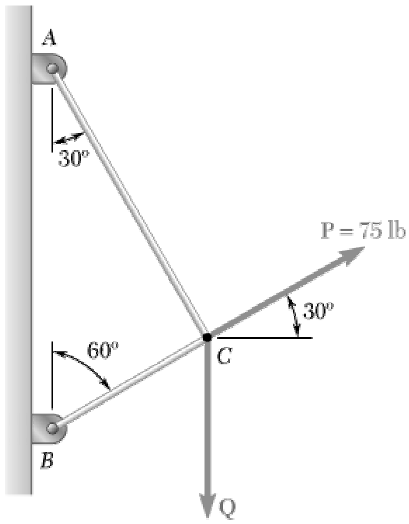
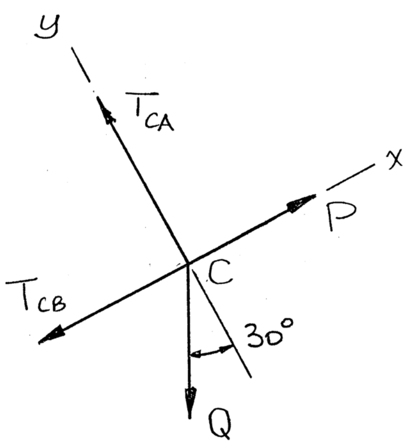
## PROBLEM 2.132




Two cables tied together at $C$ are loaded as shown. Knowing that $Q = 60$ lb, determine the tension (*a*) in cable $AC$, (*b*) in cable $BC$.

## SOLUTION




$$\Sigma F_y = 0: \quad T_{CA} - Q\cos 30° = 0$$

With $\quad Q = 60 \text{ lb}$

(*a*) $\quad T_{CA} = (60 \text{ lb})(0.866)$

$$T_{CA} = 52.0 \text{ lb} \blacktriangleleft$$

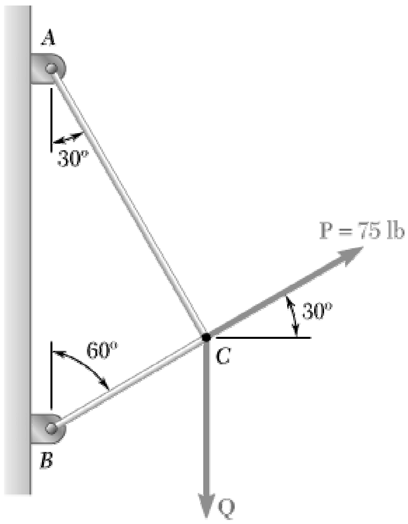
(*b*) $\quad \Sigma F_x = 0: \quad P - T_{CB} - Q\sin 30° = 0$

With $\quad P = 75 \text{ lb}$

$$T_{CB} = 75 \text{ lb} - (60 \text{ lb})(0.50)$$

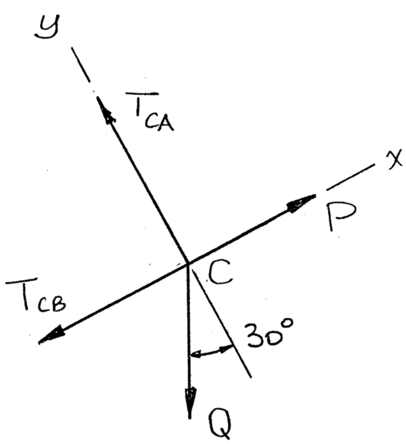
or $\quad T_{CB} = 45.0 \text{ lb} \blacktriangleleft$

## PROBLEM 2.133




Two cables tied together at $C$ are loaded as shown. Determine the range of values of $Q$ for which the tension will not exceed 60 lb in either cable.

## SOLUTION




Have $\quad \Sigma F_x = 0: \quad T_{CA} - Q\cos 30° = 0$

or $\quad T_{CA} = 0.8660 \text{ Q}$

Then for $\quad T_{CA} \le 60 \text{ lb}$

$$0.8660Q < 60 \text{ lb}$$

or $\quad Q \le 69.3 \text{ lb}$

From $\quad \Sigma F_y = 0: \quad T_{CB} = P - Q\sin 30°$

or $\quad T_{CB} = 75 \text{ lb} - 0.50Q$

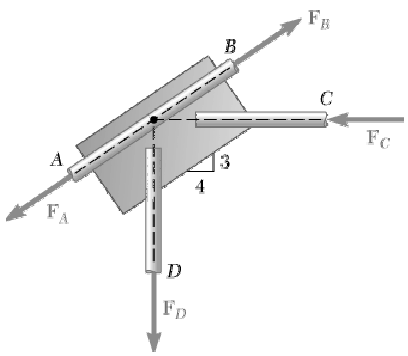
For $\quad T_{CB} \le 60 \text{ lb}$

$$75 \text{ lb} - 0.50Q \le 60 \text{ lb}$$

or $\quad 0.50Q \ge 15 \text{ lb}$

Thus, $\quad Q \ge 30 \text{ lb}$

Therefore, $\quad 30.0 \le Q \le 69.3 \text{ lb}$ ◀

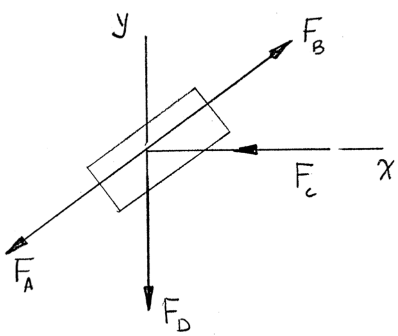



## PROBLEM 2.134

A welded connection is in equilibrium under the action of the four forces shown. Knowing that $F_A = 8$ kN and $F_B = 16$ kN, determine the magnitudes of the other two forces.

## SOLUTION

**Free-Body Diagram of Connection**




$$\Sigma F_x = 0: \quad \frac{3}{5}F_B - F_C - \frac{3}{5}F_A = 0$$

With $$F_A = 8 \text{ kN}, \; F_B = 16 \text{ kN}$$

$$F_C = \frac{4}{5}(16 \text{ kN}) - \frac{4}{5}(8 \text{ kN})$$

$$F_C = 6.40 \text{ kN} \blacktriangleleft$$

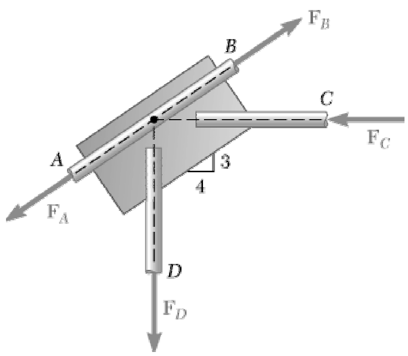
$$\Sigma F_y = 0: \quad -F_D + \frac{3}{5}F_B - \frac{3}{5}F_A = 0$$

With $F_A$ and $F_B$ as above:

$$F_D = \frac{3}{5}(16 \text{ kN}) - \frac{3}{5}(8 \text{ kN})$$

$$F_D = 4.80 \text{ kN} \blacktriangleleft$$

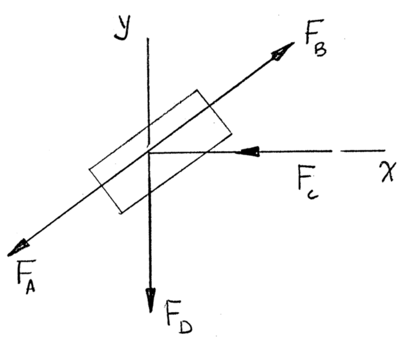
## PROBLEM 2.135




A welded connection is in equilibrium under the action of the four forces shown. Knowing that $F_A = 5$ kN and $F_D = 6$ kN, determine the magnitudes of the other two forces.

## SOLUTION

**Free-Body Diagram of Connection**




$$\Sigma F_y = 0: \quad -F_D - \frac{3}{5}F_A + \frac{3}{5}F_B = 0$$

or

$$F_B = F_D + \frac{3}{5}F_A$$

With

$$F_A = 5 \text{ kN}, \quad F_D = 8 \text{ kN}$$

$$F_B = \frac{5}{3}\left[6 \text{ kN} + \frac{3}{5}(5 \text{ kN})\right]$$

$$F_B = 15.00 \text{ kN} \blacktriangleleft$$

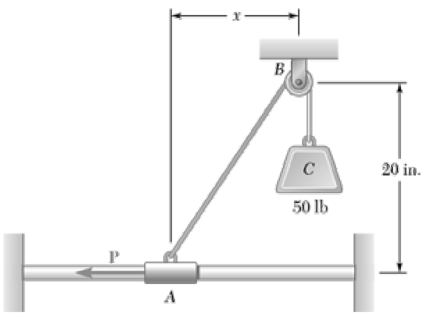
$$\Sigma F_x = 0: \quad -F_C + \frac{4}{5}F_B - \frac{4}{5}F_A = 0$$

$$F_C = \frac{4}{5}(F_B - F_A)$$

$$= \frac{4}{5}(15 \text{ kN} - 5 \text{ kN})$$

$$F_C = 8.00 \text{ kN} \blacktriangleleft$$

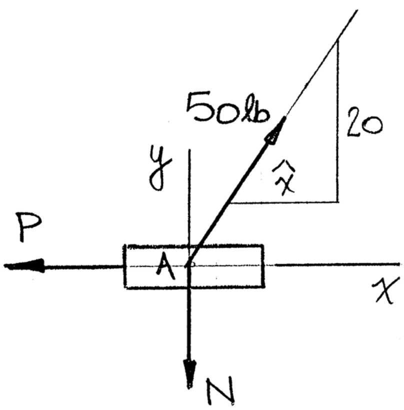
## PROBLEM 2.136



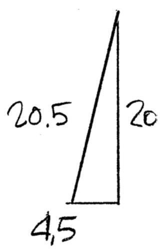

Collar $A$ is connected as shown to a 50-lb load and can slide on a frictionless horizontal rod. Determine the magnitude of the force **P** required to maintain the equilibrium of the collar when ($a$) $x = 4.5$ in., ($b$) $x = 15$ in.

## SOLUTION

**Free-Body Diagram of Collar**




($a$)

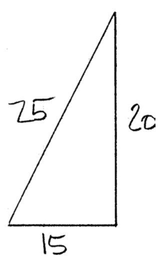



**Triangle Proportions**

$$\Sigma F_x = 0: \quad -P + \frac{4.5}{20.5}(50 \text{ lb}) = 0$$

or $P = 10.98$ lb ◀

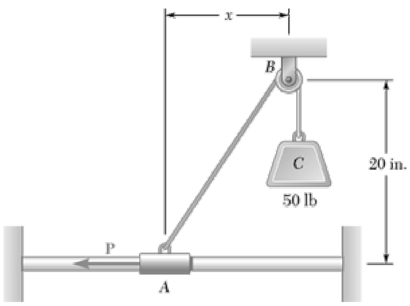
($b$)




**Triangle Proportions**

$$\Sigma F_x = 0: \quad -P + \frac{15}{25}(50 \text{ lb}) = 0$$

or $P = 30.0$ lb ◀

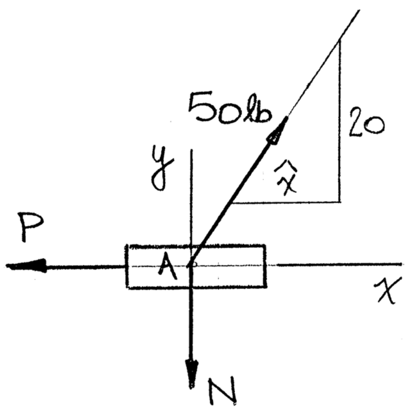


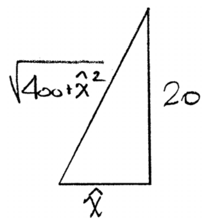

## PROBLEM 2.137

Collar $A$ is connected as shown to a 50-lb load and can slide on a frictionless horizontal rod. Determine the distance $x$ for which the collar is in equilibrium when $P = 48$ lb.

## SOLUTION

**Free-Body Diagram of Collar**




**Triangle Proportions**

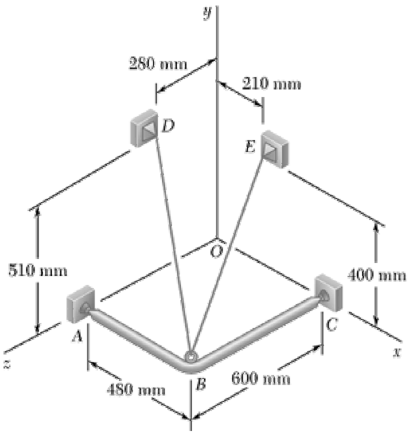
Hence: $\Sigma F_x = 0: \quad -48 + \dfrac{50\hat{x}}{\sqrt{400 + \hat{x}^2}} = 0$

or $\hat{x} = \dfrac{48}{50}\sqrt{400 + \hat{x}^2}$

$$\hat{x}^2 = 0.92 \text{ lb}\left(400 + \hat{x}^2\right)$$

$$\hat{x}^2 = 4737.7 \text{ in}^2$$

$\hat{x} = 68.6$ in. ◀




## PROBLEM 2.138

A frame *ABC* is supported in part by cable *DBE* which passes through a frictionless ring at *B*. Knowing that the tension in the cable is 385 N, determine the components of the force exerted by the cable on the support at *D*.

## SOLUTION

The force in cable *DB* can be written as the product of the magnitude of the force and the unit vector along the cable. That is, with

$$\overrightarrow{DB} = (480 \text{ mm})\mathbf{i} - (510 \text{ mm})\mathbf{j} + (320 \text{ mm})\mathbf{k}$$

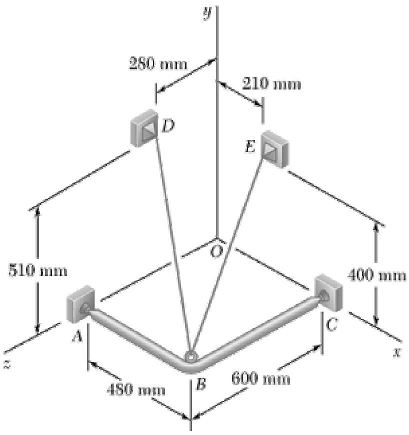
$$DB = \sqrt{(480)^2 + (510)^2 + (320)^2} = 770 \text{ mm}$$

$$\mathbf{F} = F\lambda_{DB} = F\frac{\overrightarrow{DB}}{DB} = \frac{385 \text{ N}}{770 \text{ mm}}\left[(480 \text{ mm})\mathbf{i} - (510 \text{ mm})\mathbf{j} + (320 \text{ mm})\mathbf{k}\right]$$

$$\mathbf{F} = (240 \text{ N})\mathbf{i} - (255 \text{ N})\mathbf{j} + (160 \text{ N})\mathbf{k}$$

$$F_x = +240 \text{ N}, \; F_y = -255 \text{ N}, \; F_z = +160.0 \text{ N} \blacktriangleleft$$

## PROBLEM 2.139




A frame *ABC* is supported in part by cable *DBE* which passes through a frictionless ring at *B*. Determine the magnitude and direction of the resultant of the forces exerted by the cable at *B* knowing that the tension in the cable is 385 N.

## SOLUTION

The force in each cable can be written as the product of the magnitude of the force and the unit vector along the cable. That is, with

$$\overrightarrow{BD} = -(0.48\text{ m})\mathbf{i} + (0.51\text{ m})\mathbf{j} - (0.32\text{ m})\mathbf{k}$$

$$BD = \sqrt{(-0.48\text{ m})^2 + (0.51\text{ m})^2 + (-0.32\text{ m})^2} = 0.77\text{ m}$$

$$\mathbf{T}_{BD} = T\boldsymbol{\lambda}_{BD} = T_{BD}\frac{\overrightarrow{BD}}{BD} = \frac{T_{BD}}{0.77\text{ m}}\left[-(0.48\text{ m})\mathbf{i} + (0.51\text{ m})\mathbf{j} - (0.32\text{ m})\mathbf{k}\right]$$

$$\mathbf{T}_{BD} = T_{BD}(-0.6234\mathbf{i} + 0.6623\mathbf{j} - 0.4156\mathbf{k})$$

and

$$\overrightarrow{BE} = -(0.27\text{ m})\mathbf{i} + (0.40\text{ m})\mathbf{j} - (0.6\text{ m})\mathbf{k}$$

$$BE = \sqrt{(-0.27\text{ m})^2 + (0.40\text{ m})^2 + (-0.6\text{ m})^2} = 0.770\text{ m}$$

$$\mathbf{T}_{BE} = T\boldsymbol{\lambda}_{BE} = T_{BE}\frac{\overrightarrow{BD}}{BD} = \frac{T_{BE}}{0.770\text{ m}}\left[-(0.26\text{ m})\mathbf{i} + (0.40\text{ m})\mathbf{j} - (0.6\text{ m})\mathbf{k}\right]$$

$$\mathbf{T}_{BE} = T_{BE}(-0.3506\mathbf{i} + 0.5195\mathbf{j} - 0.7792\mathbf{k})$$

Now, because of the frictionless ring at *B*, $T_{BE} = T_{BD} = 385\text{ N}$ and the force on the support due to the two cables is

$$\mathbf{F} = 385\text{ N}(-0.6234\mathbf{i} + 0.6623\mathbf{j} - 0.4156\mathbf{k} - 0.3506\mathbf{i} + 0.5195\mathbf{j} - 0.7792\mathbf{k})$$

$$= -(375\text{ N})\mathbf{i} + (455\text{ N})\mathbf{j} - (460\text{ N})\mathbf{k}$$

## PROBLEM 2.139 CONTINUED

The magnitude of the resultant is

$$F = \sqrt{F_x^2 + F_y^2 + F_z^2} = \sqrt{(-375\text{ N})^2 + (455\text{ N})^2 + (-460\text{ N})^2} = 747.83\text{ N}$$

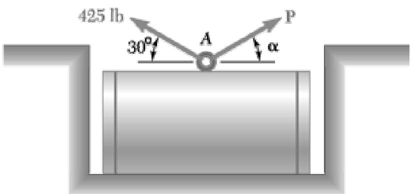
or $F = 748\text{ N}$ ◀

The direction of this force is:

$$\theta_x = \cos^{-1}\frac{-375}{747.83}$$ or $\theta_x = 120.1°$ ◀

$$\theta_y = \cos^{-1}\frac{455}{747.83}$$ or $\theta_y = 52.5°$ ◀

$$\theta_z = \cos^{-1}\frac{-460}{747.83}$$ or $\theta_z = 128.0°$ ◀

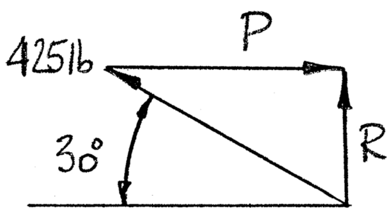



## PROBLEM 2.140

A steel tank is to be positioned in an excavation. Using trigonometry, determine (*a*) the magnitude and direction of the smallest force **P** for which the resultant **R** of the two forces applied at *A* is vertical, (*b*) the corresponding magnitude of **R**.

## SOLUTION

**Force Triangle**




(*a*) For minimum *P* it must be perpendicular to the vertical resultant *R*

$$\therefore \quad P = (425\text{ lb})\cos 30°$$

or $\mathbf{P} = 368\text{ lb} \longrightarrow$ ◀

(*b*)

$$R = (425\text{ lb})\sin 30°$$

or $R = 213\text{ lb}$ ◀