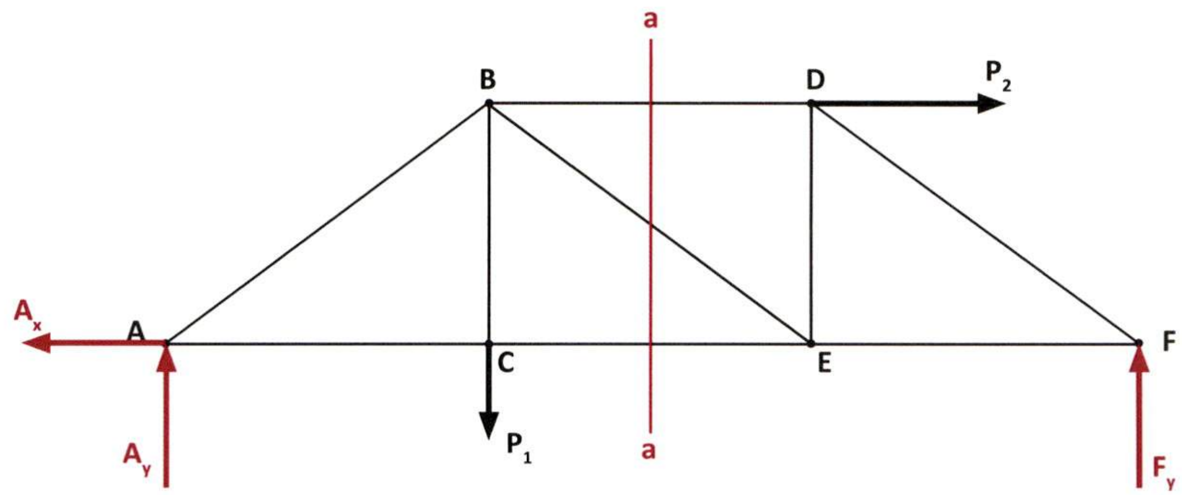
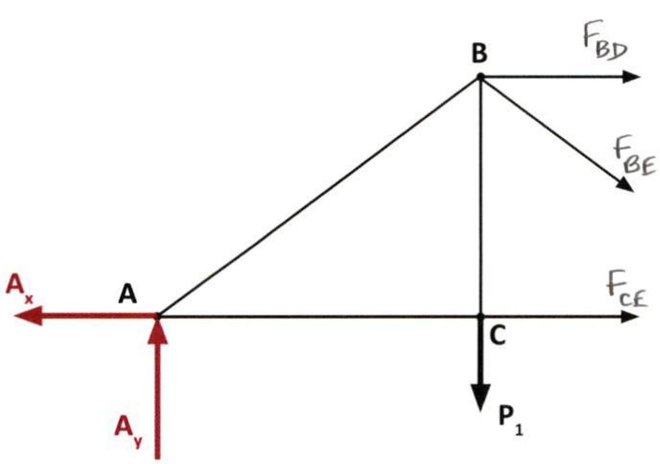
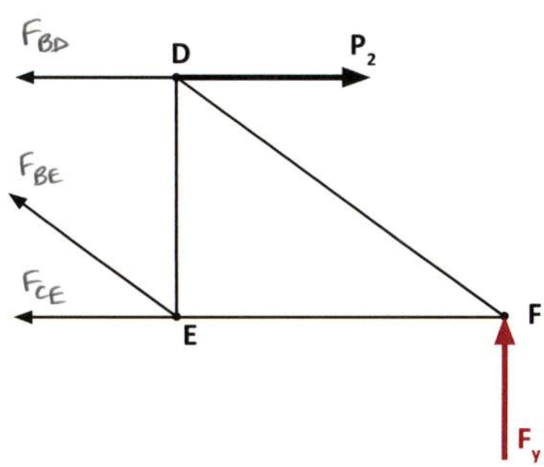
The Method of Sections

- Cut a section through the truss
- Draw a Free-Body Diagram of either portion of the truss
- Forces in the members cut become external forces
- The forces are nonconcurrent. The three independent equations of equilibrium can be used to solve for no more than three unknown member forces.





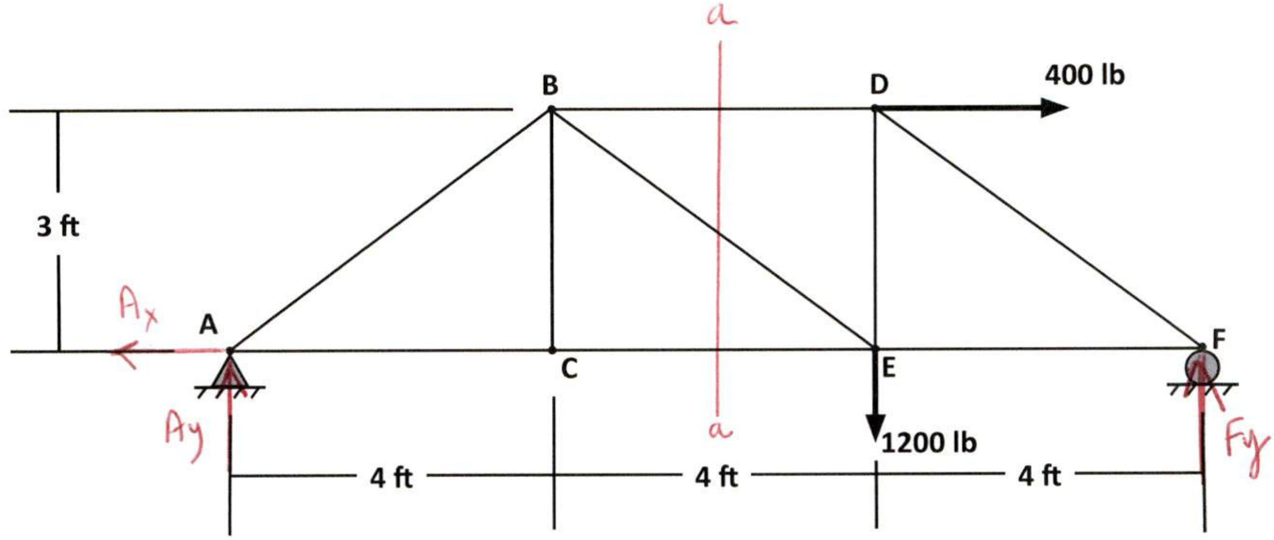


FBD
Left Portion of Section a-a

FBD
Right Portion of Section a-a

Example 1

Using the Method of Sections determine the force in members BD, BE, and CE. Indicate whether the members are in tension or compression.



Solution.

FBD- Entire Truss

Equilibrium Equations

ccw +M
cw −M

$[\Sigma F_x = 0]$ $\quad -A_x + 400 \text{ lb} = 0$

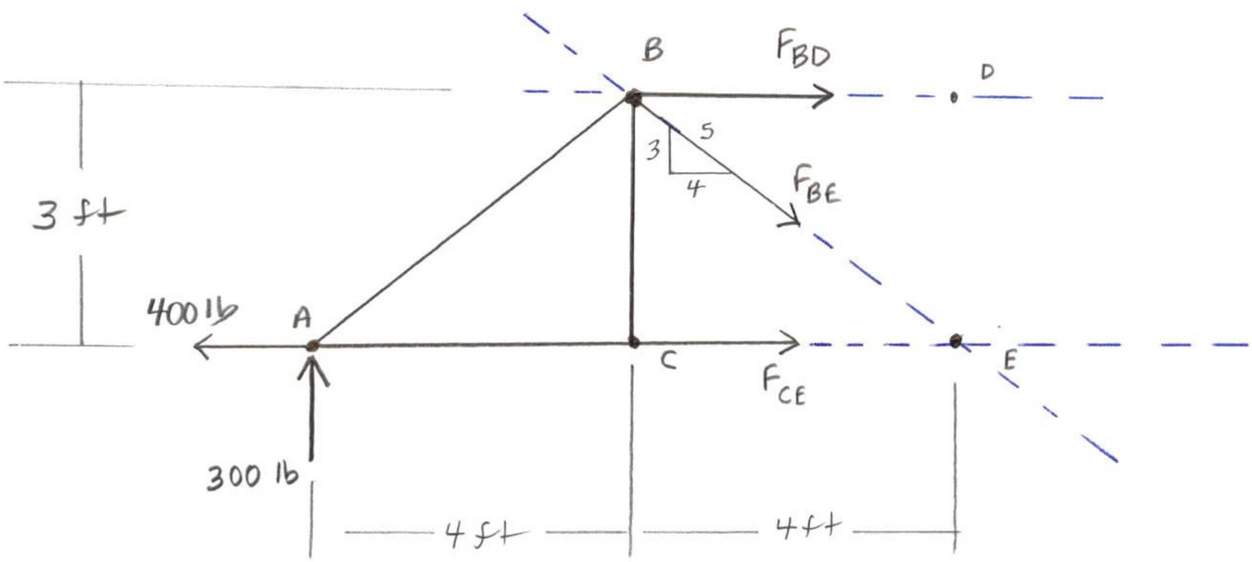
$$A_x = \underline{\underline{400 \text{ lb}}} \leftarrow$$

$[\Sigma M_A = 0]$ $\quad -1200 \text{ lb}(8 \text{ ft}) - 400 \text{ lb}(3 \text{ ft}) + F_y(12 \text{ ft}) = 0$

$$F_y = \frac{10{,}800 \text{ lb}\cdot\text{ft}}{12 \text{ ft}} = \underline{\underline{900 \text{ lb}}} \uparrow$$

$[\Sigma F_y = 0]$ $\quad A_y - 1200 \text{ lb} + F_y = 0$

$$A_y = 1200 \text{ lb} - 900 \text{ lb} = \underline{\underline{300 \text{ lb}}} \uparrow$$



FBD – Left Portion of Section a-a

Equilibrium Equations

ccw +M
cw −M

$[\Sigma M_B = 0]$ $\quad -400\text{ lb}(3\text{ ft}) - 300\text{ lb}(4\text{ ft}) + F_{CE}(3\text{ ft}) = 0$

$$F_{CE} = \frac{2400\text{ lb}\cdot\text{ft}}{3\text{ ft}} = \underline{\underline{800\text{ lb}}}\ (T)$$

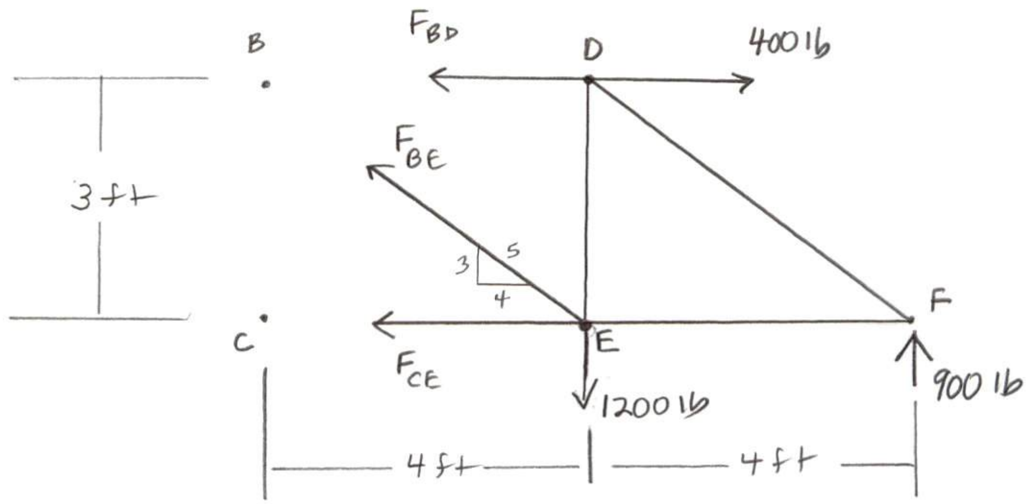
$[\Sigma M_E = 0]$ $\quad -300\text{ lb}(8\text{ ft}) - F_{BD}(3\text{ ft}) = 0$

$$F_{BD} = -\frac{2400\text{ lb}\cdot\text{ft}}{3\text{ ft}} = -800\text{ lb}\ (T)$$

and $\boxed{F_{BD} = 800\text{ lb}\ (C)}$

$[\Sigma F_y = 0]$ $\quad 300\text{ lb} - \frac{3}{5}F_{BE} = 0$

$$F_{BE} = \frac{5}{3}(300\text{ lb}) = \underline{\underline{500\text{ lb}}}\ (T)$$



FBD- Right Portion of Section a-a

Equilibrium Equations

ccw + M
cw − M

$[\Sigma M_B = 0]$ $\quad -F_{CE}(3 ft) - 1200 lb(4 ft) + 900 lb(8 ft) = 0$

$$F_{CE} = \frac{2400 \text{ lb.ft}}{3 \text{ ft}} = \underline{\underline{800 \text{ lb (T)}}}$$

$[\Sigma M_E = 0]$ $\quad F_{BD}(3 ft) - 400 lb(3 ft) + 900 lb(4 ft) = 0$

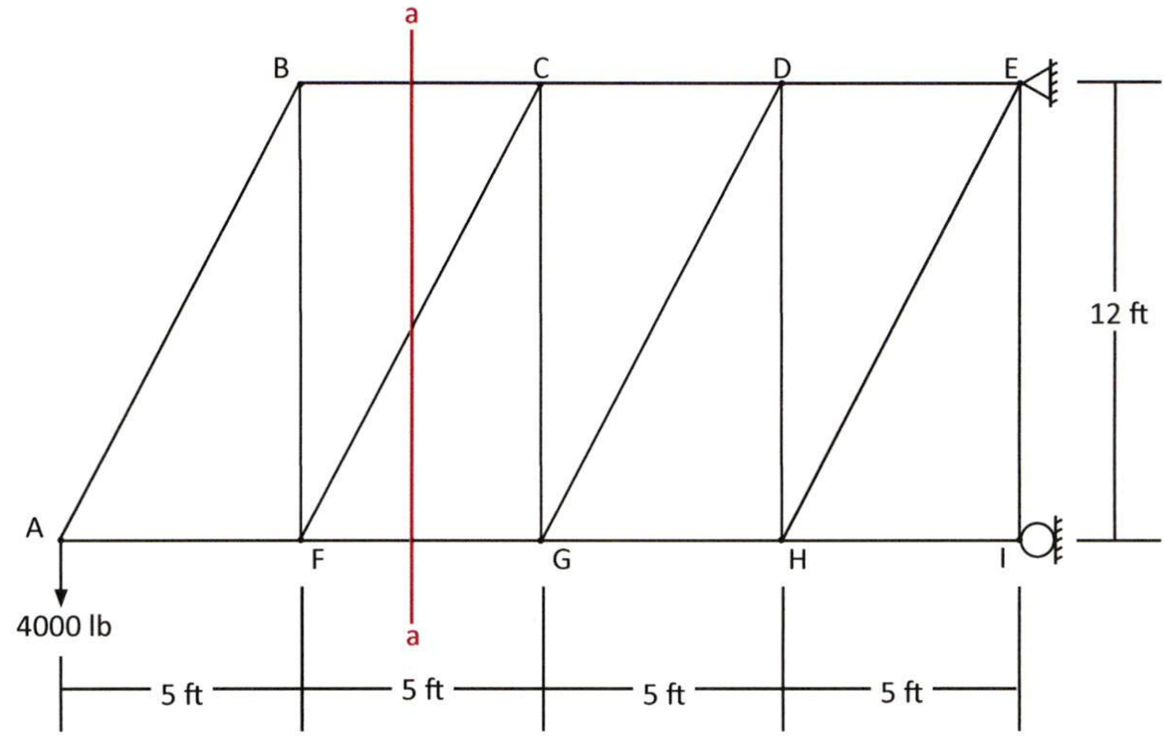
$$F_{BD} = -\frac{2400 \text{ lb.ft}}{3 \text{ ft}} = -800 \text{ lb (T)}$$

and $\boxed{F_{BD} = 800 \text{ lb (C)}}$

$[\Sigma F_y = 0]$ $\quad -1200 lb + 900 lb + \frac{3}{5} F_{BE} = 0$

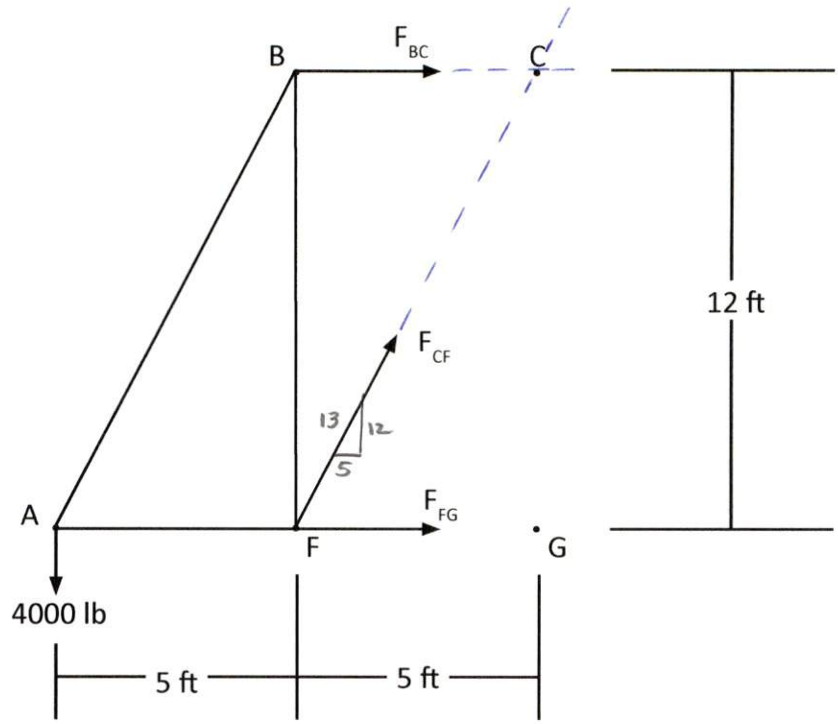
$$F_{BE} = \frac{5}{3}(300 \text{ lb}) = \underline{\underline{500 \text{ lb (T)}}}$$

Example 2. Use the Method of Sections to determine the force in members BC, CF, and FG.



Solution.

IF we use the FBD of the left portion of section a-a we do not need to solve for the reactions at the pin support at E and the roller support at I.



FBD - Left Portion of Section a-a

ccw +M
cw −M

Equilibrium Equations

$[\Sigma M_F = 0]$ $\quad -F_{BC}(12\text{ ft}) + 4000\text{ lb}(5\text{ ft}) = 0$

$$F_{BC} = \frac{20{,}000\text{ lb ft}}{12\text{ ft}} = \underline{\underline{1667}}\text{ lb (T)}$$

$[\Sigma M_C = 0]$ $\quad 4000\text{ lb}(10\text{ ft}) + F_{FG}(12\text{ ft}) = 0$

$$F_{FG} = -\frac{40{,}000\text{ lb ft}}{12\text{ ft}} = -3333\text{ lb (T)}$$

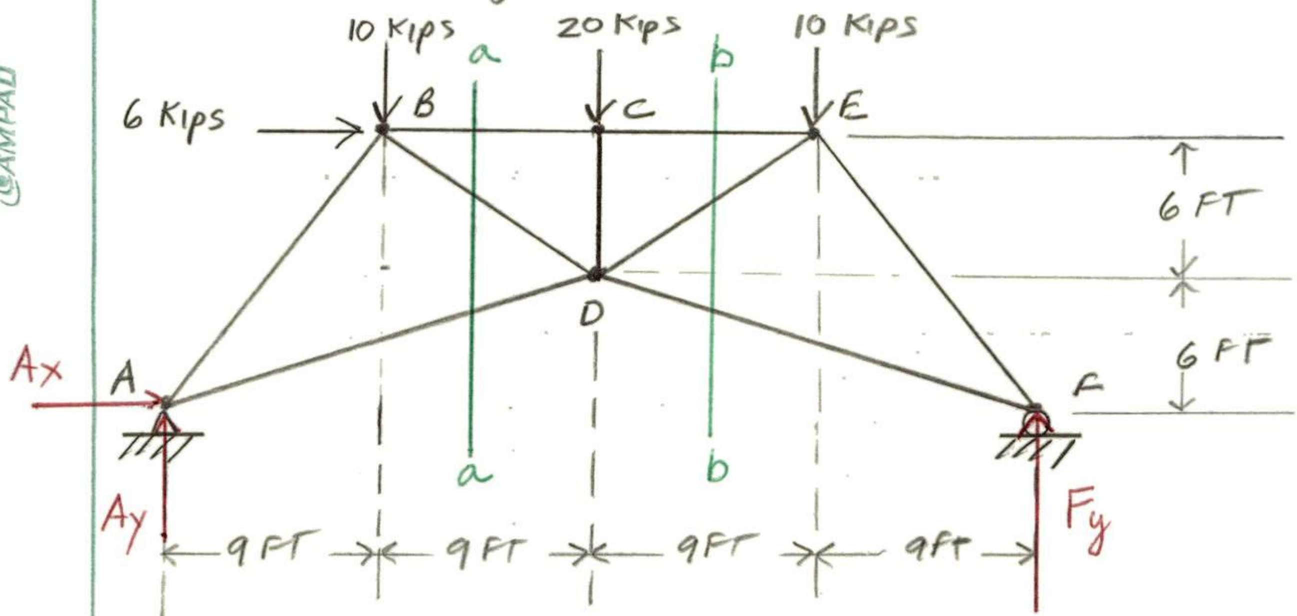
and $\boxed{F_{FG} = 3{,}333\text{ lb (C)}}$

$[\Sigma F_y = 0)$ $\quad -4000\text{ lb} + \frac{12}{13}F_{CF} = 0$

$$F_{CF} = \frac{13}{12}(4000\text{ lb}) = \underline{\underline{4{,}333}}\text{ lb (T)}$$

P-4-27

Determine the forces in all the members of the truss by <u>combined use</u> of the <u>Method of Sections</u> and the <u>method of joints</u> so that the solution of simultaneous equations can be avoided.



CCW + M
CW − M

Solution.

Step 1. Solve for the reactions at A and F

$\Sigma F_x = 0$ $\qquad A_x + 6 \text{ Kips} = 0$

$$A_x = -6 \text{ Kips} \rightarrow$$

or

$$\boxed{A_x = 6 \text{ Kips} \leftarrow}$$

$\Sigma M_A = 0$

$$-6\text{Kips}(12\text{Ft}) - 10\text{Kips}(9\text{Ft}) - 20\text{Kips}(18\text{Ft}) - 10\text{Kips}(27\text{Ft}) + F_y(36\text{Ft}) = 0$$

$$F_y(36\text{Ft}) = (72 + 90 + 360 + 270)\text{ Kips}\cdot\text{Ft}$$

$$F_y = \frac{792 \text{ Kips-FT}}{36 \text{ Ft}} = \underline{\underline{22 \text{ Kips} \uparrow}}$$

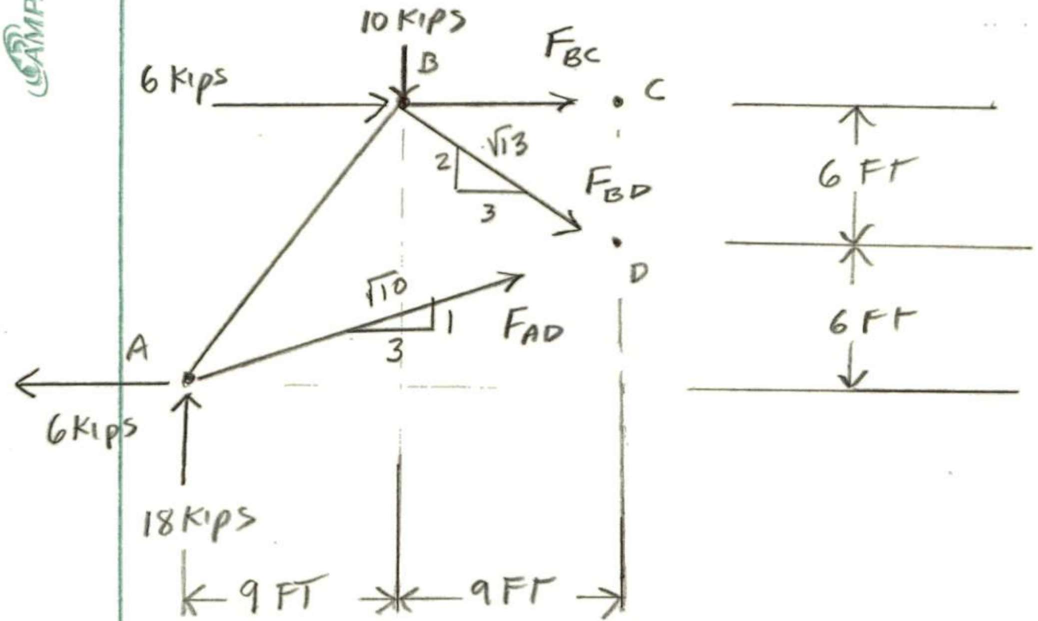
$\Sigma F_y = 0$

$$A_y - 10\text{ Kips} - 20\text{ Kips} - 10\text{ Kips} + 22\text{ Kips} = 0$$

$$A_y = (40 - 22)\text{ Kips}$$

$$A_y = \underline{\underline{18\text{ Kips}}}\ \uparrow$$

Step 2. use Method of Sections AND METHOD of Joints



CCW +M

CW −M

FBD- Left Portion of Section a-a

Equilibrium Equations

$\Sigma M_B = 0$

$$-6\text{Kips}(12\text{Ft}) - 18\text{Kips}(9\text{Ft}) - \frac{1}{\sqrt{10}}F_{AD}(9\text{FT}) + \frac{3}{\sqrt{10}}F_{AD}(12\text{FT}) = 0$$

$$2.846\, F_{AD} - 11.384\, F_{AD} = -234\text{ Kips}\cdot\text{Ft}$$

$$F_{AD} = \frac{-234\text{ Kips}\cdot\text{FT}}{-8.538\text{ FT}}$$

$$F_{AD} = \underline{\underline{27.4\text{ Kips (T)}}}$$

$\Sigma M_D = 0$

$$-18 Kips(18 FT) - 6 Kips(6 FT) - 6 Kips(6 FT) + 10 Kips(9 FT) - F_{BC}(6 FT) = 0$$

$$F_{BC}(6 FT) = (-324 - 36 - 36 + 90) Kips \cdot FT$$

$$F_{BC} = \frac{-306 \ Kips \cdot FT}{6 \ FT}$$

$$F_{BC} = -51 \ Kips \ (T)$$

or

$$\boxed{F_{BC} = 51 \ Kips \ (C)}$$

$\Sigma F_y = 0$

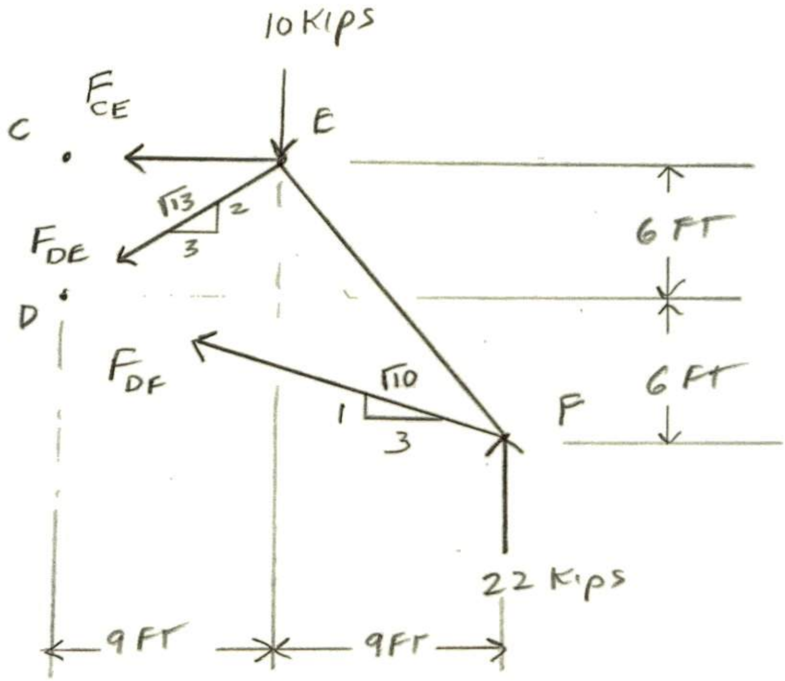
$$18 Kips - 10 Kips - \frac{2}{\sqrt{13}} F_{BD} + \frac{1}{\sqrt{10}} F_{AD} = 0$$

$$\frac{2}{\sqrt{13}} F_{BD} = 8 Kips + \frac{1}{\sqrt{10}}(27.4 Kips)$$

$$F_{BD} = \frac{(8 Kips + 8.6646 Kips)\sqrt{13}}{2}$$

$$\underline{\underline{F_{BD} = 30 \ Kips \ (T)}}$$

Use Section b-b



FBD - Right Portion of Section b-b

Equilibrium Equations

ccw +M
cw −M

$\Sigma M_E = 0$

$$22 \text{ Kips}(9\text{ft}) + \frac{1}{\sqrt{10}} F_{DF}(9\text{FT}) - \frac{3}{\sqrt{10}} F_{DF}(12\text{Ft}) = 0$$

$$(8.5381 \text{ Ft}) F_{DF} = 198 \text{ Kips} \cdot \text{Ft}$$

$$F_{DF} = \frac{198 \text{ Kips} \cdot \text{FT}}{8.5381 \text{ Ft}}$$

$$F_{DF} = \underline{\underline{23.2 \text{ Kips (T)}}}$$

$$\Sigma M_D = 0$$

$$22\text{ kips}(18\text{ ft}) - 10\text{ kips}(9\text{ ft}) + F_{CE}(6\text{ ft}) = 0$$

$$F_{CE}(6\text{ ft}) = -396\text{ kips}\cdot\text{ft} + 90\text{ kips}\cdot\text{ft}$$

$$F_{CE} = -\frac{306\text{ kips}\cdot\text{ft}}{6\text{ ft}}$$

$$F_{CE} = -51\text{ kips (T)}$$

OR

$$\boxed{F_{CE} = 51\text{ kips (C)}}$$

$$\Sigma F_x = 0$$

$$-F_{CE} - \frac{3}{\sqrt{13}}F_{DE} - \frac{3}{\sqrt{10}}F_{DF} = 0$$

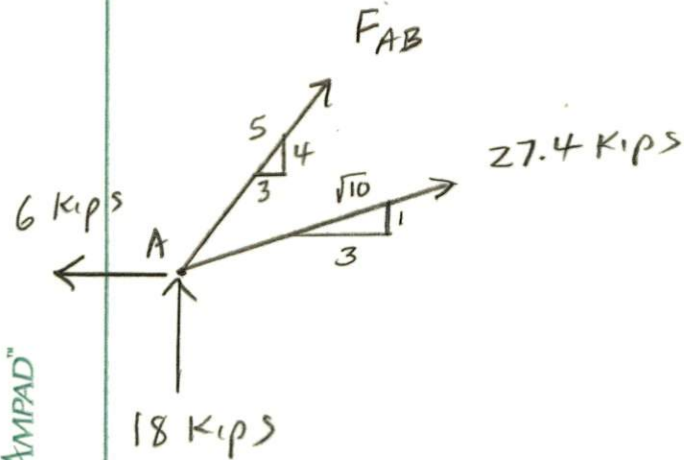
$$-\frac{3}{\sqrt{13}}F_{DE} = F_{CE} + \frac{3}{\sqrt{10}}F_{DF}$$

$$-\frac{3}{\sqrt{13}}F_{DE} = -51\text{ kips} + \frac{3}{\sqrt{10}}(23.2\text{ kips})$$

$$-\frac{3}{\sqrt{13}}F_{DE} = -28.99\text{ kips}$$

$$F_{DE} = \underline{\underline{34.8\text{ kips (T)}}}$$

Joint A



FBD

Equilibrium Equations

$\Sigma F_x = 0$

$$-6\text{ Kips} + \frac{3}{5}F_{AB} + \frac{3}{\sqrt{10}}(27.4\text{ Kips}) = 0$$

$$\frac{3}{5}F_{AB} = 6\text{ Kips} - 26\text{ Kips}$$

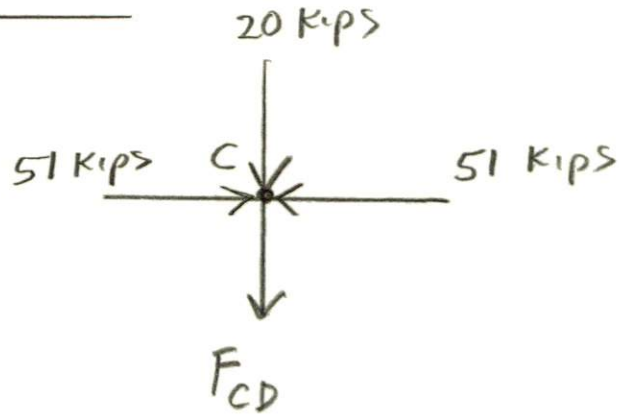
$$F_{AB} = \frac{-20\text{ Kips}\,(5)}{3}$$

$$F_{AB} = -33.3\text{ Kips (T)}$$

OR

$$\boxed{F_{AB} = 33.3\text{ Kips (C)}}$$

Joint C



FBD

Equilibrium Equations

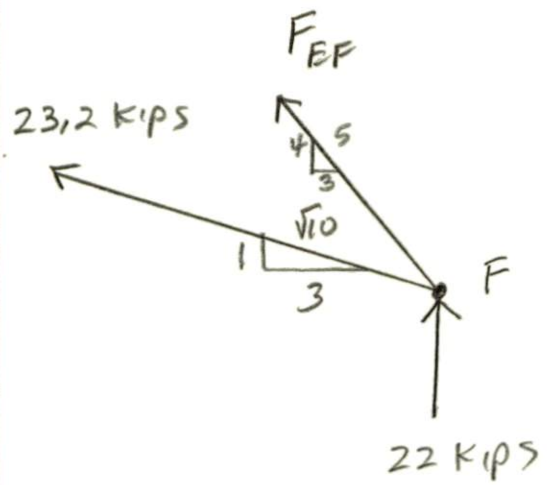
$\Sigma F_y = 0 \qquad -20 \text{ kips} - F_{CD} = 0$

$F_{CD} = -20 \text{ kips (T)}$

OR

$$\boxed{F_{CD} = 20 \text{ kips (C)}}$$

Joint F:



FBD

Equilibrium Equations

$\Sigma F_x = 0$

$$-\frac{3}{\sqrt{10}}(23.2\text{ kips}) - \frac{3}{5}F_{EF} = 0$$

$$\frac{3}{5}F_{EF} = -22\text{ kips}$$

$$F_{EF} = -22\text{ kips}\left(\frac{5}{3}\right)$$

$$F_{EF} = -36.7\text{ kips (T)}$$

OR

$$\boxed{F_{EF} = 36.7\text{ kips (C)}}$$