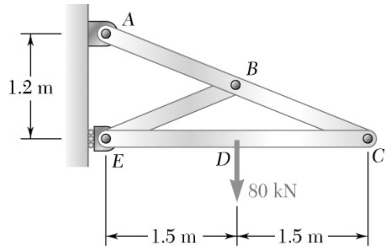
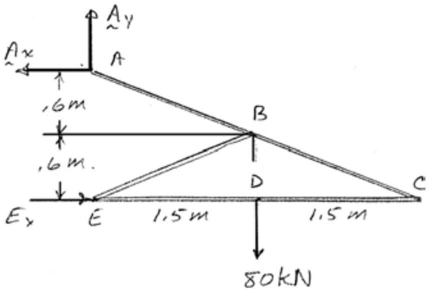
PROBLEM 6.80



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

SOLUTION

FBD Frame:

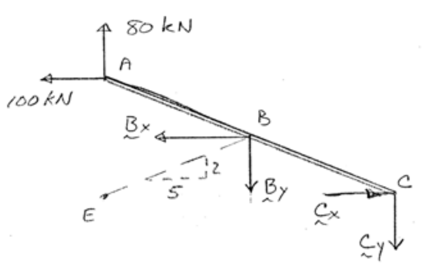


$$\circlearrowleft \Sigma M_E = 0: (1.2 \text{ m})A_x - (1.5 \text{ m})(80 \text{ kN}) = 0$$

$$\mathbf{A}_x = 100.0 \text{ kN} \longleftarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: A_y - 80 \text{ kN} = 0 \qquad \mathbf{A}_y = 80.0 \text{ kN} \uparrow \blacktriangleleft$$

FBD member ABC:



Note: *BE* is two-force member so

$$B_y = \frac{2}{5}B_x = 0.4B_x$$

$$\circlearrowleft \Sigma M_C = 0: (1.2 \text{ m})(100 \text{ kN}) - (3.0 \text{ m})(80 \text{ kN})$$

$$+ (0.6 \text{ m})(B_x) + (1.5 \text{ m})(0.4B_x) = 0$$

$$\mathbf{B}_x = 100.0 \text{ kN} \longleftarrow \blacktriangleleft$$

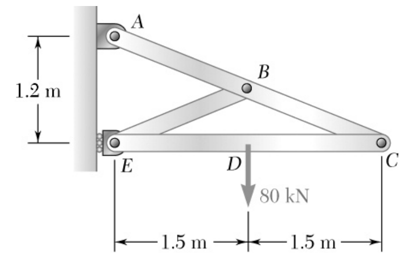
$$\text{so } \mathbf{B}_y = 40.0 \text{ kN} \downarrow \blacktriangleleft$$

$$\longrightarrow \Sigma F_x = 0: -100 \text{ kN} - 100 \text{ kN} + C_x = 0$$

$$\mathbf{C}_x = 200 \text{ kN} \longrightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: 80 \text{ kN} - 40 \text{ kN} - C_y = 0$$

$$\mathbf{C}_y = 40.0 \text{ kN} \downarrow \blacktriangleleft$$

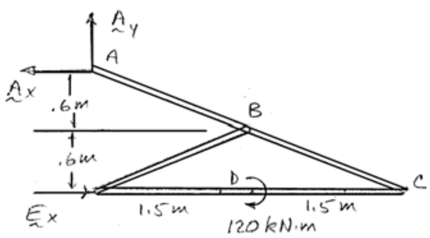


PROBLEM 6.81

Solve Prob. 6.80 assuming that the 80-kN load is replaced by a clockwise couple of magnitude 120 $\text{kN} \cdot \text{m}$ applied to member *EDC* at point *D*.

SOLUTION

FBD Frame:



$\uparrow \Sigma F_y = 0$: $\qquad \mathbf{A}_y = 0$ ◀

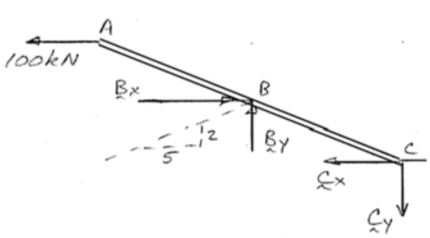
$\circlearrowleft \Sigma M_E = 0: (1.2 \text{ m})A_x - 120 \text{ kN} \cdot \text{m} = 0$

$\mathbf{A}_x = 100.0 \text{ kN} \longleftarrow$ ◀

FBD member ABC:

Note: *BE* is two-force member, so

$$B_y = \frac{2}{5}B_x = 0.4B_x$$



$\circlearrowleft \Sigma M_C = 0: (1.2 \text{ m})100 \text{ kN} - (0.6 \text{ m})B_x - (1.5 \text{ m})(0.4B_x) = 0$

$\mathbf{B}_x = 100.0 \text{ kN} \longrightarrow$ ◀

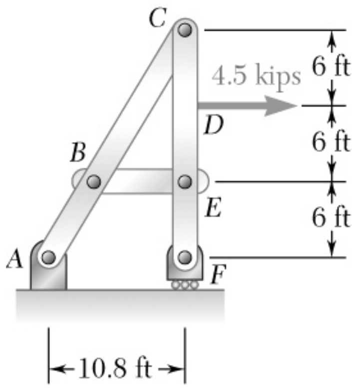
so $\mathbf{B}_y = 40.0 \text{ kN} \uparrow$ ◀

$\longrightarrow \Sigma F_x = 0: -100 \text{ kN} + 100 \text{ kN} - C_x = 0$

$\mathbf{C}_x = 0$ ◀

$\uparrow \Sigma F_y = 0: 40 \text{ kN} - C_y = 0 \qquad \mathbf{C}_y = 40.0 \text{ kN} \downarrow$ ◀

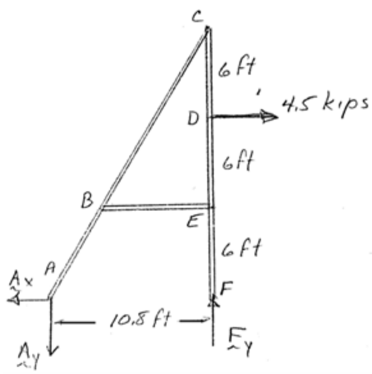
PROBLEM 6.82



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

SOLUTION

FBD Frame:



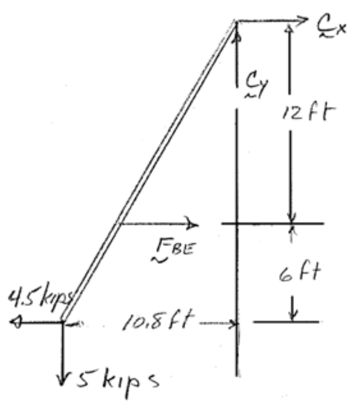
$$\circlearrowleft \Sigma M_F = 0: (10.8\text{ ft})A_y - (12\text{ ft})(4.5\text{ kips}) = 0$$

$$\mathbf{A}_y = 5.00\text{ kips} \downarrow \blacktriangleleft$$

$$\xrightarrow{} \Sigma F_x = 0: -A_x + 4.5\text{ kips} = 0$$

$$\mathbf{A}_x = 4.50\text{ kips} \longleftarrow \blacktriangleleft$$

FBD member ABC:



Note: *BE* is a two-force member

$$\circlearrowleft \Sigma M_C = 0: (12\text{ ft})F_{BE} + (10.8\text{ ft})(5\text{ kips}) - (18\text{ ft})(4.5\text{ kips}) = 0$$

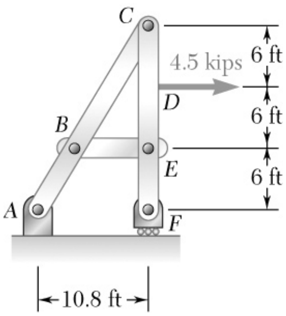
$$\mathbf{F}_{BE} = 2.25\text{ kips} \longrightarrow \blacktriangleleft$$

$$\xrightarrow{} \Sigma F_x = 0: C_x + 2.25\text{ kips} - 4.5\text{ kips} = 0$$

$$\mathbf{C}_x = 2.25\text{ kips} \longrightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: C_y - 5\text{ kips} = 0$$

$$\mathbf{C}_y = 5.00\text{ kips} \uparrow \blacktriangleleft$$

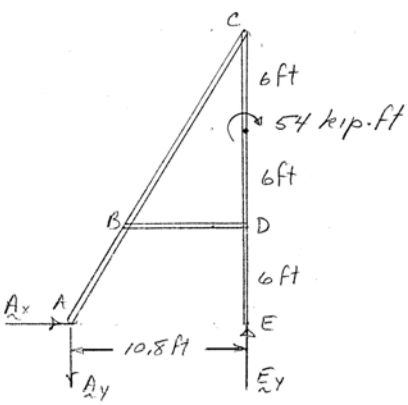


PROBLEM 6.83

Solve Prob. 6.82 assuming that the 4.5-kip load is replaced by a clockwise couple of magnitude $54\ \text{kip}\cdot\text{ft}$ applied to member *CDEF* at point *D*.

SOLUTION

FBD Frame:

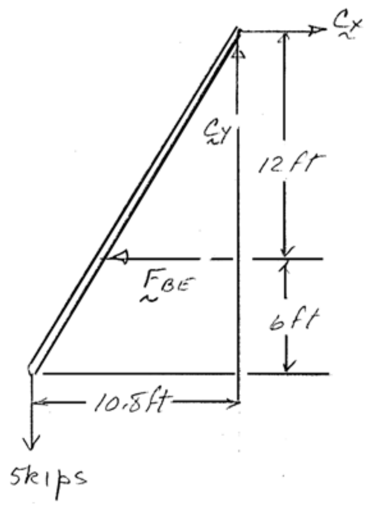


$$\xrightarrow{} \Sigma F_x = 0: \qquad \mathbf{A}_x = 0 \blacktriangleleft$$

$$\circlearrowleft\ \Sigma M_E = 0: (10.8\text{ ft})A_y - 54\text{ kip}\cdot\text{ft} = 0$$

$$\mathbf{A}_y = 5.00\text{ kips} \downarrow \blacktriangleleft$$

FBD member ABC:



$$\circlearrowleft\ \Sigma M_C = 0: (-12\text{ ft})F_{BE} + (10.8\text{ ft})(5\text{ kips}) = 0$$

$$\mathbf{F}_{BE} = 4.50\text{ kips} \longleftarrow \blacktriangleleft$$

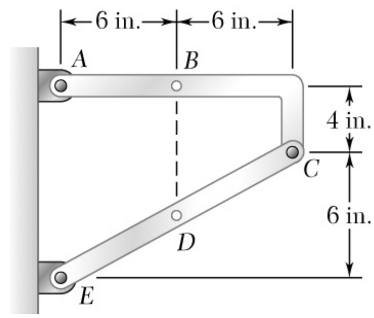
$$\xrightarrow{} \Sigma F_x = 0: C_x - 4.5\text{ kips} = 0$$

$$\mathbf{C}_x = 4.50\text{ kips} \longrightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: C_y - 5\text{ kips} = 0$$

$$\mathbf{C}_y = 5.00\text{ kips} \uparrow \blacktriangleleft$$

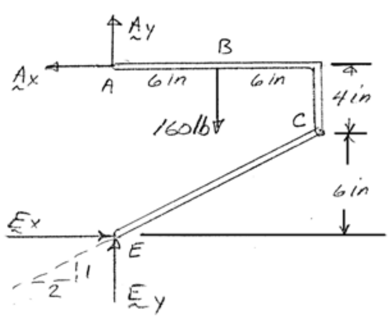
PROBLEM 6.84



Determine the components of the reactions at A and E when a 160-lb force directed vertically downward is applied (a) at B, (b) at D.

SOLUTION

FBD Frame (part a):



Note: EC is a two-force member, so

$$E_y = \frac{1}{2}E_x$$

$$\circlearrowleft \Sigma M_A = 0: (10 \text{ in.})E_x - (6 \text{ in.})(160 \text{ lb}) = 0$$

$\mathbf{E}_x = 96.0 \text{ lb} \longrightarrow$ ◀

so $\mathbf{E}_y = 48.0 \text{ lb} \uparrow$ ◀

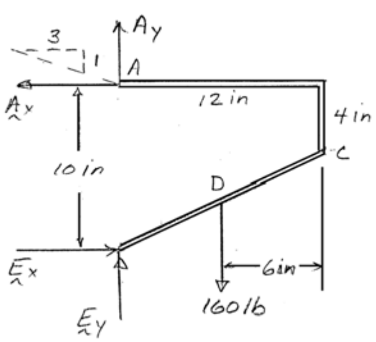
$$\longrightarrow \Sigma F_x = 0: -A_x + 96 \text{ lb} = 0$$

$\mathbf{A}_x = 96.0 \text{ lb} \longleftarrow$ ◀

$$\uparrow \Sigma F_y = 0: A_y - 160 \text{ lb} + 48 \text{ lb} = 0$$

$\mathbf{A}_y = 112.0 \text{ lb} \uparrow$ ◀

FBD member (part b):



Note: AC is a two-force member, so

$$A_x = 3A_y$$

$$\circlearrowleft \Sigma M_A = 0: \text{same as part (a)}$$

$\mathbf{E}_x = 96.0 \text{ lb} \longrightarrow$ ◀

$$\longrightarrow \Sigma F_x = 0: \text{same as part (a)}$$

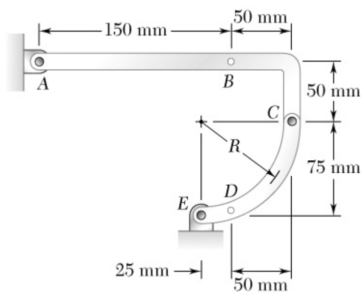
$\mathbf{A}_x = 96.0 \text{ lb} \longleftarrow$ ◀

Here $A_y = \frac{1}{3}A_x$ so $\mathbf{A}_y = 32.0 \text{ lb} \uparrow$ ◀

$$\uparrow \Sigma F_y = 0: 32 \text{ lb} + E_y - 160 \text{ lb} = 0$$

$\mathbf{E}_y = 128.0 \text{ lb} \uparrow$ ◀

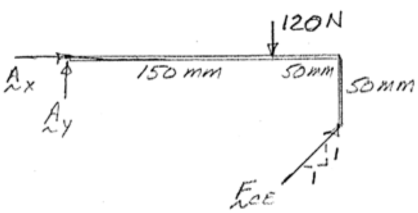
PROBLEM 6.85



Determine the components of the reactions at A and E when a 120-N force directed vertically downward is applied (a) at B, (b) at D.

SOLUTION

FBD ABC:



(a) CE is a two-force member

$$\circlearrowleft \Sigma M_A = 0: (200 \text{ mm})\frac{1}{\sqrt{2}}F_{CE} + (50 \text{ mm})\frac{1}{\sqrt{2}}F_{CE}$$

$$-150 \text{ mm}(120 \text{ N}) = 0$$

$$F_{CE} = 72\sqrt{2} \text{ N} \qquad \text{so } \mathbf{E}_x = 72.0 \text{ N} \longrightarrow \blacktriangleleft$$

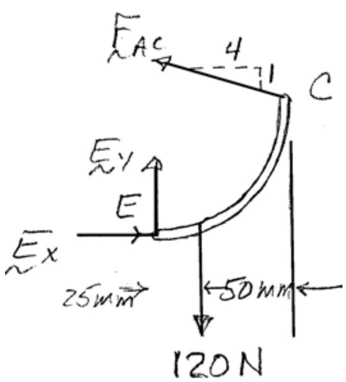
$$\mathbf{E}_y = 72.0 \text{ N} \uparrow \blacktriangleleft$$

$$\longrightarrow \Sigma F_x = 0: A_x + \frac{1}{\sqrt{2}}F_{CE} = 0 \qquad A_x = -72 \text{ N} \blacktriangleleft$$

$$\mathbf{A}_x = 72.0 \text{ N} \longleftarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: A_y - 120 \text{ N} + \frac{1}{\sqrt{2}}F_{CE} = 0 \qquad \mathbf{A}_y = 48.0 \text{ N} \uparrow \blacktriangleleft$$

FBD CE:



(b) AC is a two-force member

$$\circlearrowleft \Sigma M_E = 0: (75 \text{ mm})\left(\frac{4}{\sqrt{17}}F_{AC}\right) + (75 \text{ mm})\left(\frac{1}{\sqrt{17}}F_{AC}\right)$$

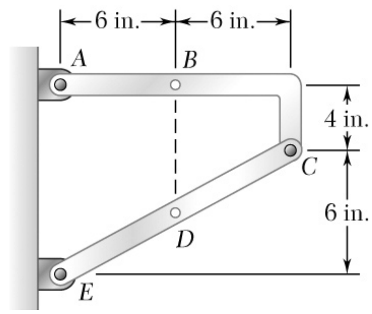
$$-(25 \text{ mm})(120 \text{ N}) = 0 \qquad F_{AC} = 8\sqrt{17} \text{ N}$$

$$\longrightarrow \Sigma F_x = 0: E_x - \frac{4}{\sqrt{17}}F_{AC} = 0 \qquad \mathbf{E}_x = 32.0 \text{ N} \longrightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: E_y + \frac{1}{\sqrt{17}}F_{AC} - 120 = 0 \qquad \mathbf{E}_y = 112.0 \text{ N} \uparrow \blacktriangleleft$$

$$\text{and } \mathbf{A}_x = 32.0 \text{ N} \longleftarrow \blacktriangleleft$$

$$\mathbf{A}_y = 8.00 \text{ N} \uparrow \blacktriangleleft$$

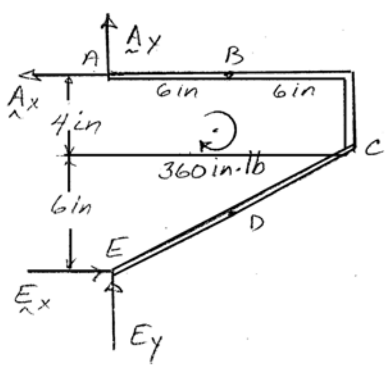


PROBLEM 6.86

Determine the components of the reactions at A and E when the frame is loaded by a clockwise couple of magnitude $360 \text{ lb} \cdot \text{in.}$ applied (a) at B, (b) at D.

SOLUTION

FBD Frame:



Note for analysis of the frame FBD, the location of the applied couple is immaterial.

$$\circlearrowleft \Sigma M_A = 0: (10 \text{ in.})E_x - 360 \text{ in} \cdot \text{lb} = 0$$

$$\mathbf{E}_x = 36.0 \text{ lb} \longrightarrow \blacktriangleleft$$

$$\circlearrowleft \Sigma M_E = 0: (10 \text{ in.})A_x - 360 \text{ in} \cdot \text{lb} = 0$$

$$\mathbf{A}_x = 36.0 \text{ lb} \longleftarrow \blacktriangleleft$$

Part (a): If couple acts at B, EC is a two-force member, so

$$E_y = \frac{1}{2}E_x \qquad \mathbf{E}_y = 18.0 \text{ lb} \uparrow \blacktriangleleft$$

and then $\uparrow \Sigma F_y = 0: A_y + 18 \text{ lb} = 0$

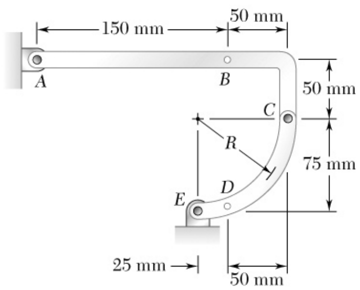
$$\mathbf{A}_y = 18.00 \text{ lb} \downarrow \blacktriangleleft$$

Part (b): If couple acts at D, AC is a two-force member, so

$$A_y = \frac{1}{3}A_x \qquad \mathbf{A}_y = 12.00 \text{ lb} \uparrow \blacktriangleleft$$

Then $\uparrow \Sigma F_y = 0: 12 \text{ lb} + E_y = 0 \qquad E_y = -12 \text{ lb}$

$$\mathbf{E}_y = 12.00 \text{ lb} \downarrow \blacktriangleleft$$

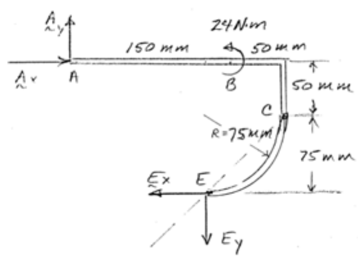


PROBLEM 6.87

Determine the components of the reactions at *A* and *E* when the frame is loaded by a counterclockwise couple of magnitude 24 N · m applied (*a*) at *B*, (*b*) at *D*.

SOLUTION

(a) FBD Frame:



Note: *CE* is a two-force member, so $E_x = E_y$

$$\circlearrowleft \Sigma M_A = 0: 24\text{ N}\cdot\text{m} - (0.125\text{ m})E_x - (0.125\text{ m})E_y = 0$$

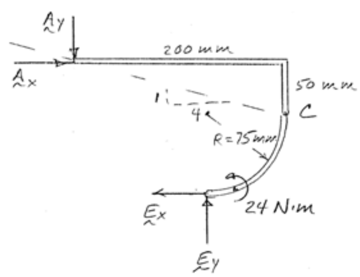
$$E_x = E_y = 96\text{ N} \qquad \mathbf{E}_x = 96.0\text{ N} \longleftarrow \blacktriangleleft$$

$$\mathbf{E}_y = 96.0\text{ N} \downarrow \blacktriangleleft$$

$$\xrightarrow{} \Sigma F_x = 0: A_x - 96\text{ N} = 0 \qquad \mathbf{A}_x = 96.0\text{ N} \longrightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: A_y - 96\text{ N} = 0 \qquad \mathbf{A}_y = 96.0\text{ N} \uparrow \blacktriangleleft$$

(b) FBD Frame:



Note: *AC* is a two-force member, so $A_x = 4A_y$

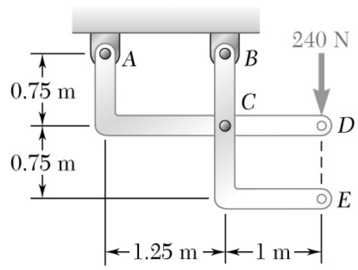
$$\circlearrowleft \Sigma M_E = 0: 24\text{ N}\cdot\text{m} + (0.125\text{ m})A_y - (0.125\text{ m})(4A_y) = 0$$

$$A_y = 64\text{ N} \qquad \mathbf{A}_y = 64.0\text{ N} \downarrow \blacktriangleleft$$

$$\mathbf{A}_x = 256\text{ N} \longrightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: E_y - 64\text{ N} = 0 \qquad \mathbf{E}_y = 64.0\text{ N} \uparrow \blacktriangleleft$$

$$\xrightarrow{} \Sigma F_x = 0: -E_x + 256\text{ N} = 0 \qquad \mathbf{E}_x = 256\text{ N} \longleftarrow \blacktriangleleft$$

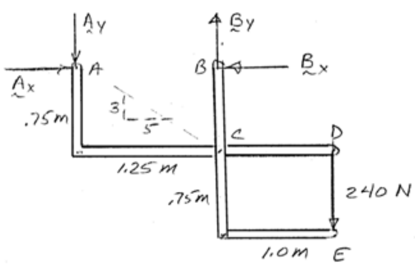


PROBLEM 6.88

Determine the components of the reactions at A and B if (a) the 240-N load is applied as shown, (b) the 240-N load is moved along its line of action and is applied at E.

SOLUTION

FBD Frame:



Regardless of the point of application of the 240 N load;

$$\Sigma M_A = 0: (1.25\text{ m})B_y - (2.25\text{ m})(240\text{ N}) = 0$$

$$\mathbf{B}_y = 432\text{ N} \uparrow \blacktriangleleft$$

$$\Sigma M_B = 0: (1.25\text{ m})A_y - (1.0\text{ m})(240\text{ N}) = 0$$

$$\mathbf{A}_y = 192.0\text{ N} \downarrow \blacktriangleleft$$

Part (a): If load at D, BCE is a two-force member, so $\mathbf{B}_x = 0 \blacktriangleleft$

Then $\rightarrow \Sigma F_x = 0: \quad A_x - B_x = 0 \qquad A_x = B_x = 0$

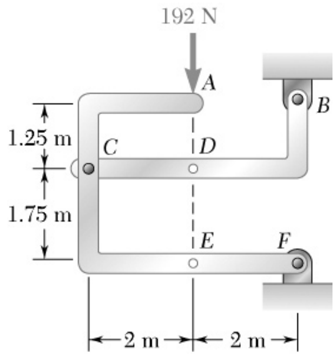
$$\mathbf{A}_x = 0 \blacktriangleleft$$

Part (b): If load at E, ACD is a two-force member, so $A_x = \dfrac{5}{3}A_y$

then $\mathbf{A}_x = 320\text{ N} \longrightarrow \blacktriangleleft$

and $\rightarrow \Sigma F_x = 0: A_x - B_x = 0$

$$\mathbf{B}_x = 320\text{ N} \longleftarrow \blacktriangleleft$$

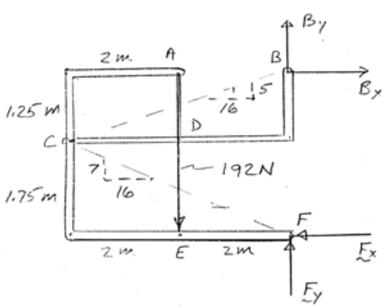


PROBLEM 6.89

The 192-N load can be moved along the line of action shown and applied at *A*, *D*, or *E*. Determine the components of the reactions at *B* and *F* when the 192-N load is applied (*a*) at *A*, (*b*) at *D*, (*c*) at *E*.

SOLUTION

FBD Frame:



Note, regardless of the point of application of the 192 N load,

$$\circlearrowleft \Sigma M_B = 0: (2\text{ m})(192\text{ N}) - (3\text{ m})F_x = 0$$

$$\mathbf{F}_x = 128.0\text{ N} \longleftarrow \blacktriangleleft$$

$$\longrightarrow \Sigma F_x = 0: B_x - 128\text{ N} = 0$$

$$\mathbf{B}_x = 128.0\text{ N} \longrightarrow \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: B_y + F_y - 192\text{ N} = 0$$

(*a*) and (*c*): If load applied at either *A* or *E*, *BC* is a two-force member

so $\quad B_y = \dfrac{5}{16}B_x \qquad \mathbf{B}_y = 40.0\text{ N} \uparrow \blacktriangleleft$

Then $\quad \uparrow \Sigma F_y = 0: 40\text{ N} + F_y - 192\text{ N} = 0$

$$\mathbf{F}_y = 152.0\text{ N} \uparrow \blacktriangleleft$$

(*b*): If load applied at *D*, *ACEF* is a two-force member, so

$$F_y = \frac{7}{16}F_y \qquad \mathbf{F}_y = 56.0\text{ N} \uparrow \blacktriangleleft$$

Then $\quad \uparrow \Sigma F_y = 0: B_y + 56\text{ N} - 192\text{ N} = 0$

$$\mathbf{B}_y = 136.0\text{ N} \uparrow \blacktriangleleft$$