kN C} \blacktriangleleft$$

(*b*)

FBD Entire linkage:

$$\circlearrowleft \Sigma M_G = 0: \quad (2.5\text{ m})(2.4525\text{ kN}) + (0.2\text{ m})\frac{1}{\sqrt{2}}F_{GH} - (0.6\text{ m})\frac{1}{\sqrt{2}}F_{GH} = 0,$$

$$F_{FH} = 21.677\text{ kN}, \qquad F_{FH} = 21.7\text{ kN C} \blacktriangleleft$$

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Chapter 6, Solution 151.

FBD Central Gear:

By symmetry: $F_1 = F_2 = F_3 = F$

$\circlearrowleft \Sigma M_A = 0: \quad 3(r_A F) - 15 \text{ N}\cdot\text{m} = 0, \qquad F = \dfrac{5}{r_A}\text{N}\cdot\text{m}$

FBD Gear *C*:

$\circlearrowleft \Sigma M_C = 0: \quad r_B(F - F_4) = 0, \qquad F_4 = F$

$\searrow \Sigma F_{x'} = 0: \quad C_{x'} = 0$

$\nearrow \Sigma F_{y'} = 0: \quad C_{y'} - 2F = 0, \qquad C_{y'} = 2F$

Gears *B* and *D* are analogous, each having a central force of $2F$

FBD Spider:

$\circlearrowleft \Sigma M_A = 0: \quad 75 \text{ N}\cdot\text{m} - 3(r_A + r_B)2F = 0$

$$25 \text{ N}\cdot\text{m} - (r_A + r_B)\frac{10}{r_A}\text{N}\cdot\text{m} = 0$$

$$\frac{r_A + r_B}{r_A} = 2.5 = 1 + \frac{r_B}{r_A}, \qquad r_B = 1.5 r_A$$

Since $r_A = 24$ mm, $\quad (a) \quad r_B = 36.0$ mm ◀

FBD Outer gear:

$\circlearrowleft \Sigma M_A = 0: \quad 3(r_A + 2r_B)F - M_E = 0$

$$3(24 \text{ mm} + 72 \text{ mm})\frac{5 \text{ N}\cdot\text{m}}{24 \text{ mm}} - M_E = 0$$

$(b) \qquad \mathbf{M}_E = 60.0 \text{ N}\cdot\text{m} \circlearrowright$ ◀

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Chapter 6, Solution 152.

FBD Gear *A*: looking from *C*

(*a*)

$M_A = 15 \text{ lb}\cdot\text{ft} \qquad r_A = 4 \text{ in.}$

$\circlearrowleft \Sigma M_A = 0: \quad M_A - Pr_A = 0 \qquad P = \dfrac{M_A}{r_A} = \dfrac{180 \text{ lb}\cdot\text{in.}}{4 \text{ in.}}$

$P = 45 \text{ lb}$

FBD Gear *B*: looking from *F*

$\circlearrowleft \Sigma M_B = 0: \quad M_0 - r_B P = 0$

$M_0 = r_B P = (2.5 \text{ in.})(45 \text{ lb}) = 112.5 \text{ lb}\cdot\text{in.} \circlearrowright$

$\mathbf{M}_0 = 112.5 \text{ lb}\cdot\text{in.}\ \mathbf{i}$ ◀

FBD *ABC*: looking down

(*b*)

$\circlearrowleft \Sigma M_B = 0: \quad (2 \text{ in.})(45 \text{ lb}) - (5 \text{ in.})C = 0 \qquad \mathbf{C} = 18 \text{ lb}\ \mathbf{k}$

$\downarrow \Sigma F_z = 0: \quad 45 \text{ lb} - B + 18 \text{ lb} = 0 \qquad \mathbf{B} = -63 \text{ lb}\ \mathbf{k}$

FBD *BEG*:

By analogy, using FBD *DEF* $\quad \mathbf{E} = 63 \text{ lb}\ \mathbf{k} \quad \mathbf{F} = 18 \text{ lb}\ \mathbf{k}$

$\leftarrow \Sigma F_z = 0: \quad G_z + 63 \text{ lb} - 63 \text{ lb} = 0$

$G_z = 0$

$\uparrow \Sigma F_y = 0 \qquad G_y = 0$

$\circlearrowleft \Sigma M_G = 0 \qquad M_G - (6.5 \text{ in.})(63 \text{ lb}) = 0$

$\mathbf{M}_G = (410 \text{ lb}\cdot\text{in.})\mathbf{i}$ ◀

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FBD *CFH*:

$$\Sigma \mathbf{F} = 0: \quad H_z = H_y = 0$$

$$\circlearrowleft \Sigma M_H = 0$$

$$M_H = -(6.5 \text{ in.})(18 \text{ lb})$$

$$= -117 \text{ lb}\cdot\text{in.}$$

$$\mathbf{M}_G = -(117.0 \text{ lb}\cdot\text{in.})\mathbf{i} \blacktriangleleft$$

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Chapter 6, Solution 153.

Note: The couples exerted by the two yokes on the crosspiece must be equal and opposite. Since neither yoke can exert a couple along the arm of the crosspiece it contacts, these equal and opposite couples must be normal to the plane of the crosspiece.

If the crosspiece arm attached to shaft *CF* is horizontal, the plane of the crosspiece is normal to shaft *AC*, so couple $\mathbf{M}_C$ is along *AC*.

FBDs shafts with yokes:

(*a*) FBD *CDE*: $\circlearrowleft \Sigma M_x = 0$: $\quad M_C \cos 30° - 50\ \text{N}\cdot\text{m} = 0 \qquad M_C = 57.735\ \text{N}\cdot\text{m}$

FBD *BC*: $\Sigma M_{x'} = 0$: $M_A - M_C = 0 \qquad M_A = 57.7\ \text{N}\cdot\text{m}$ ◀

(*b*) $\Sigma \mathbf{M}_C = 0$: $M_A \mathbf{i}' + (0.5\ \text{m}) B_z \mathbf{j}' - (0.5\ \text{m}) B_{y'} \mathbf{k} = 0 \qquad \mathbf{B} = 0$ ◀

$\Sigma \mathbf{F} = 0$: $\mathbf{B} + \mathbf{C} = 0 \qquad$ so $\qquad \mathbf{C} = 0$

FBD *CDF*: $\Sigma M_{Dy} = 0$: $-(0.6\ \text{m}) E_z + (57.735\ \text{N}\cdot\text{m}) \sin 30° = 0$

$$\mathbf{E}_z = 48.1\ \text{N}\ \mathbf{k}$$

$$\Sigma F_x = 0:\ E_x = 0$$

$\Sigma M_{Dz} = 0$: $(0.6\ \text{m}) E_y = 0 \qquad E_y = 0 \qquad$ so $\mathbf{E} = (48.1\ \text{N})\mathbf{k}$ ◀

$\Sigma \mathbf{F} = 0$: $\cancel{\mathbf{C}}^{\,0} + \mathbf{D} + \mathbf{E} = 0 \qquad \mathbf{D} = -\mathbf{E} = -(48.1\ \text{N})\mathbf{k}$ ◀

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Chapter 6, Solution 154.

Note: The couples exerted by the two yokes on the crosspiece must be equal and opposite. Since neither yoke can exert a couple along the arm of the crosspiece it contacts, these equal and opposite couples must be normal to the plane of the crosspiece.

If the crosspiece arm attached to *CF* is vertical, the plane of the crosspiece is normal to *CF*, so the couple $\mathbf{M}_C$ is along *CF*.

(*a*) FBD *CDE*: $\rightarrow \Sigma M_x = 0$: $M_C - 50\text{ N}\cdot\text{m} = 0 \qquad M_C = 50\text{ N}\cdot\text{m}$

FBD *BC*: $\Sigma M_{x'} = 0$: $M_A - M_C\cos 30° = 0 \qquad M_A = (50\text{ N}\cdot\text{m})\cos 30°$

$M_A = 43.3\text{ N}\cdot\text{m}$ ◀

(*b*) $\Sigma M_{Cy'} = 0$: $M_C \sin 30° + (0.5\text{ m})B_z = 0 \qquad B_z = -\dfrac{(50\text{ N}\cdot\text{m})(0.5)}{0.5\text{ m}} = -50\text{ N}$

$\Sigma M_{Cz} = 0$: $-(0.5\text{ m})B_y = 0 \qquad B_y = 0$ so $\mathbf{B} = -(50.0\text{ N})\mathbf{k}$ ◀

$\Sigma\mathbf{F} = 0$: $\mathbf{B} + \mathbf{C} = 0 \qquad \mathbf{C} = -\mathbf{B}$ so $\mathrm{C} = (50\text{ N})\mathbf{k}$ on BC

FBD *CDE*: $\Sigma M_{Dy} = 0$: $-(0.4\text{ m})C_z - (0.6\text{ m})E_z = 0 \qquad E_z = -(50\text{ N})\left(\dfrac{4}{6}\right) = -33.3\text{ N}$

$\Sigma M_{Dz} = 0$: $E_y = 0$

$\rightarrow \Sigma F_x = 0$: $E_x = 0$ so $\mathbf{E} = -(33.3\text{ N})\ \mathbf{k}$ ◀

$\Sigma\mathbf{F} = 0$: $\mathbf{C} + \mathbf{D} + \mathbf{E} = 0 \qquad -(50\text{ N})\ \mathbf{k} + \mathbf{D} - (33.3\text{ N})\ \mathbf{k} = 0$

$\mathbf{D} = (83.3\text{ N})\ \mathbf{k}$ ◀

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Chapter 6, Solution 155.

FBD Joint *A*:

By inspection of *FBD* of entire device, $F_A = w = 1500 \text{ lb}$

By symmetry, $F_{AB} = F_{AC}$

$$\uparrow \Sigma F_y = 0: \quad 1500 \text{ lb} - 2\left(\frac{1}{\sqrt{5}} F_{AC}\right) = 0, \qquad F_{AC} = 750\sqrt{5} \text{ lb}$$

FBD *CDF*:

$$\rightarrow \Sigma F_x = 0: \quad D_x - F_x - \frac{2}{\sqrt{5}}\left(750\sqrt{5} \text{ lb}\right) = 0,$$

$$D_x - F_x = 1500 \text{ lb} \qquad (1)$$

$$\uparrow \Sigma F_y = 0: \quad F_y - D_y + \frac{1}{\sqrt{5}}\left(750\sqrt{5} \text{ lb}\right) = 0,$$

$$D_y - F_y = 750 \text{ lb} \qquad (2)$$

$$\circlearrowleft \Sigma M_D = 0: \quad (4.6 \text{ ft})\left[\frac{1}{\sqrt{5}}\left(750\sqrt{5} \text{ lb}\right)\right] + (0.6 \text{ ft})\left[\frac{2}{\sqrt{5}}\left(750\sqrt{5} \text{ lb}\right)\right]$$

$$-(1 \text{ ft})F_y - (3.6 \text{ ft})F_x = 0,$$

$$3.6\, F_x + F_y = 4350 \text{ lb} \qquad (3)$$

FBD *EF*:

By symmetry: $E_x = D_x, \quad E_y = D_y$ (4), (5)

$$H_y = J_y = \frac{w}{2} = 750 \text{ lb}, \qquad \mathbf{H}_y = 750 \text{ lb} \downarrow \blacktriangleleft$$

$$\circlearrowleft \Sigma M_F = 0: \quad (3 \text{ ft})E_y - (3.6 \text{ ft})E_x - (1 \text{ ft})H_y + (0.6 \text{ ft})(750 \text{ lb}) = 0$$

$$3.6E_x - 3E_y + H_y = 450 \text{ lb} \qquad (6)$$

$$\rightarrow \Sigma F_x = 0: \quad D_x + F_x - H_x = 0, \qquad (7)$$

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Solving Eqns, (1)–(7), on *EFH*

$\mathbf{F}_x = 540$ lb →

$\mathbf{F}_y = 2410$ lb ↓

$\mathbf{E}_x = 2040$ lb →

$\mathbf{E}_y = 3160$ lb ↑

$\mathbf{H}_x = 2580$ lb ←

$\mathbf{H}_y = 750$ lb ↓

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Chapter 6, Solution 156.

FBD Truss:

$\circlearrowleft \Sigma M_E = 0$: $(9\text{ ft})F_y - (6.75\text{ ft})(4\text{ kips}) - (13.5\text{ ft})(4\text{ kips}) = 0$

$\mathbf{F}_y = 9\text{ kips} \uparrow$

$\uparrow \Sigma F_y = 0$: $-E_y + 9\text{ kips} = 0$ $\qquad \mathbf{E}_y = 9\text{ kips} \downarrow$

$\rightarrow \Sigma F_x = 0$: $-E_x + 4\text{ kips} + 4\text{ kips} = 0$ $\qquad \mathbf{E}_x = 8\text{ kips} \leftarrow$

By inspection of joint E: $\qquad F_{EC} = 9.00\text{ kips T} \blacktriangleleft$

$F_{EF} = 8.00\text{ kips T} \blacktriangleleft$

Joint FBDs:

Joint F:

By inspection of joint B: $\qquad F_{AB} = 0 \blacktriangleleft$

$F_{BD} = 0 \blacktriangleleft$

$\rightarrow \Sigma F_x = 0$: $\frac{4}{5}F_{CF} - 8\text{ kips} = 0$ $\qquad F_{CF} = 10.00\text{ kips C} \blacktriangleleft$

$\uparrow \Sigma F_y = 0$: $F_{DF} - \frac{3}{5}(10\text{ kips}) = 0$ $\qquad F_{DF} = 6.00\text{ kips T} \blacktriangleleft$

Joint C:

$\rightarrow \Sigma F_x = 0$: $4\text{ kips} - \frac{4}{5}(10\text{ kips}) + F_{CD} = 0$

$F_{CD} = 4.00\text{ kips T} \blacktriangleleft$

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$$\uparrow \Sigma F_y = 0: F_{AC} - 9 \text{ kips} + \frac{3}{5}(10 \text{ kips}) = 0$$

$$F_{AC} = 3.00 \text{ kips T} \blacktriangleleft$$

Joint A:

$$\rightarrow \Sigma F_x = 0: 4 \text{ kips} - \frac{4}{5} F_{AD} = 0 \qquad F_{AD} = 5.00 \text{ kips C} \blacktriangleleft$$

Vector Mechanics for Engineers: Statics and Dynamics, 8/e, Ferdinand P. Beer, E. Russell Johnston, Jr., Elliot R. Eisenberg, William E. Clausen, David Mazurek, Phillip J. Cornwell
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Chapter 6, Solution 157.

FBD Truss:

$$\circlearrowleft \Sigma M_A = 0: (6\text{ ft})\left[6L_y - 3(0.5\text{ kip}) - 2(1\text{ kip}) - 1(1\text{ kip})\right] = 0$$

$$\mathbf{L}_y = 0.75\text{ kip} \uparrow$$

Inspection of joints K, J, and I, in order, shows that $F_{JK} = 0$ ◀

$F_{IJ} = 0$ ◀

$F_{HI} = 0$ ◀

Joint FBDs:

and that $F_{IK} = F_{KL}$; $F_{HJ} = F_{JL}$ and $F_{GI} = F_{IK}$

$$\frac{0.75}{1} = \frac{F_{JL}}{\sqrt{8}} = \frac{F_{KL}}{\sqrt{5}} \qquad F_{JL} = 2.1213\text{ kips} \qquad F_{JL} = 2.12\text{ kips C} ◀$$

$$F_{KL} = 1.6771\text{ kips} \qquad F_{KL} = 1.677\text{ kips T} ◀$$

and, from above: $F_{HJ} = 2.12\text{ kips C}$ ◀

$F_{GI} = F_{IK} = 1.677\text{ kips T}$ ◀

$$\rightarrow \Sigma F_x = 0: \frac{2}{\sqrt{5}}(F_{FH} + F_{GH}) - \frac{1}{\sqrt{2}}(2.1213\text{ kips}) = 0$$

$$\uparrow \Sigma F_y = 0: \frac{1}{\sqrt{5}}(F_{GH} + F_{FH}) + \frac{1}{\sqrt{2}}(2.1213\text{ kips}) = 0$$

Solving: $F_{FH} = 2.516\text{ kips}$ $\qquad F_{FH} = 2.52\text{ kips C}$ ◀

$F_{GH} = -0.8383\text{ kips}$ $\qquad F_{GH} = 0.838\text{ kips T}$ ◀

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$\rightarrow \Sigma F_x = 0: \frac{2}{\sqrt{5}}(F_{DF} - 2.516 \text{ kips}) = 0$ $\qquad F_{DF} = 2.52 \text{ kips C}$

$\uparrow \Sigma F_y = 0: F_{FG} - 0.5 \text{ kip} + \frac{1}{\sqrt{5}}(2)(2.516 \text{ kips}) = 0$

$F_{FG} = 1.750 \text{ kips T}$ ◀

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Chapter 6, Solution 158.

FBD Truss:

$$\circlearrowleft \Sigma M_F = 0: (10\text{ m})G_y - (7.5\text{ m})(80\text{ kN}) - (8\text{ m})(30\text{ kN}) = 0$$

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

$$\rightarrow \Sigma F_x = 0: -F_x + 30\text{ kN} = 0 \qquad \mathbf{F}_x = 30\text{ kN} \leftarrow$$

$$\uparrow \Sigma F_y = 0: F_y + 84\text{ kN} - 80\text{ kN} = 0 \qquad \mathbf{F}_y = 4\text{ kN} \downarrow$$

By inspection of joint G: $F_{EG} = 0$ ◀

$F_{CG} = 84\text{ kN C}$ ◀

Joint FBDs:

$$\frac{84\text{ kN}}{8} = \frac{F_{CE}}{\sqrt{61}} = \frac{F_{AC}}{\sqrt{29}} = 10.5\text{ kN}$$

$F_{CE} = 82.0\text{ kN T}$ ◀

$F_{AC} = 56.5\text{ kN C}$ ◀

$$\uparrow \Sigma F_y = 0: \frac{2}{\sqrt{5}}F_{AE} + \frac{6}{\sqrt{61}}(82.0\text{ kN}) - 80\text{ kN} = 0$$

$$F_{AE} = 19.01312 \qquad F_{AE} = 19.01\text{ kN T}$$ ◀

$$\rightarrow \Sigma F_x = 0: -F_{DE} - \frac{1}{\sqrt{5}}(19.013\text{ kN}) + \frac{5}{\sqrt{61}}(82.0\text{ kN}) = 0$$

$$F_{DE} = 43.99\text{ kN} \qquad F_{DE} = 44.0\text{ kN T}$$ ◀

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$\rightarrow \Sigma F_x = 0: \frac{1}{\sqrt{5}} F_{DF} - 30 \text{ kN} = 0$

$F_{DF} = 67.082 \text{ kN}$ $\qquad F_{DF} = 67.1 \text{ kN T} \blacktriangleleft$

$\uparrow \Sigma F_y = 0: \frac{2}{\sqrt{5}}(67.082 \text{ kN}) - F_{BF} - 4 \text{ kN} = 0$

$F_{BF} = 56.00 \text{ kN}$ $\qquad F_{BF} = 56.0 \text{ kN C} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0: 30 \text{ kN} + \frac{5}{\sqrt{61}} F_{BD} - \frac{5}{\sqrt{29}} F_{AB} = 0$

$\uparrow \Sigma F_y = 0: 56 \text{ kN} - \frac{6}{\sqrt{61}} F_{BD} - \frac{3}{\sqrt{29}} F_{AB} = 0$

Solving: $\qquad F_{BD} = 42.956 \text{ kN}$ $\qquad F_{BD} = 43.0 \text{ kN T} \blacktriangleleft$

$F_{AB} = 61.929 \text{ kN}$ $\qquad F_{AB} = 61.9 \text{ kN C} \blacktriangleleft$

$\uparrow \Sigma F_y = 0: \frac{6}{\sqrt{61}}(42.956 \text{ N}) + \frac{2}{\sqrt{5}}(F_{AD} - 67.082 \text{ N}) = 0$

$F_{AD} = 30.157 \text{ kN}$ $\qquad F_{AD} = 30.2 \text{ N T} \blacktriangleleft$

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Chapter 6, Solution 159.

FBD Truss:

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

By load symmetry, $\mathbf{A}_y = \mathbf{I}_y = 8 \text{ kips} \uparrow$

FBD Section:

$$\circlearrowleft \Sigma M_D = 0: \quad (7 \text{ ft})(2 \text{ kips} - 8 \text{ kips}) + (3 \text{ ft})(F_{CE}) = 0$$

$$F_{CE} = 14 \text{ kips} \qquad F_{CE} = 14.00 \text{ kips T} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_E = 0: \quad (7 \text{ ft})\left[1(4 \text{ kips}) + 2(2 \text{ kips} - 8 \text{ kips})\right]$$

$$(4.5 \text{ ft})\frac{7}{\sqrt{51.25}} F_{DF} = 0$$

$$F_{DF} = \frac{8\sqrt{51.25}}{4.5} \text{ kips} \qquad F_{DF} = 12.73 \text{ kips C} \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: 8 \text{ kips} - 2 \text{ kips} - 4 \text{ kips} + \frac{1.5}{\sqrt{51.25}} \frac{8\sqrt{51.25}}{4.5} \text{ kips} - \frac{3}{\sqrt{58}} F_{DE} = 0$$

$$F_{DE} = -1.692 \text{ kips} \qquad F_{DE} = 1.692 \text{ kips C} \blacktriangleleft$$

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Chapter 6, Solution 160.

FBD Section:

Note: $\widehat{BG} = \dfrac{8.4}{12.0}(2.7\text{ m}) = 1.89\text{ m}$

$$\circlearrowleft \Sigma M_A = 0: \quad (2.7\text{ m})F_{FG} - (3.6\text{ m})(8\text{ kN}) - (7.8\text{ m})(8\text{ kN}) - (12\text{ m})(4\text{ kN}) = 0$$

$$F_{FG} = 51.56\text{ kN} \qquad F_{FG} = 51.6\text{ kN C} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_G = 0: \quad (1.89\text{ m})\left(\frac{12}{12.3}F_{AB}\right) - (4.2\text{ m})(8\text{ kN}) - (8.4\text{ m})(4\text{ kN}) = 0$$

$$F_{AB} = 36.44\text{ kN} \qquad F_{AB} = 36.4\text{ kN T} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_D = 0: \quad (4.2\text{ m})(8\text{ kN}) + (8.4\text{ m})(8\text{ kN}) - (8.4\text{ m})\left(\frac{3}{5}F_{AG}\right) = 0 \qquad F_{AG} = 20.0\text{ kN T} \blacktriangleleft$$

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Chapter 6, Solution 161.

FBD Truss:

$$\circlearrowleft \Sigma M_A = 0: \quad (24\text{ ft})K_x - (18\text{ ft})(2\text{ kips}) - (36\text{ ft})(2\text{ kips}) = 0$$

$$\mathbf{K}_x = 4.5\text{ kips} \rightarrow$$

FBD Section:

$$\circlearrowleft \Sigma M_F = 0: \quad (12\text{ ft})(4.5\text{ kips}) - (18\text{ ft})(2\text{ kips}) - (36\text{ ft})(2\text{ kips}) + (36\text{ ft})F_{EJ} = 0$$

$$F_{EJ} = 1.500\text{ kips T} \blacktriangleleft$$

$$\circlearrowleft \Sigma M_J = 0: \quad (18\text{ ft})(2\text{ kips}) + (12\text{ ft})(4.5\text{ kips}) - (36\text{ ft})F_{AF} = 0$$

$$F_{AF} = 2.50\text{ kips T} \blacktriangleleft$$

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Chapter 6, Solution 162.

FBD Frame:

$\circlearrowleft \Sigma M_F = 0: \quad (10.8 \text{ ft})A_y - (12 \text{ ft})(4.5 \text{ kips}) = 0$

$\mathbf{A}_y = 5.00 \text{ kips} \downarrow$ ◀

$\rightarrow \Sigma F_x = 0: \quad -A_x + 4.5 \text{ kips} = 0$

$\mathbf{A}_x = 4.50 \text{ kips} \leftarrow$ ◀

FBD member *ABC*:

Note: *BE* is a two-force member

$\circlearrowleft \Sigma M_C = 0: \quad (12 \text{ ft})F_{BE} + (10.8 \text{ ft})(5 \text{ kips}) - (18 \text{ ft})(4.5 \text{ kips}) = 0$

$\mathbf{F}_{BE} = 2.25 \text{ kips} \rightarrow$ ◀

$\rightarrow \Sigma F_x = 0: \quad C_x + 2.25 \text{ kips} - 4.5 \text{ kips} = 0$

$\mathbf{C}_x = 2.25 \text{ kips} \rightarrow$ ◀

$\uparrow \Sigma F_y = 0: \quad C_y - 5 \text{ kips} = 0$

$\mathbf{C}_y = 5.00 \text{ kips} \uparrow$ ◀

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Chapter 6, Solution 163.

FBD Frame:

$$\circlearrowleft \Sigma M_E = 0: \quad (3.75 \text{ in.})B_x + (8.75 \text{ in.})(75 \text{ lb}) = 0$$

$$B_x = 175 \text{ lb} \qquad \mathbf{B}_x = 175.0 \text{ lb} \leftarrow \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad E_x - B_x = 0 \qquad \mathbf{E}_x = 175.0 \text{ lb} \rightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad E_y + B_y - 75 \text{ lb} = 0$$

$$B_y = 75 \text{ lb} - E_y$$

FBD member *ACE*:

$$\circlearrowleft \Sigma M_C = 0: \quad -(1.25 \text{ in.})(75 \text{ lb}) + (3.75 \text{ in.})(175 \text{ lb}) - (4.5 \text{ in.})E_y = 0$$

$$\mathbf{E}_y = 125.0 \text{ lb} \uparrow \blacktriangleleft$$

Thus $\quad B_y = 75 \text{ lb} - 125 \text{ lb} = -50 \text{ lb}$

$$\mathbf{B}_y = 50.0 \text{ lb} \downarrow \blacktriangleleft$$

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Chapter 6, Solution 164.

FBD Frame:

$$P = 15 \text{ N} \downarrow \qquad Q = 65 \text{ N} \downarrow$$

$$\circlearrowleft \Sigma M_D = 0: \quad (0.25 \text{ m})(P+Q) - (.15 \text{ m})(P+Q) - (0.08 \text{ m})E_x = 0$$

$$E_x = 1.2(P+Q) = 100 \text{ N} \leftarrow \qquad (b) \quad \mathbf{E}_x = 100.0 \text{ N} \leftarrow \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: \quad D_x - E_x = 0 = D_x - 100 \text{ N} \qquad D_x = 100 \text{ N} \rightarrow$$

$$(a) \quad \mathbf{D}_x = 100.0 \text{ N} \rightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad E_y - D_y - 2P - 2Q = 0$$

$$E_y = D_y + 2(P+Q) = D_y + 160 \text{ N}$$

FBD member *BF*:

$$\circlearrowleft \Sigma M_C = 0: \quad (0.15 \text{ m})(65 \text{ N}) - (0.1 \text{ m})D_y - (0.04 \text{ m})(100 \text{ N})$$

$$-(0.25 \text{ m})(15 \text{ N}) = 0$$

$$D_y = 20 \text{ N} \qquad (a) \quad \mathbf{D}_y = 20.0 \text{ N} \downarrow \blacktriangleleft$$

From above $\quad E_y = 20 \text{ N} + 160 \text{ N} = 180 \text{ N} \quad (b) \quad \mathbf{E}_y = 180.0 \text{ N} \uparrow \blacktriangleleft$

$$\rightarrow \Sigma F_x = 0: \quad -C_x + 100 \text{ N} = 0$$

$$(a) \quad \mathbf{C}_x = 100.0 \text{ N} \leftarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \quad -65 \text{ N} + C_y - 20 \text{ N} - 15 \text{ N} = 0$$

$$(a) \quad \mathbf{C}_y = 100.0 \text{ N} \uparrow \blacktriangleleft$$

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Chapter 6, Solution 165.

Member FBDs:

FBD I:

$\circlearrowleft \Sigma M_C = 0: \quad R\left(F_{BD}\sin 30°\right)$

$$-\left[R\left(1-\cos 30°\right)\right]\left(200\text{ N}\right) - R\left(100\text{ N}\right) = 0$$

$F_{BD} = 253.6\text{ N} \qquad (b) \qquad F_{BD} = 254\text{ N T}$ ◀

$\rightarrow \Sigma F_x = 0: \quad -C_x + \left(253.6\text{ N}\right)\cos 30° = 0$

$\mathbf{C}_x = 219.6\text{ N} \leftarrow$

$\uparrow \Sigma F_y = 0: \quad C_y + \left(253.6\text{ N}\right)\sin 30° - 200\text{ N} - 100\text{ N} = 0$

$\mathbf{C}_y = 173.2\text{ N} \uparrow \qquad (c) \quad$ so $\mathbf{C} = 280\text{ N} \measuredangle 38.3°$ ◀

FBD II: $\circlearrowleft \Sigma M_A = 0: \quad aP - a\left[\left(253.6\text{ N}\right)\cos 30°\right] = 0$

$(a) \qquad \mathbf{P} = 220\text{ N} \rightarrow$ ◀

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Chapter 6, Solution 166.

FBD jaw *AB*:

$$\rightarrow \Sigma F_x = 0: B_x = 0$$

$$\circlearrowleft \Sigma M_B = 0: \quad (0.01\text{ m})G - (0.03\text{ m})A = 0$$

$$A = \frac{G}{3}$$

$$\uparrow \Sigma F_y = 0: \quad A + G - B_y = 0$$

$$B_y = A + G = \frac{4G}{3}$$

FBD handle *ACE*:

By symmetry and FBD jaw *DE*: $D = A = \frac{G}{3}, E_x = B_x = 0,$

$$E_y = B_y = \frac{4G}{3}$$

$$\circlearrowleft \Sigma M_C = 0: \quad (0.105\text{ m})(240\text{ N}) + (0.015\text{ m})\frac{G}{3} - (0.015\text{ m})\frac{4G}{3} = 0$$

$$G = 1680\text{ N} \blacktriangleleft$$

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Chapter 6, Solution 167.

Note: By symmetry the vertical components of pin forces **C** and **D** are zero.

FBD handle *ACF*: (not to scale)

$\uparrow \Sigma F_y = 0: \quad A_y = 0$

$\circlearrowleft \Sigma M_C = 0: \quad (13.5 \text{ in.})(20 \text{ lb}) - (1.5 \text{ in.})A_x = 0 \quad A_x = 180 \text{ lb}$

$\rightarrow \Sigma F_x = 0: \quad C - A_x - 20 \text{ lb} = 0 \quad C = (180 + 20) \text{ lb} = 200 \text{ lb}$

FBD blade *DE*:

$\circlearrowright \Sigma M_D = 0: \quad (9 \text{ in.})E - (3 \text{ in.})(180 \text{ lb}) = 0$

$E = 60.0 \text{ lb}$ ◀

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