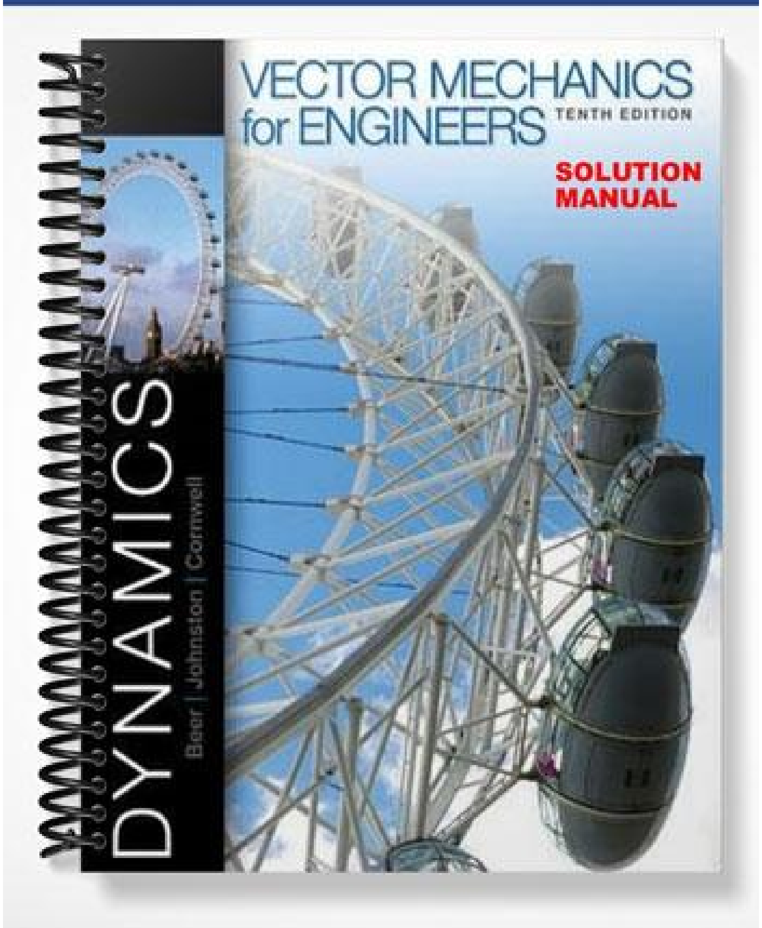
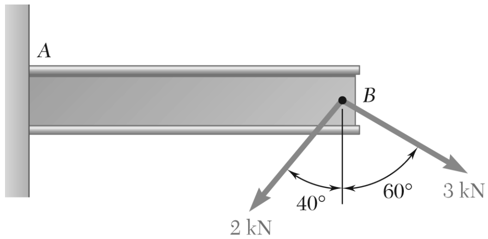
SOLUTIONS MANUAL



CHAPTER 2

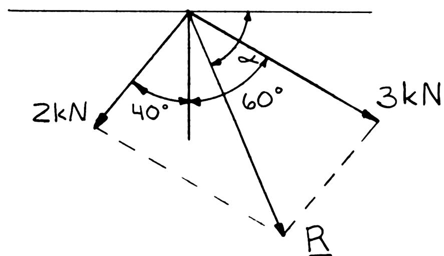


PROBLEM 2.1

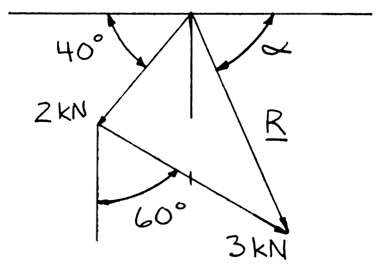
Two forces are applied at point B of beam AB. Determine graphically the magnitude and direction of their resultant using (a) the parallelogram law, (b) the triangle rule.

SOLUTION

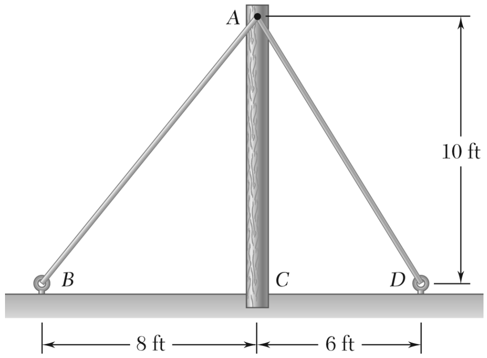
(a) Parallelogram law:



(b) Triangle rule:



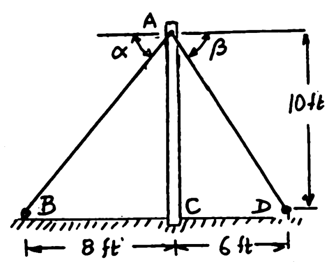
We measure: $R = 3.30$ kN, $\alpha = 66.6°$ **R** = 3.30 kN ↘ 66.6° ◀



PROBLEM 2.2

The cable stays *AB* and *AD* help support pole *AC*. Knowing that the tension is 120 lb in *AB* and 40 lb in *AD*, determine graphically the magnitude and direction of the resultant of the forces exerted by the stays at *A* using (*a*) the parallelogram law, (*b*) the triangle rule.

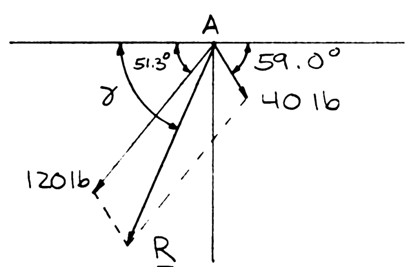
SOLUTION



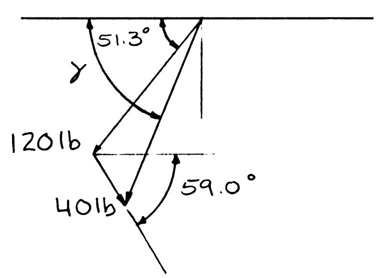
We measure: $\alpha = 51.3°$

$\beta = 59.0°$

(*a*) Parallelogram law:

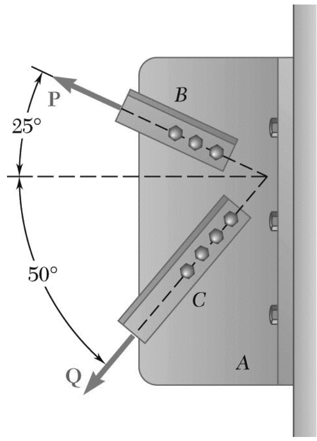


(*b*) Triangle rule:



We measure: $R = 139.1$ lb, $\gamma = 67.0°$ $R = 139.1$ lb ↙ $67.0°$ ◀

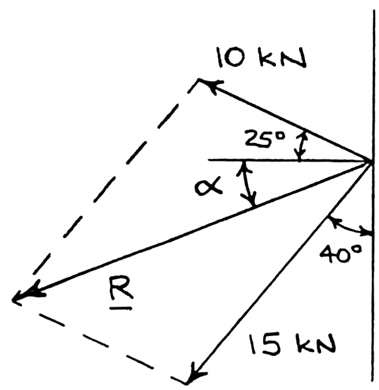
PROBLEM 2.3



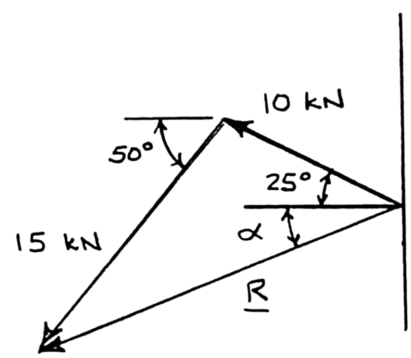
Two structural members *B* and *C* are bolted to bracket *A*. Knowing that both members are in tension and that $P = 10$ kN and $Q = 15$ kN, determine graphically the magnitude and direction of the resultant force exerted on the bracket using (*a*) the parallelogram law, (*b*) the triangle rule.

SOLUTION

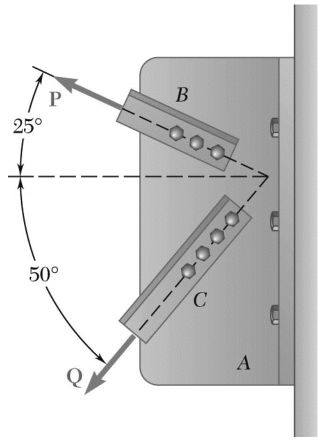
(*a*) Parallelogram law:



(*b*) Triangle rule:



We measure: $R = 20.1$ kN, $\alpha = 21.2°$ $\quad$ $\mathbf{R} = 20.1$ kN ⦣ 21.2° ◀

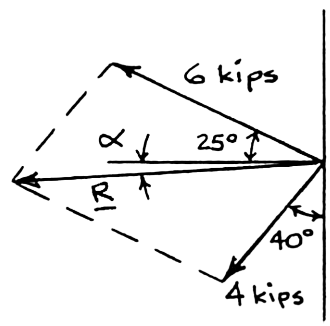


PROBLEM 2.4

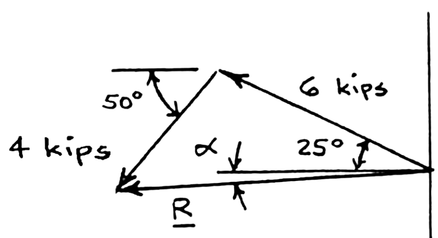
Two structural members *B* and *C* are bolted to bracket *A*. Knowing that both members are in tension and that $P = 6$ kips and $Q = 4$ kips, determine graphically the magnitude and direction of the resultant force exerted on the bracket using (*a*) the parallelogram law, (*b*) the triangle rule.

SOLUTION

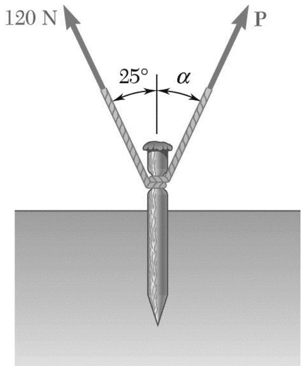
(*a*) Parallelogram law:



(*b*) Triangle rule:



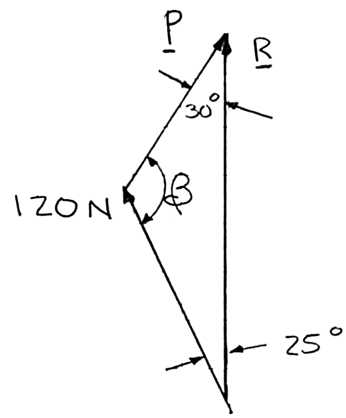
We measure: $R = 8.03$ kips, $\alpha = 3.8°$ **R** $= 8.03$ kips ↙ 3.8° ◀



PROBLEM 2.5

A stake is being pulled out of the ground by means of two ropes as shown. Knowing that $\alpha = 30°$, determine by trigonometry (*a*) the magnitude of the force **P** so that the resultant force exerted on the stake is vertical, (*b*) the corresponding magnitude of the resultant.

SOLUTION



Using the triangle rule and the law of sines:

(*a*)

$$\frac{120\text{ N}}{\sin 30°} = \frac{P}{\sin 25°}$$

$P = 101.4\text{ N}$ ◀

(*b*)

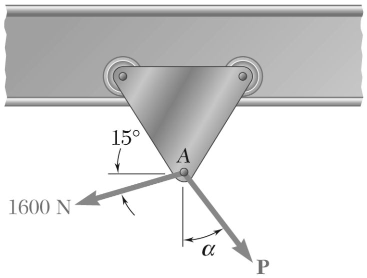
$$30° + \beta + 25° = 180°$$

$$\beta = 180° - 25° - 30°$$

$$= 125°$$

$$\frac{120\text{ N}}{\sin 30°} = \frac{R}{\sin 125°}$$

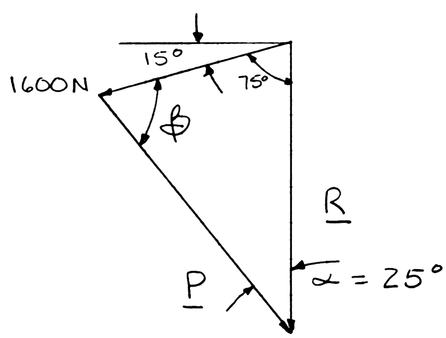
$R = 196.6\text{ N}$ ◀



PROBLEM 2.6

A trolley that moves along a horizontal beam is acted upon by two forces as shown. (*a*) Knowing that $\alpha = 25°$, determine by trigonometry the magnitude of the force **P** so that the resultant force exerted on the trolley is vertical. (*b*) What is the corresponding magnitude of the resultant?

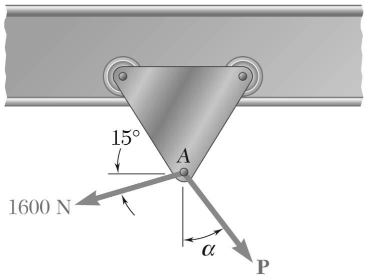
SOLUTION



Using the triangle rule and the law of sines:

(*a*)
$$\frac{1600 \text{ N}}{\sin 25°} = \frac{P}{\sin 75°}$$
$P = 3660$ N ◀

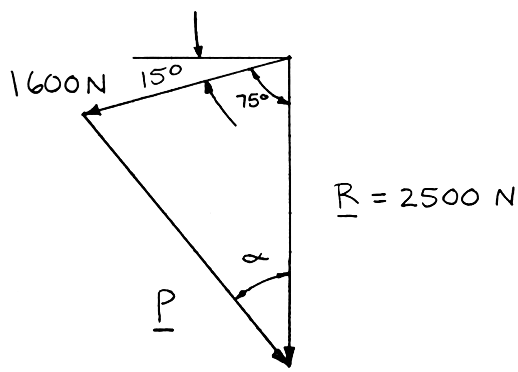
(*b*)
$$25° + \beta + 75° = 180°$$
$$\beta = 180° - 25° - 75°$$
$$= 80°$$
$$\frac{1600 \text{ N}}{\sin 25°} = \frac{R}{\sin 80°}$$
$R = 3730$ N ◀



PROBLEM 2.7

A trolley that moves along a horizontal beam is acted upon by two forces as shown. Determine by trigonometry the magnitude and direction of the force **P** so that the resultant is a vertical force of 2500 N.

SOLUTION



Using the law of cosines: $P^2 = (1600\text{ N})^2 + (2500\text{ N})^2 - 2(1600\text{ N})(2500\text{ N})\cos 75°$

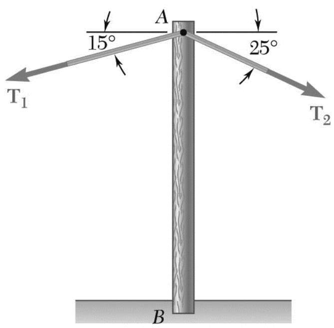
$$P = 2596\text{ N}$$

Using the law of sines: $\dfrac{\sin\alpha}{1600\text{ N}} = \dfrac{\sin 75°}{2596\text{ N}}$

$$\alpha = 36.5°$$

P is directed $90° - 36.5°$ or $53.5°$ below the horizontal.

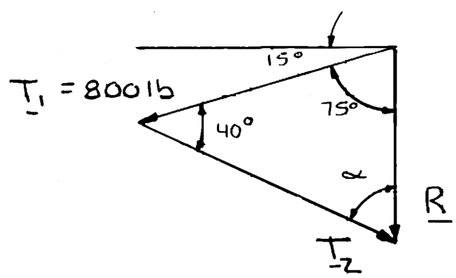
P = 2600 N ⦪ 53.5° ◀



PROBLEM 2.8

A telephone cable is clamped at *A* to the pole *AB*. Knowing that the tension in the left-hand portion of the cable is T_1 = 800 lb, determine by trigonometry (*a*) the required tension T_2 in the right-hand portion if the resultant **R** of the forces exerted by the cable at *A* is to be vertical, (*b*) the corresponding magnitude of **R**.

SOLUTION



Using the triangle rule and the law of sines:

(*a*)

$$75° + 40° + \alpha = 180°$$

$$\alpha = 180° - 75° - 40°$$

$$= 65°$$

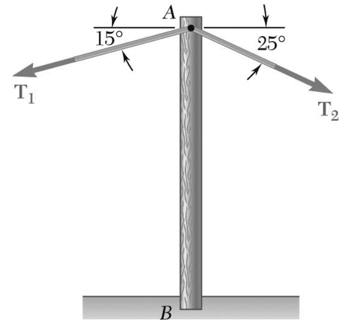
$$\frac{800 \text{ lb}}{\sin 65°} = \frac{T_2}{\sin 75°}$$

$T_2 = 853$ lb ◀

(*b*)

$$\frac{800 \text{ lb}}{\sin 65°} = \frac{R}{\sin 40°}$$

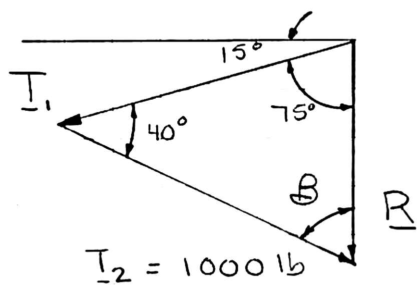
$R = 567$ lb ◀



PROBLEM 2.9

A telephone cable is clamped at *A* to the pole *AB*. Knowing that the tension in the right-hand portion of the cable is $T_2 = 1000$ lb, determine by trigonometry (*a*) the required tension T_1 in the left-hand portion if the resultant **R** of the forces exerted by the cable at *A* is to be vertical, (*b*) the corresponding magnitude of **R**.

SOLUTION



Using the triangle rule and the law of sines:

(*a*)

$$75° + 40° + \beta = 180°$$

$$\beta = 180° - 75° - 40°$$

$$= 65°$$

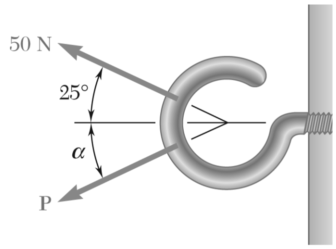
$$\frac{1000 \text{ lb}}{\sin 75°} = \frac{T_1}{\sin 65°}$$

$T_1 = 938$ lb ◀

(*b*)

$$\frac{1000 \text{ lb}}{\sin 75°} = \frac{R}{\sin 40°}$$

$R = 665$ lb ◀

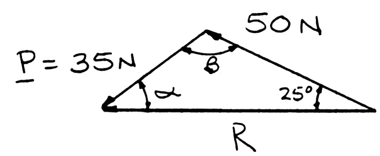


PROBLEM 2.10

Two forces are applied as shown to a hook support. Knowing that the magnitude of **P** is 35 N, determine by trigonometry (*a*) the required angle α if the resultant **R** of the two forces applied to the support is to be horizontal, (*b*) the corresponding magnitude of **R**.

SOLUTION

Using the triangle rule and law of sines:



(*a*)

$$\frac{\sin\alpha}{50\text{ N}} = \frac{\sin 25°}{35\text{ N}}$$

$$\sin\alpha = 0.60374$$

$$\alpha = 37.138°$$

$\alpha = 37.1°$ ◀

(*b*)

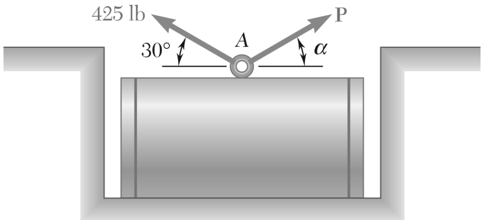
$$\alpha + \beta + 25° = 180°$$

$$\beta = 180° - 25° - 37.138°$$

$$= 117.862°$$

$$\frac{R}{\sin 117.862°} = \frac{35\text{ N}}{\sin 25°}$$

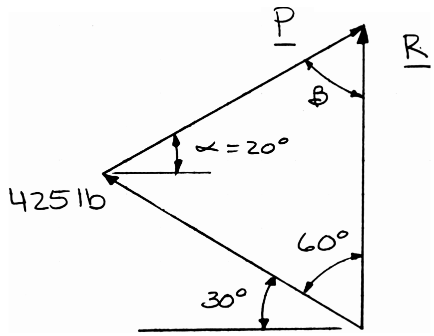
$R = 73.2$ N ◀



PROBLEM 2.11

A steel tank is to be positioned in an excavation. Knowing that $\alpha = 20°$, determine by trigonometry (*a*) the required magnitude of the force **P** if the resultant **R** of the two forces applied at *A* is to be vertical, (*b*) the corresponding magnitude of **R**.

SOLUTION



Using the triangle rule and the law of sines:

(*a*) $$\beta + 50° + 60° = 180°$$

$$\beta = 180° - 50° - 60°$$

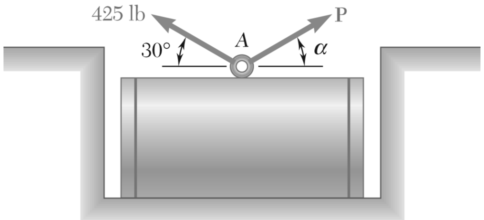
$$= 70°$$

$$\frac{425 \text{ lb}}{\sin 70°} = \frac{P}{\sin 60°}$$

$P = 392$ lb ◀

(*b*) $$\frac{425 \text{ lb}}{\sin 70°} = \frac{R}{\sin 50°}$$

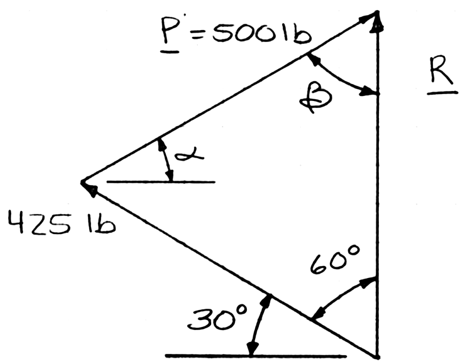
$R = 346$ lb ◀



PROBLEM 2.12

A steel tank is to be positioned in an excavation. Knowing that the magnitude of **P** is 500 lb, determine by trigonometry (*a*) the required angle α if the resultant **R** of the two forces applied at *A* is to be vertical, (*b*) the corresponding magnitude of **R**.

SOLUTION



Using the triangle rule and the law of sines:

(*a*)

$$(\alpha + 30°) + 60° + \beta = 180°$$

$$\beta = 180° - (\alpha + 30°) - 60°$$

$$\beta = 90° - \alpha$$

$$\frac{\sin(90° - \alpha)}{425 \text{ lb}} = \frac{\sin 60°}{500 \text{ lb}}$$

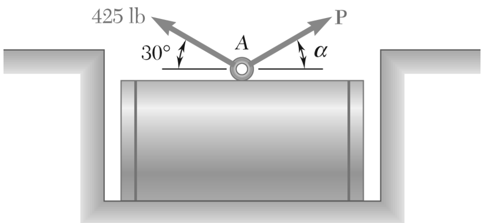
$$90° - \alpha = 47.402°$$

$\alpha = 42.6°$ ◀

(*b*)

$$\frac{R}{\sin(42.598° + 30°)} = \frac{500 \text{ lb}}{\sin 60°}$$

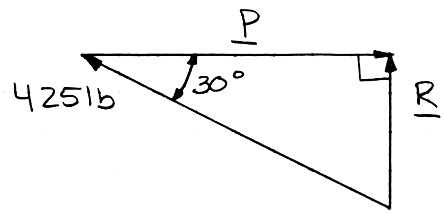
$R = 551$ lb ◀



PROBLEM 2.13

A steel tank is to be positioned in an excavation. Determine by trigonometry (*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**.

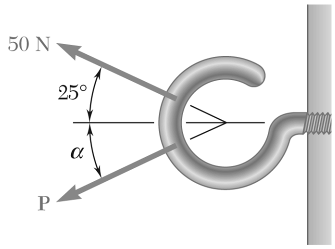
SOLUTION



The smallest force *P* will be perpendicular to *R*.

(*a*) $P = (425 \text{ lb})\cos 30°$ $\qquad$ $\mathbf{P} = 368 \text{ lb} \longrightarrow$ ◀

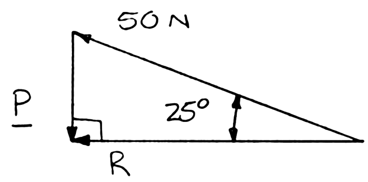
(*b*) $R = (425 \text{ lb})\sin 30°$ $\qquad$ $R = 213 \text{ lb}$ ◀



PROBLEM 2.14

For the hook support of Prob. 2.10, determine by trigonometry (*a*) the magnitude and direction of the smallest force **P** for which the resultant **R** of the two forces applied to the support is horizontal, (*b*) the corresponding magnitude of **R**.

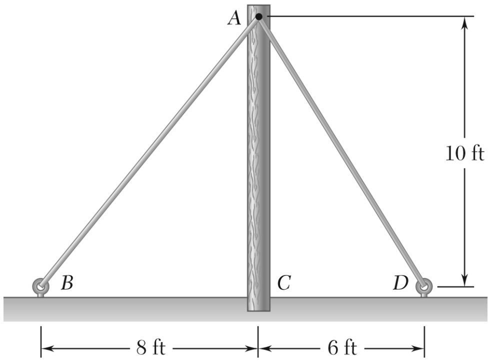
SOLUTION



The smallest force P will be perpendicular to R.

(*a*) $P = (50\text{ N})\sin 25°$ $\qquad$ $\mathbf{P} = 21.1\text{ N}\downarrow$ ◀

(*b*) $R = (50\text{ N})\cos 25°$ $\qquad$ $R = 45.3\text{ N}$ ◀

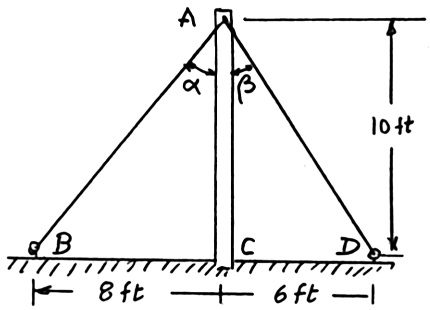


PROBLEM 2.15

Solve Problem 2.2 by trigonometry.

PROBLEM 2.2 The cable stays AB and AD help support pole AC. Knowing that the tension is 120 lb in AB and 40 lb in AD, determine graphically the magnitude and direction of the resultant of the forces exerted by the stays at A using (a) the parallelogram law, (b) the triangle rule.

SOLUTION

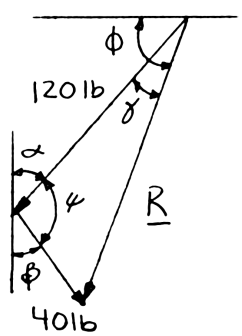


$$\tan\alpha = \frac{8}{10}$$

$$\alpha = 38.66^\circ$$

$$\tan\beta = \frac{6}{10}$$

$$\beta = 30.96^\circ$$



Using the triangle rule:

$$\alpha + \beta + \psi = 180^\circ$$

$$38.66^\circ + 30.96^\circ + \psi = 180^\circ$$

$$\psi = 110.38^\circ$$

Using the law of cosines:

$$R^2 = (120 \text{ lb})^2 + (40 \text{ lb})^2 - 2(120 \text{ lb})(40 \text{ lb})\cos 110.38^\circ$$

$$R = 139.08 \text{ lb}$$

Using the law of sines:

$$\frac{\sin\gamma}{40 \text{ lb}} = \frac{\sin 110.38^\circ}{139.08 \text{ lb}}$$

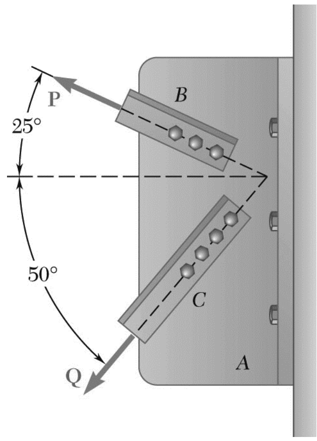
$$\gamma = 15.64^\circ$$

$$\phi = (90^\circ - \alpha) + \gamma$$

$$\phi = (90^\circ - 38.66^\circ) + 15.64^\circ$$

$$\phi = 66.98^\circ$$

$\mathbf{R} = 139.1 \text{ lb} \measuredangle 67.0^\circ$ ◀



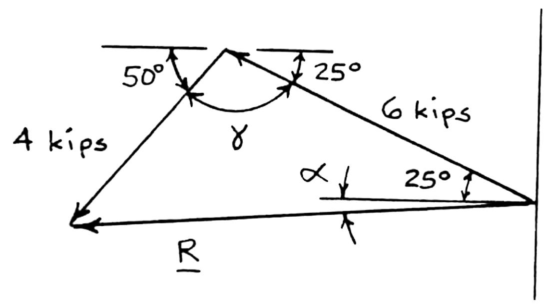
PROBLEM 2.16

Solve Problem 2.4 by trigonometry.

PROBLEM 2.4 Two structural members B and C are bolted to bracket A. Knowing that both members are in tension and that $P = 6$ kips and $Q = 4$ kips, determine graphically the magnitude and direction of the resultant force exerted on the bracket using (*a*) the parallelogram law, (*b*) the triangle rule.

SOLUTION

Using the force triangle and the laws of cosines and sines:



We have:

$$\gamma = 180° - (50° + 25°)$$
$$= 105°$$

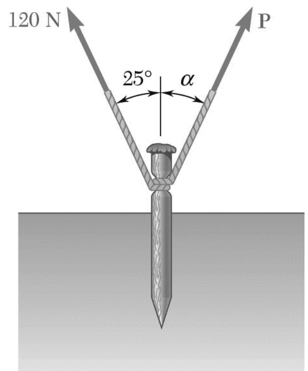
Then

$$R^2 = (4 \text{ kips})^2 + (6 \text{ kips})^2 - 2(4 \text{ kips})(6 \text{ kips})\cos 105°$$
$$= 64.423 \text{ kips}^2$$
$$R = 8.0264 \text{ kips}$$

And

$$\frac{4 \text{ kips}}{\sin(25° + \alpha)} = \frac{8.0264 \text{ kips}}{\sin 105°}$$
$$\sin(25° + \alpha) = 0.48137$$
$$25° + \alpha = 28.775°$$
$$\alpha = 3.775°$$

$\mathbf{R} = 8.03$ kips ⦩ 3.8° ◀

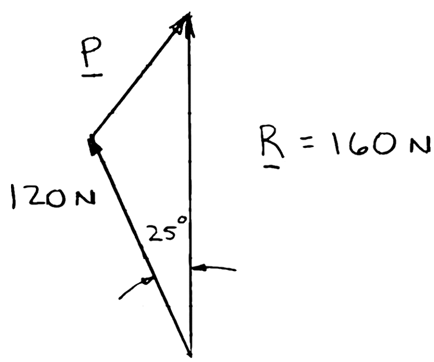


PROBLEM 2.17

For the stake of Prob. 2.5, knowing that the tension in one rope is 120 N, determine by trigonometry the magnitude and direction of the force **P** so that the resultant is a vertical force of 160 N.

PROBLEM 2.5 A stake is being pulled out of the ground by means of two ropes as shown. Knowing that $\alpha = 30°$, determine by trigonometry (*a*) the magnitude of the force **P** so that the resultant force exerted on the stake is vertical, (*b*) the corresponding magnitude of the resultant.

SOLUTION

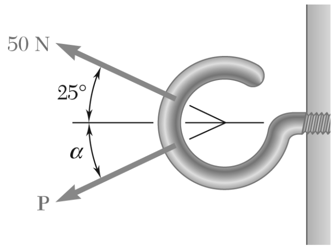


Using the laws of cosines and sines:

$$P^2 = (120\text{ N})^2 + (160\text{ N})^2 - 2(120\text{ N})(160\text{ N})\cos 25°$$
$$P = 72.096\text{ N}$$

And
$$\frac{\sin\alpha}{120\text{ N}} = \frac{\sin 25°}{72.096\text{ N}}$$
$$\sin\alpha = 0.70343$$
$$\alpha = 44.703°$$

$\mathbf{P} = 72.1\text{ N} \measuredangle\ 44.7°$ ◀



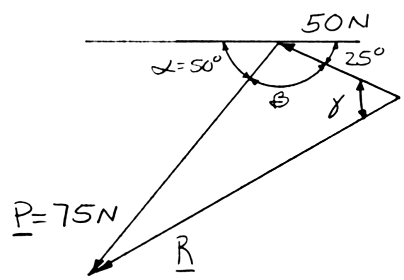
PROBLEM 2.18

For the hook support of Prob. 2.10, knowing that $P = 75$ N and $\alpha = 50°$, determine by trigonometry the magnitude and direction of the resultant of the two forces applied to the support.

PROBLEM 2.10 Two forces are applied as shown to a hook support. Knowing that the magnitude of **P** is 35 N, determine by trigonometry (*a*) the required angle α if the resultant **R** of the two forces applied to the support is to be horizontal, (*b*) the corresponding magnitude of **R**.

SOLUTION

Using the force triangle and the laws of cosines and sines:

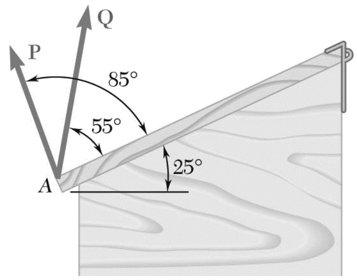


We have $\beta = 180° - (50° + 25°)$
$= 105°$

Then
$$R^2 = (75\text{ N})^2 + (50\text{ N})^2 - 2(75\text{ N})(50\text{ N})\cos 105°$$
$$R^2 = 10{,}066.1\text{ N}^2$$
$$R = 100.330\text{ N}$$

and
$$\frac{\sin\gamma}{75\text{ N}} = \frac{\sin 105°}{100.330\text{ N}}$$
$$\sin\gamma = 0.72206$$
$$\gamma = 46.225°$$

Hence: $\gamma - 25° = 46.225° - 25° = 21.225°$ **R** $= 100.3$ N $\measuredangle$ 21.2° ◀

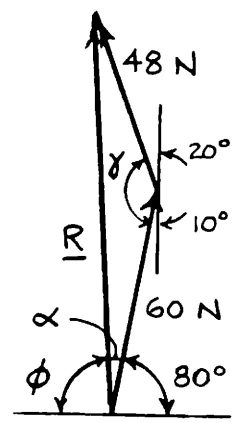


PROBLEM 2.19

Two forces **P** and **Q** are applied to the lid of a storage bin as shown. Knowing that P = 48 N and Q = 60 N, determine by trigonometry the magnitude and direction of the resultant of the two forces.

SOLUTION

Using the force triangle and the laws of cosines and sines:



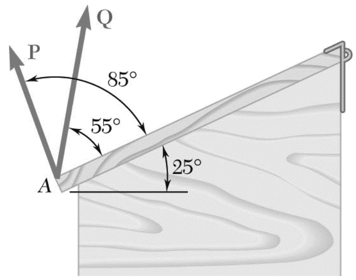
We have
$$\gamma = 180° - (20° + 10°)$$
$$= 150°$$

Then
$$R^2 = (48\text{ N})^2 + (60\text{ N})^2$$
$$-2(48\text{ N})(60\text{ N})\cos 150°$$
$$R = 104.366\text{ N}$$

and
$$\frac{48\text{ N}}{\sin\alpha} = \frac{104.366\text{ N}}{\sin 150°}$$
$$\sin\alpha = 0.22996$$
$$\alpha = 13.2947°$$

Hence:
$$\phi = 180° - \alpha - 80°$$
$$= 180° - 13.2947° - 80°$$
$$= 86.705°$$

R $= 104.4$ N $\measuredangle$ 86.7° ◀

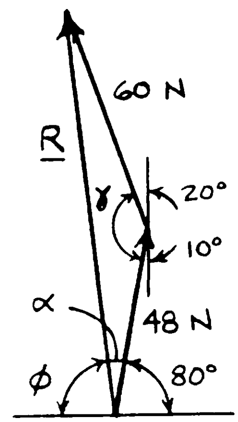


PROBLEM 2.20

Two forces **P** and **Q** are applied to the lid of a storage bin as shown. Knowing that P = 60 N and Q = 48 N, determine by trigonometry the magnitude and direction of the resultant of the two forces.

SOLUTION

Using the force triangle and the laws of cosines and sines:



We have $\gamma = 180° - (20° + 10°)$

$$= 150°$$

Then $R^2 = (60\text{ N})^2 + (48\text{ N})^2$

$$-2(60\text{ N})(48\text{ N})\cos 150°$$

$$R = 104.366\text{ N}$$

and $\dfrac{60\text{ N}}{\sin\alpha} = \dfrac{104.366\text{ N}}{\sin 150°}$

$$\sin\alpha = 0.28745$$

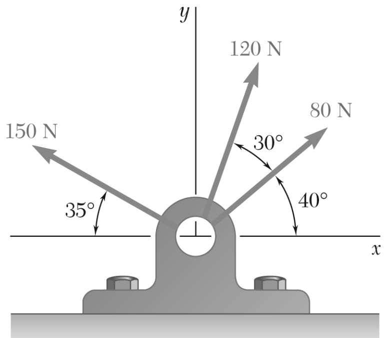
$$\alpha = 16.7054°$$

Hence: $\phi = 180° - \alpha - 180°$

$$= 180° - 16.7054° - 80°$$

$$= 83.295°$$

$\mathbf{R} = 104.4\text{ N} \measuredangle\ 83.3°$ ◀

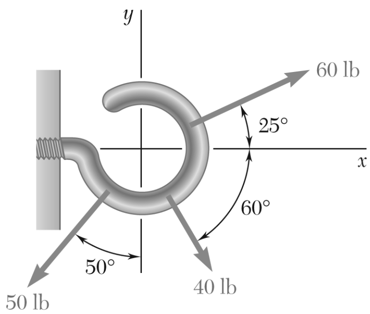


PROBLEM 2.21

Determine the x and y components of each of the forces shown.

SOLUTION

80-N Force:	$F_x = +(80\text{ N})\cos 40°$	$F_x = 61.3\text{ N}$ ◀
	$F_y = +(80\text{ N})\sin 40°$	$F_y = 51.4\text{ N}$ ◀
120-N Force:	$F_x = +(120\text{ N})\cos 70°$	$F_x = 41.0\text{ N}$ ◀
	$F_y = +(120\text{ N})\sin 70°$	$F_y = 112.8\text{ N}$ ◀
150-N Force:	$F_x = -(150\text{ N})\cos 35°$	$F_x = -122.9\text{ N}$ ◀
	$F_y = +(150\text{ N})\sin 35°$	$F_y = 86.0\text{ N}$ ◀



PROBLEM 2.22

Determine the x and y components of each of the forces shown.

SOLUTION

40-lb Force: $F_x = +(40 \text{ lb})\cos 60°$ $\quad F_x = 20.0 \text{ lb}$ ◀

$F_y = -(40 \text{ lb})\sin 60°$ $\quad F_y = -34.6 \text{ lb}$ ◀

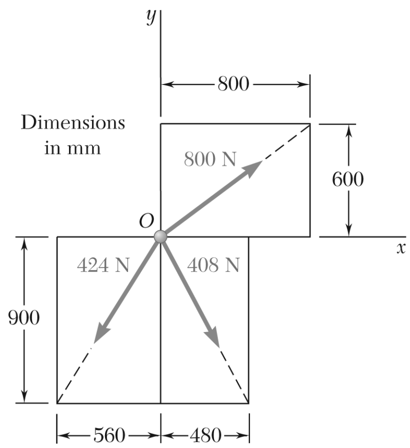
50-lb Force: $F_x = -(50 \text{ lb})\sin 50°$ $\quad F_x = -38.3 \text{ lb}$ ◀

$F_y = -(50 \text{ lb})\cos 50°$ $\quad F_y = -32.1 \text{ lb}$ ◀

60-lb Force: $F_x = +(60 \text{ lb})\cos 25°$ $\quad F_x = 54.4 \text{ lb}$ ◀

$F_y = +(60 \text{ lb})\sin 25°$ $\quad F_y = 25.4 \text{ lb}$ ◀

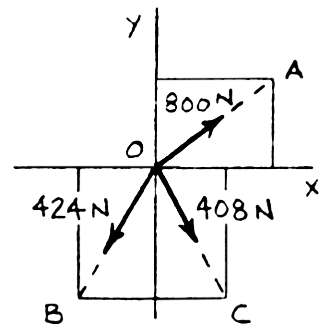
PROBLEM 2.23



Determine the x and y components of each of the forces shown.

SOLUTION

Compute the following distances:



$$OA = \sqrt{(600)^2 + (800)^2}$$
$$= 1000 \text{ mm}$$
$$OB = \sqrt{(560)^2 + (900)^2}$$
$$= 1060 \text{ mm}$$
$$OC = \sqrt{(480)^2 + (900)^2}$$
$$= 1020 \text{ mm}$$

800-N Force: $F_x = +(800 \text{ N})\dfrac{800}{1000}$ $\qquad F_x = +640 \text{ N}$ ◀

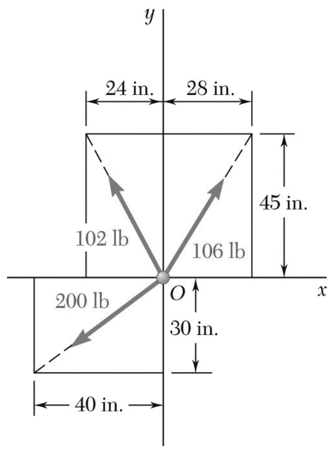
$F_y = +(800 \text{ N})\dfrac{600}{1000}$ $\qquad F_y = +480 \text{ N}$ ◀

424-N Force: $F_x = -(424 \text{ N})\dfrac{560}{1060}$ $\qquad F_x = -224 \text{ N}$ ◀

$F_y = -(424 \text{ N})\dfrac{900}{1060}$ $\qquad F_y = -360 \text{ N}$ ◀

408-N Force: $F_x = +(408 \text{ N})\dfrac{480}{1020}$ $\qquad F_x = +192.0 \text{ N}$ ◀

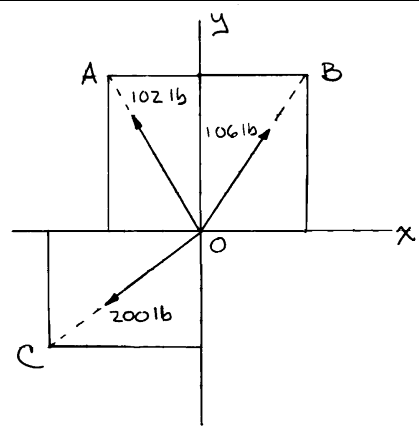
$F_y = -(408 \text{ N})\dfrac{900}{1020}$ $\qquad F_y = -360 \text{ N}$ ◀



PROBLEM 2.24

Determine the x and y components of each of the forces shown.

SOLUTION



Compute the following distances:

$$OA = \sqrt{(24 \text{ in.})^2 + (45 \text{ in.})^2}$$
$$= 51.0 \text{ in.}$$
$$OB = \sqrt{(28 \text{ in.})^2 + (45 \text{ in.})^2}$$
$$= 53.0 \text{ in.}$$
$$OC = \sqrt{(40 \text{ in.})^2 + (30 \text{ in.})^2}$$
$$= 50.0 \text{ in.}$$

102-lb Force: $F_x = -102 \text{ lb}\dfrac{24 \text{ in.}}{51.0 \text{ in.}}$ $\qquad F_x = -48.0 \text{ lb}$ ◀

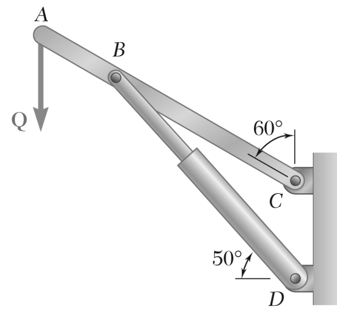
$F_y = +102 \text{ lb}\dfrac{45 \text{ in.}}{51.0 \text{ in.}}$ $\qquad F_y = +90.0 \text{ lb}$ ◀

106-lb Force: $F_x = +106 \text{ lb}\dfrac{28 \text{ in.}}{53.0 \text{ in.}}$ $\qquad F_x = +56.0 \text{ lb}$ ◀

$F_y = +106 \text{ lb}\dfrac{45 \text{ in.}}{53.0 \text{ in.}}$ $\qquad F_y = +90.0 \text{ lb}$ ◀

200-lb Force: $F_x = -200 \text{ lb}\dfrac{40 \text{ in.}}{50.0 \text{ in.}}$ $\qquad F_x = -160.0 \text{ lb}$ ◀

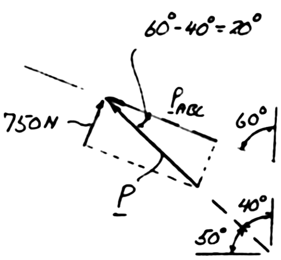
$F_y = -200 \text{ lb}\dfrac{30 \text{ in.}}{50.0 \text{ in.}}$ $\qquad F_y = -120.0 \text{ lb}$ ◀



PROBLEM 2.25

The hydraulic cylinder *BD* exerts on member *ABC* a force **P** directed along line *BD*. Knowing that **P** must have a 750-N component perpendicular to member *ABC*, determine (*a*) the magnitude of the force **P**, (*b*) its component parallel to *ABC*.

SOLUTION

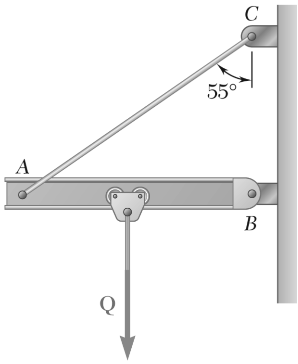


(*a*) $750\text{ N} = P\sin 20°$

$P = 2192.9\text{ N}$ $\qquad P = 2190\text{ N}$ ◀

(*b*) $P_{ABC} = P\cos 20°$

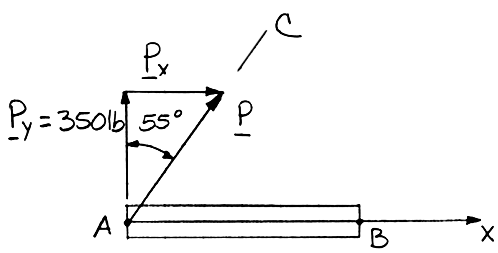
$= (2192.9\text{ N})\cos 20°$ $\qquad P_{ABC} = 2060\text{ N}$ ◀



PROBLEM 2.26

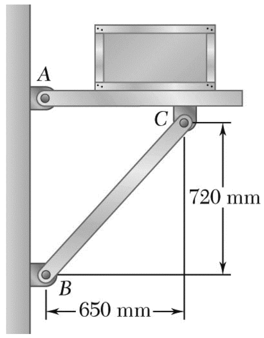
Cable AC exerts on beam AB a force **P** directed along line AC. Knowing that **P** must have a 350-lb vertical component, determine (*a*) the magnitude of the force **P**, (*b*) its horizontal component.

SOLUTION



(*a*)
$$P = \frac{P_y}{\cos 55°}$$
$$= \frac{350 \text{ lb}}{\cos 55°}$$
$$= 610.21 \text{ lb}$$
$P = 610 \text{ lb}$ ◀

(*b*)
$$P_x = P \sin 55°$$
$$= (610.21 \text{ lb}) \sin 55°$$
$$= 499.85 \text{ lb}$$
$P_x = 500 \text{ lb}$ ◀

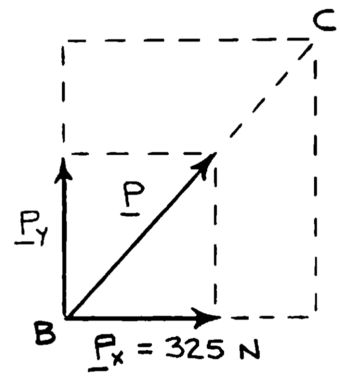


PROBLEM 2.27

Member BC exerts on member AC a force $\mathbf{P}$ directed along line BC. Knowing that $\mathbf{P}$ must have a 325-N horizontal component, determine (*a*) the magnitude of the force $\mathbf{P}$, (*b*) its vertical component.

SOLUTION

$$BC = \sqrt{(650\text{ mm})^2 + (720\text{ mm})^2}$$
$$= 970\text{ mm}$$



(*a*)

$$P_x = P\left(\frac{650}{970}\right)$$

or

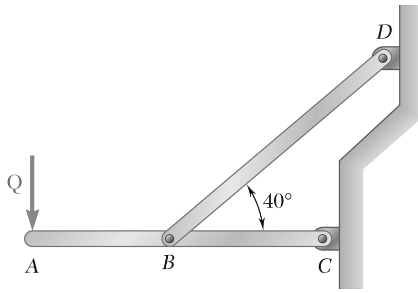
$$P = P_x\left(\frac{970}{650}\right)$$
$$= 325\text{ N}\left(\frac{970}{650}\right)$$
$$= 485\text{ N}$$

$P = 485$ N ◀

(*b*)

$$P_y = P\left(\frac{720}{970}\right)$$
$$= 485\text{ N}\left(\frac{720}{970}\right)$$
$$= 360\text{ N}$$

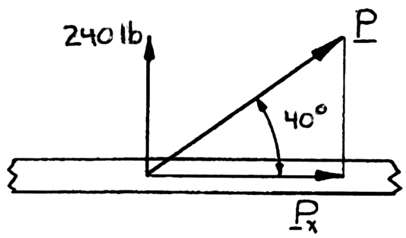
$P_y = 970$ N ◀



PROBLEM 2.28

Member *BD* exerts on member *ABC* a force **P** directed along line *BD*. Knowing that **P** must have a 240-lb vertical component, determine (*a*) the magnitude of the force **P**, (*b*) its horizontal component.

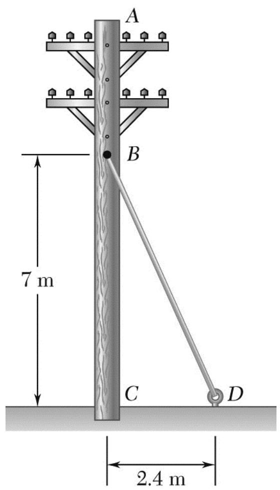
SOLUTION



(*a*) $$P = \frac{P_y}{\sin 40°} = \frac{240 \text{ lb}}{\sin 40°}$$ or $P = 373$ lb ◀

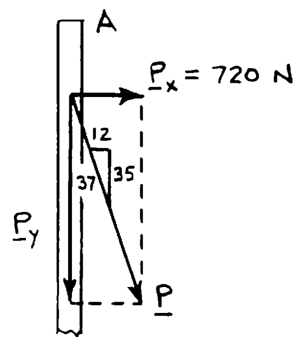
(*b*) $$P_x = \frac{P_y}{\tan 40°} = \frac{240 \text{ lb}}{\tan 40°}$$ or $P_x = 286$ lb ◀

PROBLEM 2.29



The guy wire BD exerts on the telephone pole AC a force $\mathbf{P}$ directed along BD. Knowing that $\mathbf{P}$ must have a 720-N component perpendicular to the pole AC, determine (*a*) the magnitude of the force $\mathbf{P}$, (*b*) its component along line AC.

SOLUTION



(*a*)

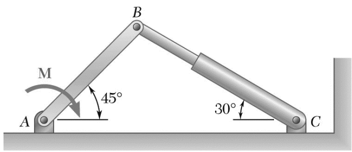
$$P = \frac{37}{12}P_x$$
$$= \frac{37}{12}(720\text{ N})$$
$$= 2220\text{ N}$$

$P = 2.22$ kN ◀

(*b*)

$$P_y = \frac{35}{12}P_x$$
$$= \frac{35}{12}(720\text{ N})$$
$$= 2100\text{ N}$$

$P_y = 2.10$ kN ◀

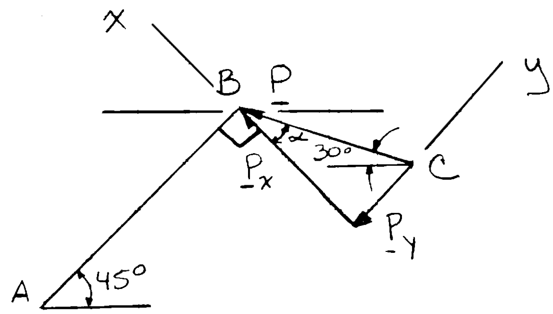


PROBLEM 2.30

The hydraulic cylinder *BC* exerts on member *AB* a force **P** directed along line *BC*. Knowing that **P** must have a 600-N component perpendicular to member *AB*, determine (*a*) the magnitude of the force **P**, (*b*) its component along line *AB*.

SOLUTION

$$180° = 45° + \alpha + 90° + 30°$$
$$\alpha = 180° - 45° - 90° - 30°$$
$$= 15°$$



(*a*)

$$\cos\alpha = \frac{P_x}{P}$$
$$P = \frac{P_x}{\cos\alpha}$$
$$= \frac{600 \text{ N}}{\cos 15°}$$
$$= 621.17 \text{ N}$$

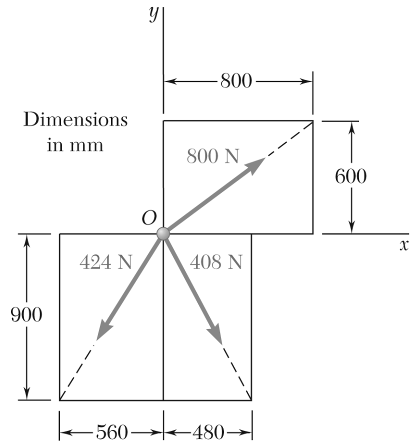
$P = 621$ N ◀

(*b*)

$$\tan\alpha = \frac{P_y}{P_x}$$
$$P_y = P_x \tan\alpha$$
$$= (600 \text{ N})\tan 15°$$
$$= 160.770 \text{ N}$$

$P_y = 160.8$ N ◀

PROBLEM 2.31



Determine the resultant of the three forces of Problem 2.23.

PROBLEM 2.23 Determine the *x* and *y* components of each of the forces shown.

SOLUTION

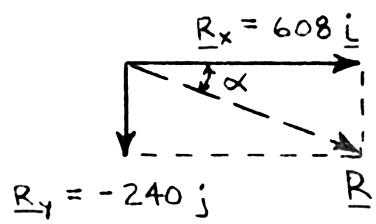
Components of the forces were determined in Problem 2.23:

Force	*x* Comp. (N)	*y* Comp. (N)
800 lb	+640	+480
424 lb	–224	–360
408 lb	+192	–360
	$R_x = +608$	$R_y = -240$

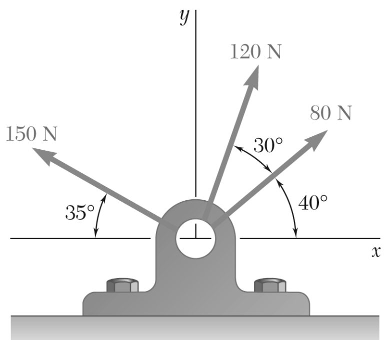
$$\mathbf{R} = R_x\mathbf{i} + R_y\mathbf{j}$$
$$= (608 \text{ lb})\mathbf{i} + (-240 \text{ lb})\mathbf{j}$$

$$\tan\alpha = \frac{R_y}{R_x}$$
$$= \frac{240}{608}$$
$$\alpha = 21.541°$$

$$R = \frac{240 \text{ N}}{\sin(21.541°)}$$
$$= 653.65 \text{ N}$$



$\mathbf{R} = 654$ N $\measuredangle$ 21.5° ◀



PROBLEM 2.32

Determine the resultant of the three forces of Problem 2.21.

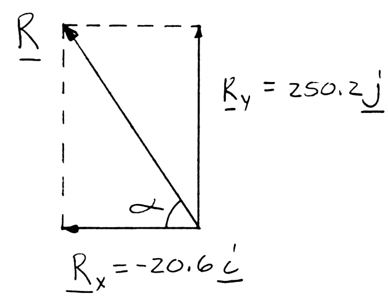
PROBLEM 2.21 Determine the x and y components of each of the forces shown.

SOLUTION

Components of the forces were determined in Problem 2.21:

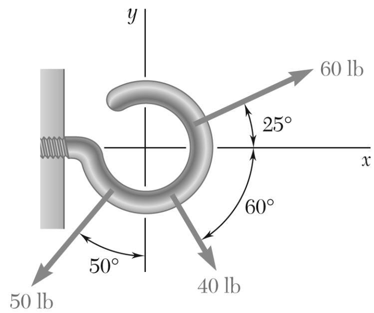
Force	x Comp. (N)	y Comp. (N)
80 N	+61.3	+51.4
120 N	+41.0	+112.8
150 N	–122.9	+86.0
	$R_x = -20.6$	$R_y = +250.2$

$$\mathbf{R} = R_x\mathbf{i} + R_y\mathbf{j}$$
$$= (-20.6 \text{ N})\mathbf{i} + (250.2 \text{ N})\mathbf{j}$$



$$\tan\alpha = \frac{R_y}{R_x}$$
$$\tan\alpha = \frac{250.2 \text{ N}}{20.6 \text{ N}}$$
$$\tan\alpha = 12.1456$$
$$\alpha = 85.293°$$
$$R = \frac{250.2 \text{ N}}{\sin 85.293°}$$

$\mathbf{R} = 251$ N ⦣ 85.3° ◀



PROBLEM 2.33

Determine the resultant of the three forces of Problem 2.22.

PROBLEM 2.22 Determine the x and y components of each of the forces shown.

SOLUTION

Force	x Comp. (lb)	y Comp. (lb)
40 lb	+20.00	–34.64
50 lb	–38.30	–32.14
60 lb	+54.38	+25.36
	$R_x = +36.08$	$R_y = -41.42$

$$\mathbf{R} = R_x\mathbf{i} + R_y\mathbf{j}$$

$$= (+36.08 \text{ lb})\mathbf{i} + (-41.42 \text{ lb})\mathbf{j}$$

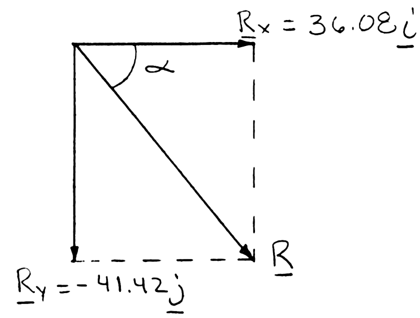
$$\tan\alpha = \frac{R_y}{R_x}$$

$$\tan\alpha = \frac{41.42 \text{ lb}}{36.08 \text{ lb}}$$

$$\tan\alpha = 1.14800$$

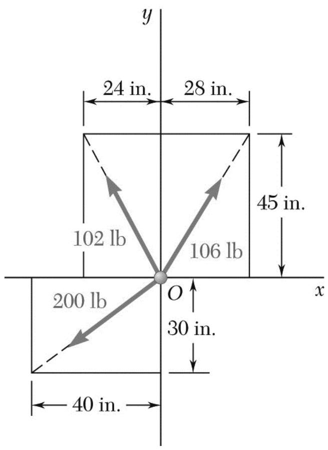
$$\alpha = 48.942°$$

$$R = \frac{41.42 \text{ lb}}{\sin 48.942°}$$



$\mathbf{R} = 54.9 \text{ lb} \measuredangle 48.9°$ ◀

PROBLEM 2.34



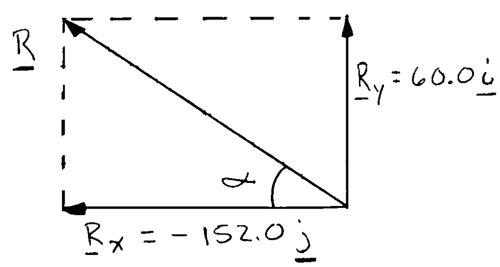
Determine the resultant of the three forces of Problem 2.24.

PROBLEM 2.24 Determine the x and y components of each of the forces shown.

SOLUTION

Components of the forces were determined in Problem 2.24:

Force	x Comp. (lb)	y Comp. (lb)
102 lb	–48.0	+90.0
106 lb	+56.0	+90.0
200 lb	–160.0	–120.0
	$R_x = -152.0$	$R_y = 60.0$



$$\mathbf{R} = R_x\mathbf{i} + R_y\mathbf{j}$$

$$= (-152 \text{ lb})\mathbf{i} + (60.0 \text{ lb})\mathbf{j}$$

$$\tan\alpha = \frac{R_y}{R_x}$$

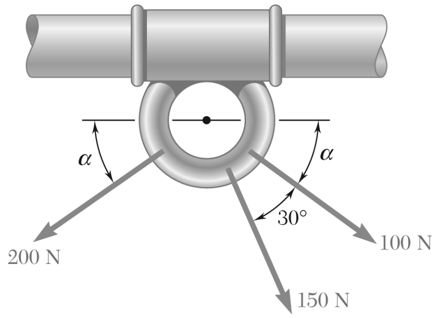
$$\tan\alpha = \frac{60.0 \text{ lb}}{152.0 \text{ lb}}$$

$$\tan\alpha = 0.39474$$

$$\alpha = 21.541°$$

$$R = \frac{60.0 \text{ lb}}{\sin 21.541°}$$

$\mathbf{R} = 163.4$ lb 21.5° ◀



PROBLEM 2.35

Knowing that $\alpha = 35°$, determine the resultant of the three forces shown.

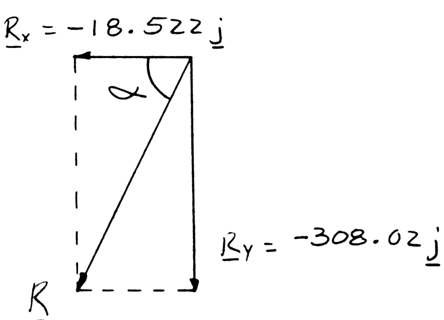
SOLUTION

100-N Force:
$$F_x = +(100\text{ N})\cos 35° = +81.915\text{ N}$$
$$F_y = -(100\text{ N})\sin 35° = -57.358\text{ N}$$

150-N Force:
$$F_x = +(150\text{ N})\cos 65° = +63.393\text{ N}$$
$$F_y = -(150\text{ N})\sin 65° = -135.946\text{ N}$$

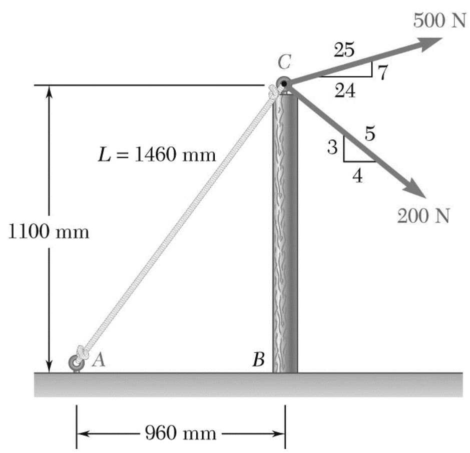
200-N Force:
$$F_x = -(200\text{ N})\cos 35° = -163.830\text{ N}$$
$$F_y = -(200\text{ N})\sin 35° = -114.715\text{ N}$$

Force	x Comp. (N)	y Comp. (N)
100 N	+81.915	−57.358
150 N	+63.393	−135.946
200 N	−163.830	−114.715
	$R_x = -18.522$	$R_y = -308.02$



$$\mathbf{R} = R_x\mathbf{i} + R_y\mathbf{j}$$
$$= (-18.522\text{ N})\mathbf{i} + (-308.02\text{ N})\mathbf{j}$$
$$\tan\alpha = \frac{R_y}{R_x}$$
$$= \frac{308.02}{18.522}$$
$$\alpha = 86.559°$$
$$R = \frac{308.02\text{ N}}{\sin 86.559}$$

$\mathbf{R} = 309$ N ↙ 86.6° ◀

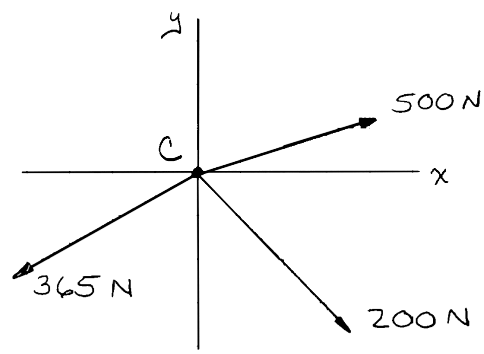


PROBLEM 2.36

Knowing that the tension in rope AC is 365 N, determine the resultant of the three forces exerted at point C of post BC.

SOLUTION

Determine force components:



Cable force AC:

$$F_x = -(365\text{ N})\frac{960}{1460} = -240\text{ N}$$

$$F_y = -(365\text{ N})\frac{1100}{1460} = -275\text{ N}$$

500-N Force:

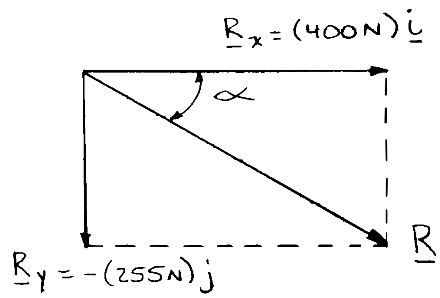
$$F_x = (500\text{ N})\frac{24}{25} = 480\text{ N}$$

$$F_y = (500\text{ N})\frac{7}{25} = 140\text{ N}$$

200-N Force:

$$F_x = (200\text{ N})\frac{4}{5} = 160\text{ N}$$

$$F_y = -(200\text{ N})\frac{3}{5} = -120\text{ N}$$



and

$$R_x = \Sigma F_x = -240\text{ N} + 480\text{ N} + 160\text{ N} = 400\text{ N}$$

$$R_y = \Sigma F_y = -275\text{ N} + 140\text{ N} - 120\text{ N} = -255\text{ N}$$

$$R = \sqrt{R_x^2 + R_y^2}$$

$$= \sqrt{(400\text{ N})^2 + (-255\text{ N})^2}$$

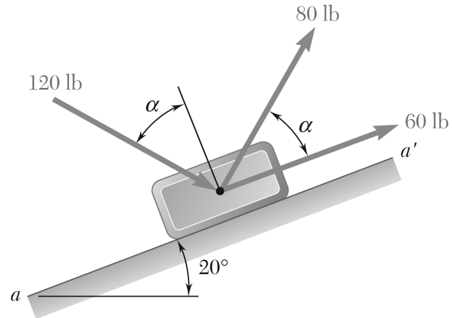
$$= 474.37\text{ N}$$

Further:

$$\tan\alpha = \frac{255}{400}$$

$$\alpha = 32.5°$$

R = 474 N ↘ 32.5° ◀



PROBLEM 2.37

Knowing that $\alpha = 40°$, determine the resultant of the three forces shown.

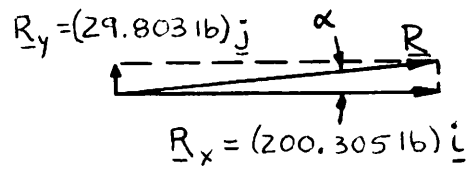
SOLUTION

60-lb Force:

$$F_x = (60 \text{ lb})\cos 20° = 56.382 \text{ lb}$$
$$F_y = (60 \text{ lb})\sin 20° = 20.521 \text{ lb}$$

80-lb Force:

$$F_x = (80 \text{ lb})\cos 60° = 40.000 \text{ lb}$$
$$F_y = (80 \text{ lb})\sin 60° = 69.282 \text{ lb}$$



120-lb Force:

$$F_x = (120 \text{ lb})\cos 30° = 103.923 \text{ lb}$$
$$F_y = -(120 \text{ lb})\sin 30° = -60.000 \text{ lb}$$

and

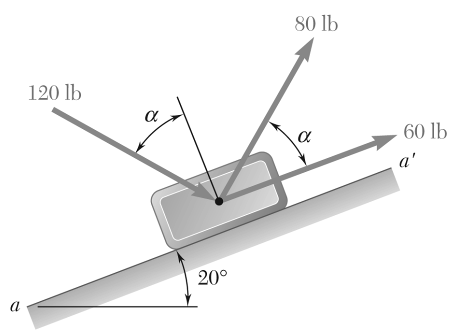
$$R_x = \Sigma F_x = 200.305 \text{ lb}$$
$$R_y = \Sigma F_y = 29.803 \text{ lb}$$
$$R = \sqrt{(200.305 \text{ lb})^2 + (29.803 \text{ lb})^2}$$
$$= 202.510 \text{ lb}$$

Further:

$$\tan\alpha = \frac{29.803}{200.305}$$

$$\alpha = \tan^{-1}\frac{29.803}{200.305}$$
$$= 8.46°$$

R = 203 lb ∡ 8.46° ◀



PROBLEM 2.38

Knowing that $\alpha = 75°$, determine the resultant of the three forces shown.

SOLUTION

60-lb Force:

$$F_x = (60\text{ lb})\cos 20° = 56.382\text{ lb}$$
$$F_y = (60\text{ lb})\sin 20° = 20.521\text{ lb}$$

80-lb Force:

$$F_x = (80\text{ lb})\cos 95° = -6.9725\text{ lb}$$
$$F_y = (80\text{ lb})\sin 95° = 79.696\text{ lb}$$

120-lb Force:

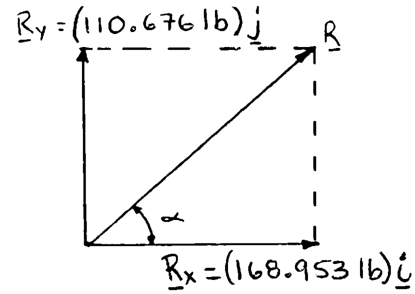
$$F_x = (120\text{ lb})\cos 5° = 119.543\text{ lb}$$
$$F_y = (120\text{ lb})\sin 5° = 10.459\text{ lb}$$

Then

$$R_x = \Sigma F_x = 168.953\text{ lb}$$
$$R_y = \Sigma F_y = 110.676\text{ lb}$$

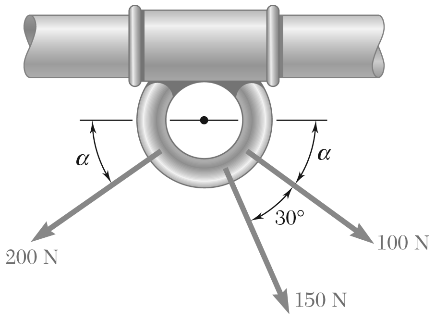
and

$$R = \sqrt{(168.953\text{ lb})^2 + (110.676\text{ lb})^2}$$
$$= 201.976\text{ lb}$$



$$\tan\alpha = \frac{110.676}{168.953}$$
$$\tan\alpha = 0.65507$$
$$\alpha = 33.228°$$

R = 202 lb ∠ 33.2° ◀



PROBLEM 2.39

For the collar of Problem 2.35, determine (*a*) the required value of α if the resultant of the three forces shown is to be vertical, (*b*) the corresponding magnitude of the resultant.

SOLUTION

$$R_x = \Sigma F_x$$
$$= (100\text{ N})\cos\alpha + (150\text{ N})\cos(\alpha + 30°) - (200\text{ N})\cos\alpha$$
$$R_x = -(100\text{ N})\cos\alpha + (150\text{ N})\cos(\alpha + 30°) \quad (1)$$

$$R_y = \Sigma F_y$$
$$= -(100\text{ N})\sin\alpha - (150\text{ N})\sin(\alpha + 30°) - (200\text{ N})\sin\alpha$$
$$R_y = -(300\text{ N})\sin\alpha - (150\text{ N})\sin(\alpha + 30°) \quad (2)$$

(*a*) For **R** to be vertical, we must have $R_x = 0$. We make $R_x = 0$ in Eq. (1):

$$-100\cos\alpha + 150\cos(\alpha + 30°) = 0$$
$$-100\cos\alpha + 150(\cos\alpha\cos 30° - \sin\alpha\sin 30°) = 0$$
$$29.904\cos\alpha = 75\sin\alpha$$

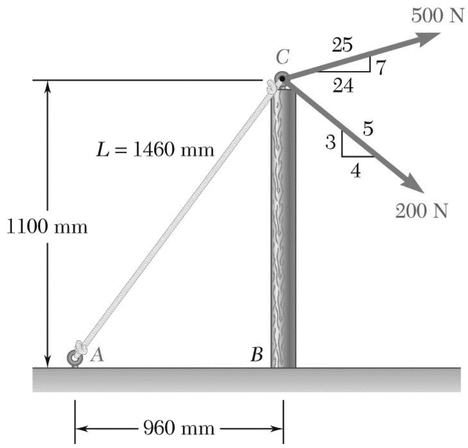
$$\tan\alpha = \frac{29.904}{75}$$
$$= 0.39872$$
$$\alpha = 21.738°$$

$\alpha = 21.7°$ ◀

(*b*) Substituting for α in Eq. (2):

$$R_y = -300\sin 21.738° - 150\sin 51.738°$$
$$= -228.89\text{ N}$$
$$R = |R_y| = 228.89\text{ N}$$

$R = 229$ N ◀



PROBLEM 2.40

For the post of Prob. 2.36, determine (*a*) the required tension in rope AC if the resultant of the three forces exerted at point C is to be horizontal, (*b*) the corresponding magnitude of the resultant.

SOLUTION

$$R_x = \Sigma F_x = -\frac{960}{1460}T_{AC} + \frac{24}{25}(500 \text{ N}) + \frac{4}{5}(200 \text{ N})$$

$$R_x = -\frac{48}{73}T_{AC} + 640 \text{ N} \qquad (1)$$

$$R_y = \Sigma F_y = -\frac{1100}{1460}T_{AC} + \frac{7}{25}(500 \text{ N}) - \frac{3}{5}(200 \text{ N})$$

$$R_y = -\frac{55}{73}T_{AC} + 20 \text{ N} \qquad (2)$$

(*a*) For **R** to be horizontal, we must have $R_y = 0$.

Set $R_y = 0$ in Eq. (2):

$$-\frac{55}{73}T_{AC} + 20 \text{ N} = 0$$

$$T_{AC} = 26.545 \text{ N}$$

$T_{AC} = 26.5$ N ◀

(*b*) Substituting for T_{AC} into Eq. (1) gives

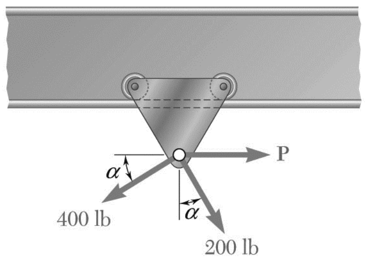
$$R_x = -\frac{48}{73}(26.545 \text{ N}) + 640 \text{ N}$$

$$R_x = 622.55 \text{ N}$$

$$R = R_x = 623 \text{ N}$$

$R = 623$ N ◀

PROBLEM 2.41



A hoist trolley is subjected to the three forces shown. Knowing that $\alpha = 40°$, determine (*a*) the required magnitude of the force **P** if the resultant of the three forces is to be vertical, (*b*) the corresponding magnitude of the resultant.

SOLUTION

$$R_x = \xrightarrow{+} \Sigma F_x = P + (200 \text{ lb})\sin 40° - (400 \text{ lb})\cos 40°$$

$$R_x = P - 177.860 \text{ lb} \tag{1}$$

$$R_y = +\!\downarrow \Sigma F_y = (200 \text{ lb})\cos 40° + (400 \text{ lb})\sin 40°$$

$$R_y = 410.32 \text{ lb} \tag{2}$$

(*a*) For **R** to be vertical, we must have $R_x = 0$.

Set $R_x = 0$ in Eq. (1)

$$0 = P - 177.860 \text{ lb}$$

$$P = 177.860 \text{ lb}$$

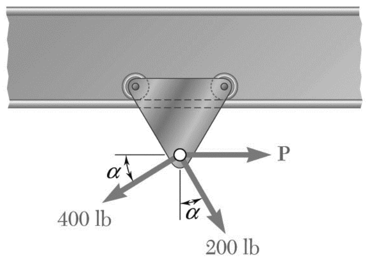
$P = 177.9$ lb ◀

(*b*) Since **R** is to be vertical:

$$R = R_y = 410 \text{ lb}$$

$R = 410$ lb ◀

PROBLEM 2.42



A hoist trolley is subjected to the three forces shown. Knowing that P = 250 lb, determine (*a*) the required value of α if the resultant of the three forces is to be vertical, (*b*) the corresponding magnitude of the resultant.

SOLUTION

$$R_x = \xrightarrow{+} \Sigma F_x = 250 \text{ lb} + (200 \text{ lb})\sin\alpha - (400 \text{ lb})\cos\alpha$$

$$R_x = 250 \text{ lb} + (200 \text{ lb})\sin\alpha - (400 \text{ lb})\cos\alpha \qquad (1)$$

$$R_y = +\!\downarrow \Sigma F_y = (200 \text{ lb})\cos\alpha + (400 \text{ lb})\sin\alpha$$

(*a*) For **R** to be vertical, we must have $R_x = 0$.

Set $\quad R_x = 0$ in Eq. (1)

$$0 = 250 \text{ lb} + (200 \text{ lb})\sin\alpha - (400 \text{ lb})\cos\alpha$$

$$(400 \text{ lb})\cos\alpha = (200 \text{ lb})\sin\alpha + 250 \text{ lb}$$

$$2\cos\alpha = \sin\alpha + 1.25$$

$$4\cos^2\alpha = \sin^2\alpha + 2.5\sin\alpha + 1.5625$$

$$4(1-\sin^2\alpha) = \sin^2\alpha + 2.5\sin\alpha + 1.5625$$

$$0 = 5\sin^2\alpha + 2.5\sin\alpha - 2.4375$$

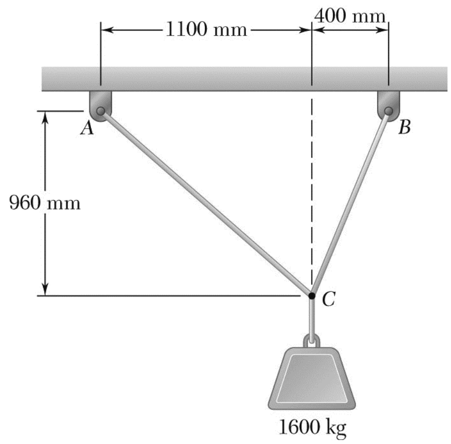
Using the quadratic formula to solve for the roots gives

$$\sin\alpha = 0.49162$$

or $\quad \alpha = 29.447° \qquad \alpha = 29.4°$ ◀

(*b*) Since **R** is to be vertical:

$R = R_y = (200 \text{ lb})\cos 29.447° + (400 \text{ lb})\sin 29.447° \qquad$ **R** $= 371$ lb ◀

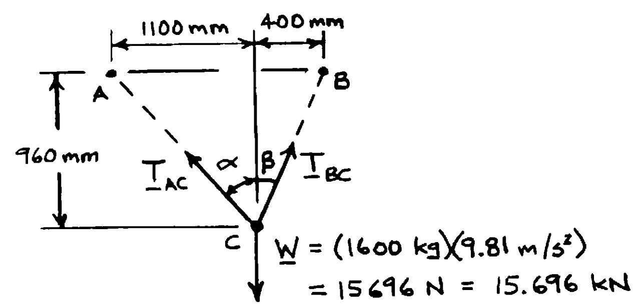


PROBLEM 2.43

Two cables are tied together at C and are loaded as shown. Determine the tension (a) in cable AC, (b) in cable BC.

SOLUTION

Free-Body Diagram



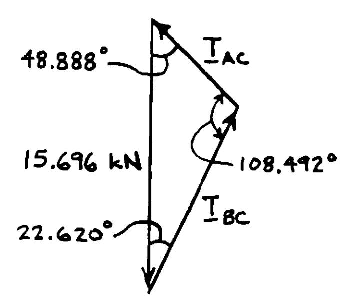
$$\tan\alpha = \frac{1100}{960}$$

$$\alpha = 48.888°$$

$$\tan\beta = \frac{400}{960}$$

$$\beta = 22.620°$$

Force Triangle

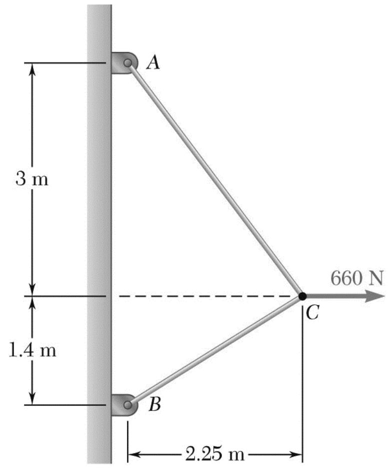


Law of sines:

$$\frac{T_{AC}}{\sin 22.620°} = \frac{T_{BC}}{\sin 48.888°} = \frac{15.696\text{ kN}}{\sin 108.492°}$$

(a) $$T_{AC} = \frac{15.696\text{ kN}}{\sin 108.492°}(\sin 22.620°)$$ $T_{AC} = 6.37\text{ kN}$ ◀

(b) $$T_{BC} = \frac{15.696\text{ kN}}{\sin 108.492°}(\sin 48.888°)$$ $T_{BC} = 12.47\text{ kN}$ ◀



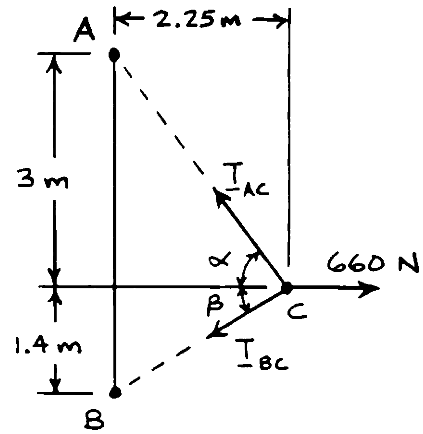
PROBLEM 2.44

Two cables are tied together at C and are loaded as shown. Determine the tension (a) in cable AC, (b) in cable BC.

SOLUTION

$$\tan\alpha = \frac{3}{2.25}$$
$$\alpha = 53.130°$$
$$\tan\beta = \frac{1.4}{2.25}$$
$$\beta = 31.891°$$

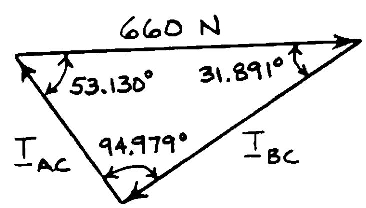
Free-Body Diagram



Law of sines:

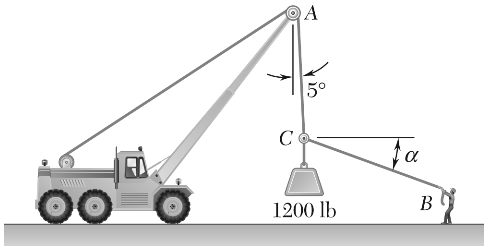
$$\frac{T_{AC}}{\sin 31.891°} = \frac{T_{BC}}{\sin 53.130°} = \frac{660 \text{ N}}{\sin 94.979°}$$

Force-Triangle



(a) $$T_{AC} = \frac{660 \text{ N}}{\sin 94.979°}(\sin 31.891°)$$ $T_{AC} = 350 \text{ N}$ ◀

(b) $$T_{BC} = \frac{660 \text{ N}}{\sin 94.979°}(\sin 53.130°)$$ $T_{BC} = 530 \text{ N}$ ◀

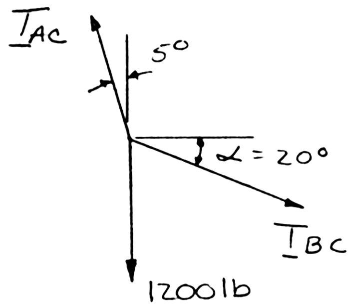


PROBLEM 2.45

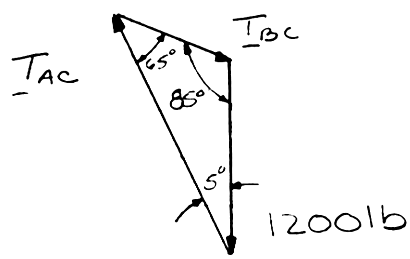
Knowing that $\alpha = 20°$, determine the tension (*a*) in cable *AC*, (*b*) in rope *BC*.

SOLUTION

Free-Body Diagram



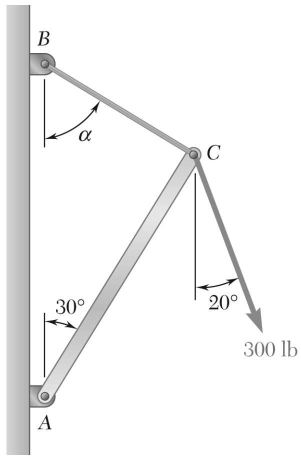
Force Triangle



Law of sines: $$\frac{T_{AC}}{\sin 110°} = \frac{T_{BC}}{\sin 5°} = \frac{1200 \text{ lb}}{\sin 65°}$$

(*a*) $$T_{AC} = \frac{1200 \text{ lb}}{\sin 65°} \sin 110°$$ $T_{AC} = 1244$ lb ◀

(*b*) $$T_{BC} = \frac{1200 \text{ lb}}{\sin 65°} \sin 5°$$ $T_{BC} = 115.4$ lb ◀

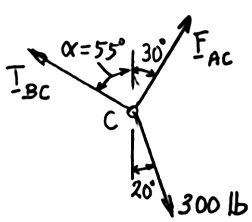


PROBLEM 2.46

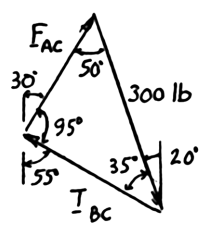
Knowing that $\alpha = 55°$ and that boom AC exerts on pin C a force directed along line AC, determine (*a*) the magnitude of that force, (*b*) the tension in cable BC.

SOLUTION

Free-Body Diagram



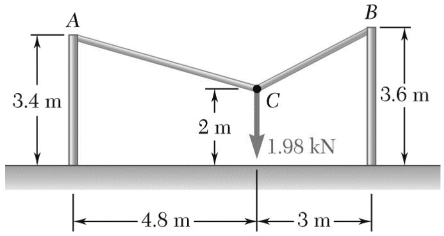
Force Triangle



Law of sines:
$$\frac{F_{AC}}{\sin 35°} = \frac{T_{BC}}{\sin 50°} = \frac{300 \text{ lb}}{\sin 95°}$$

(*a*)
$$F_{AC} = \frac{300 \text{ lb}}{\sin 95°} \sin 35°$$
$F_{AC} = 172.7 \text{ lb}$ ◀

(*b*)
$$T_{BC} = \frac{300 \text{ lb}}{\sin 95°} \sin 50°$$
$T_{BC} = 231 \text{ lb}$ ◀



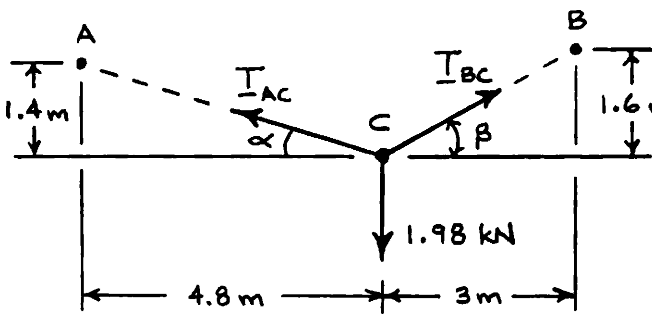
PROBLEM 2.47

Two cables are tied together at C and loaded as shown. Determine the tension (a) in cable AC, (b) in cable BC.

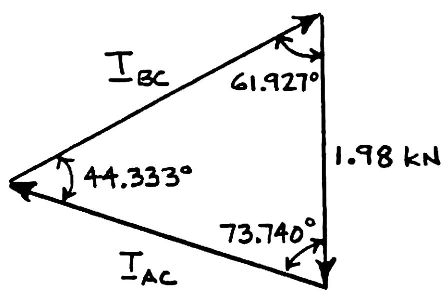
SOLUTION

Free-Body Diagram

$$\tan\alpha = \frac{1.4}{4.8}$$
$$\alpha = 16.2602°$$
$$\tan\beta = \frac{1.6}{3}$$
$$\beta = 28.073°$$



Force Triangle

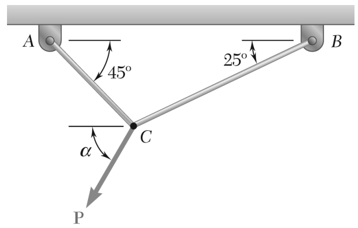


Law of sines:

$$\frac{T_{AC}}{\sin 61.927°} = \frac{T_{BC}}{\sin 73.740°} = \frac{1.98\text{ kN}}{\sin 44.333°}$$

(a) $$T_{AC} = \frac{1.98\text{ kN}}{\sin 44.333°}\sin 61.927°$$ $T_{AC} = 2.50$ kN ◀

(b) $$T_{BC} = \frac{1.98\text{ kN}}{\sin 44.333°}\sin 73.740°$$ $T_{BC} = 2.72$ kN ◀

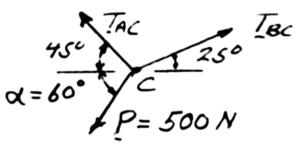


PROBLEM 2.48

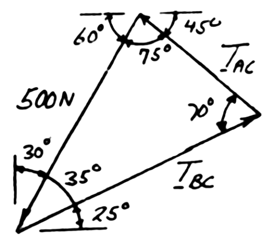
Two cables are tied together at C and are loaded as shown. Knowing that **P** = 500 N and $\alpha = 60°$, determine the tension in (a) in cable AC, (b) in cable BC.

SOLUTION

Free-Body Diagram



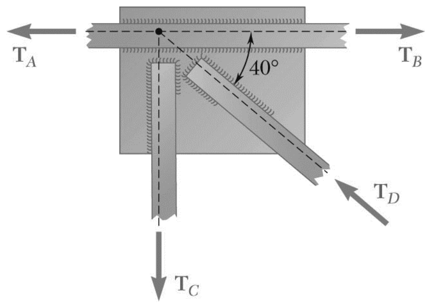
Force Triangle



Law of sines: $$\frac{T_{AC}}{\sin 35°} = \frac{T_{BC}}{\sin 75°} = \frac{500 \text{ N}}{\sin 70°}$$

(a) $$T_{AC} = \frac{500 \text{ N}}{\sin 70°} \sin 35°$$ $T_{AC} = 305$ N ◀

(b) $$T_{BC} = \frac{500 \text{ N}}{\sin 70°} \sin 75°$$ $T_{BC} = 514$ N ◀

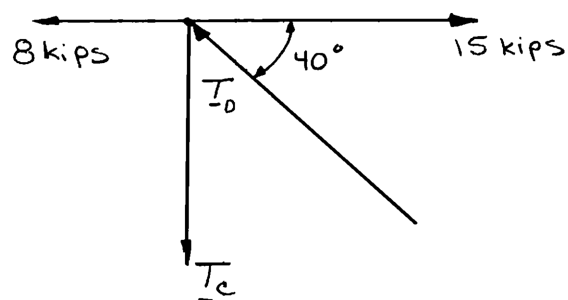


PROBLEM 2.49

Two forces of magnitude $T_A = 8$ kips and $T_B = 15$ kips are applied as shown to a welded connection. Knowing that the connection is in equilibrium, determine the magnitudes of the forces T_C and T_D.

SOLUTION

Free-Body Diagram



$\xrightarrow{+} \Sigma F_x = 0 \qquad 15\text{ kips} - 8\text{ kips} - T_D \cos 40° = 0$

$$T_D = 9.1379\text{ kips}$$

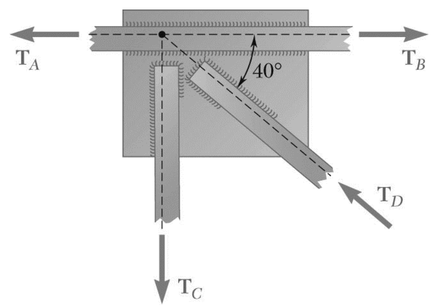
$+\uparrow \Sigma F_y = 0 \qquad T_D \sin 40° - T_C = 0$

$$(9.1379\text{ kips})\sin 40° - T_C = 0$$

$$T_C = 5.8737\text{ kips}$$

$T_C = 5.87$ kips ◀

$T_D = 9.14$ kips ◀

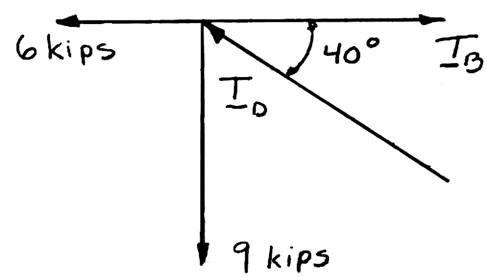


PROBLEM 2.50

Two forces of magnitude T_A = 6 kips and T_C = 9 kips are applied as shown to a welded connection. Knowing that the connection is in equilibrium, determine the magnitudes of the forces T_B and T_D.

SOLUTION

Free-Body Diagram



$\xrightarrow{+} \Sigma F_x = 0 \qquad T_B - 6\text{ kips} - T_D \cos 40° = 0 \qquad (1)$

$+\uparrow \Sigma F_y = 0 \qquad T_D \sin 40° - 9\text{ kips} = 0$

$$T_D = \frac{9\text{ kips}}{\sin 40°}$$

$$T_D = 14.0015\text{ kips}$$

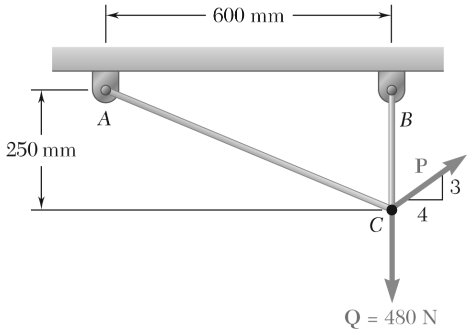
Substituting for T_D into Eq. (1) gives:

$$T_B - 6\text{ kips} - (14.0015\text{ kips})\cos 40° = 0$$

$$T_B = 16.7258\text{ kips}$$

$T_B = 16.73$ kips ◀

$T_D = 14.00$ kips ◀

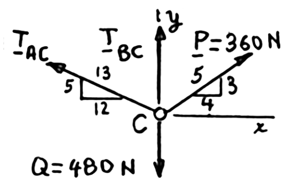


PROBLEM 2.51

Two cables are tied together at C and loaded as shown. Knowing that $P = 360$ N, determine the tension (*a*) in cable AC, (*b*) in cable BC.

SOLUTION

Free Body: *C*

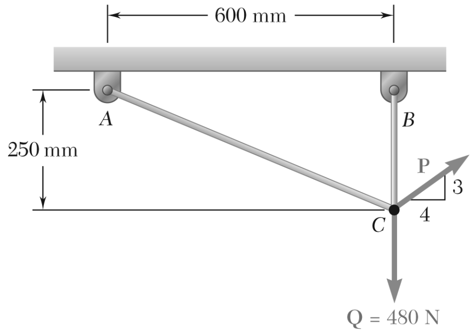


(*a*) $\Sigma F_x = 0: \quad -\frac{12}{13}T_{AC} + \frac{4}{5}(360 \text{ N}) = 0$ $\qquad T_{AC} = 312 \text{ N}$ ◀

(*b*) $\Sigma F_y = 0: \quad \frac{5}{13}(312 \text{ N}) + T_{BC} + \frac{3}{5}(360 \text{ N}) - 480 \text{ N} = 0$

$T_{BC} = 480 \text{ N} - 120 \text{ N} - 216 \text{ N}$ $\qquad T_{BC} = 144 \text{ N}$ ◀

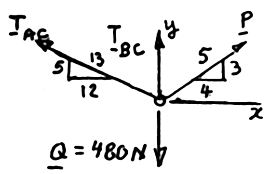
PROBLEM 2.52



Two cables are tied together at C and loaded as shown. Determine the range of values of P for which both cables remain taut.

SOLUTION

Free Body: *C*



$$\Sigma F_x = 0: \quad -\frac{12}{13}T_{AC} + \frac{4}{5}\mathbf{P} = 0$$

$$T_{AC} = \frac{13}{15}P \qquad (1)$$

$$\Sigma F_y = 0: \quad \frac{5}{13}T_{AC} + T_{BC} + \frac{3}{5}P - 480\text{ N} = 0$$

Substitute for T_{AC} from (1):

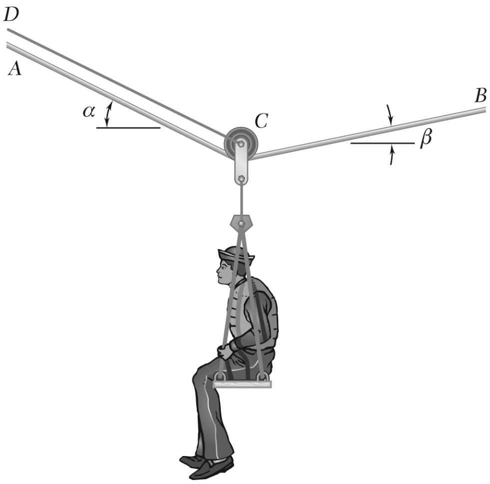
$$\left(\frac{5}{13}\right)\left(\frac{13}{15}\right)P + T_{BC} + \frac{3}{5}P - 480\text{ N} = 0$$

$$T_{BC} = 480\text{ N} - \frac{14}{15}P \qquad (2)$$

From (1), $T_{AC} > 0$ requires $P > 0$.

From (2), $T_{BC} > 0$ requires $\frac{14}{15}P < 480\text{ N}, \quad P < 514.29\text{ N}$

Allowable range: $0 < P < 514\text{ N}$ ◀

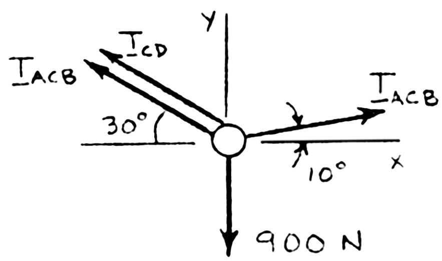


PROBLEM 2.53

A sailor is being rescued using a boatswain's chair that is suspended from a pulley that can roll freely on the support cable ACB and is pulled at a constant speed by cable CD. Knowing that $\alpha = 30°$ and $\beta = 10°$ and that the combined weight of the boatswain's chair and the sailor is 900 N, determine the tension (*a*) in the support cable ACB, (*b*) in the traction cable CD.

SOLUTION

Free-Body Diagram



$$\xrightarrow{+} \Sigma F_x = 0: \quad T_{ACB}\cos 10° - T_{ACB}\cos 30° - T_{CD}\cos 30° = 0$$

$$T_{CD} = 0.137158 T_{ACB} \qquad (1)$$

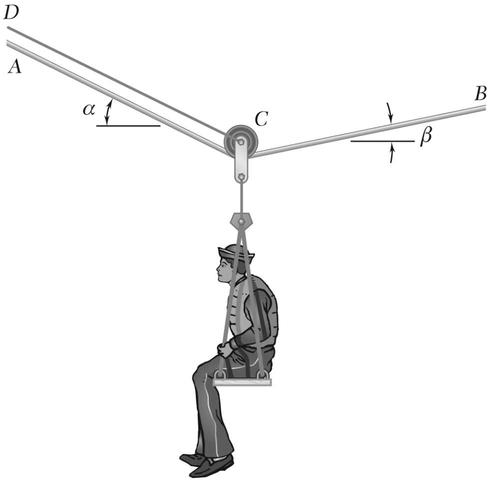
$$+\uparrow \Sigma F_y = 0: \quad T_{ACB}\sin 10° + T_{ACB}\sin 30° + T_{CD}\sin 30° - 900 = 0$$

$$0.67365 T_{ACB} + 0.5 T_{CD} = 900 \qquad (2)$$

(*a*) Substitute (1) into (2): $0.67365 T_{ACB} + 0.5(0.137158 T_{ACB}) = 900$

$T_{ACB} = 1212.56$ N $\qquad T_{ACB} = 1213$ N ◀

(*b*) From (1): $T_{CD} = 0.137158(1212.56 \text{ N})$ $\qquad T_{CD} = 166.3$ N ◀

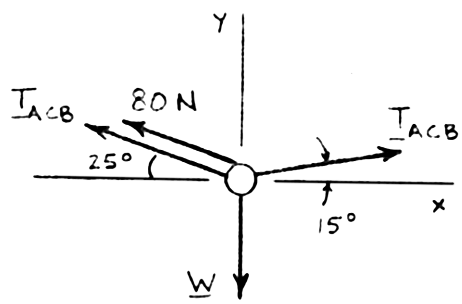


PROBLEM 2.54

A sailor is being rescued using a boatswain's chair that is suspended from a pulley that can roll freely on the support cable *ACB* and is pulled at a constant speed by cable *CD*. Knowing that $\alpha = 25°$ and $\beta = 15°$ and that the tension in cable *CD* is 80 N, determine (*a*) the combined weight of the boatswain's chair and the sailor, (*b*) in tension in the support cable *ACB*.

SOLUTION

Free-Body Diagram



$$\xrightarrow{+} \Sigma F_x = 0: \quad T_{ACB} \cos 15° - T_{ACB} \cos 25° - (80 \text{ N}) \cos 25° = 0$$

$$T_{ACB} = 1216.15 \text{ N}$$

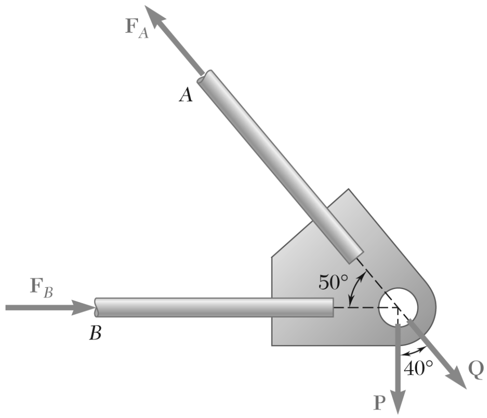
$$+\!\uparrow \Sigma F_y = 0: \quad (1216.15 \text{ N}) \sin 15° + (1216.15 \text{ N}) \sin 25°$$

$$+ (80 \text{ N}) \sin 25° - W = 0$$

$$W = 862.54 \text{ N}$$

(*a*) $W = 863 \text{ N}$ ◀

(*b*) $T_{ACB} = 1216 \text{ N}$ ◀

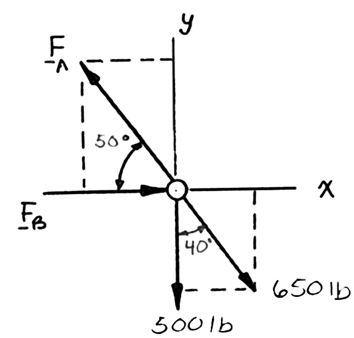


PROBLEM 2.55

Two forces **P** and **Q** are applied as shown to an aircraft connection. Knowing that the connection is in equilibrium and that $P = 500$ lb and $Q = 650$ lb, determine the magnitudes of the forces exerted on the rods *A* and *B*.

SOLUTION

Free-Body Diagram



Resolving the forces into *x*- and *y*-directions:

$$\mathbf{R} = \mathbf{P} + \mathbf{Q} + \mathbf{F}_A + \mathbf{F}_B = 0$$

Substituting components:

$$\begin{aligned}\mathbf{R} = &-(500\text{ lb})\mathbf{j} + [(650\text{ lb})\cos 50°]\mathbf{i} \\ &-[(650\text{ lb})\sin 50°]\mathbf{j} \\ &+F_B\mathbf{i} - (F_A\cos 50°)\mathbf{i} + (F_A\sin 50°)\mathbf{j} = 0\end{aligned}$$

In the *y*-direction (one unknown force):

$$-500\text{ lb} - (650\text{ lb})\sin 50° + F_A\sin 50° = 0$$

Thus,

$$F_A = \frac{500\text{ lb} + (650\text{ lb})\sin 50°}{\sin 50°}$$

$$= 1302.70\text{ lb} \qquad F_A = 1303\text{ lb} ◀$$

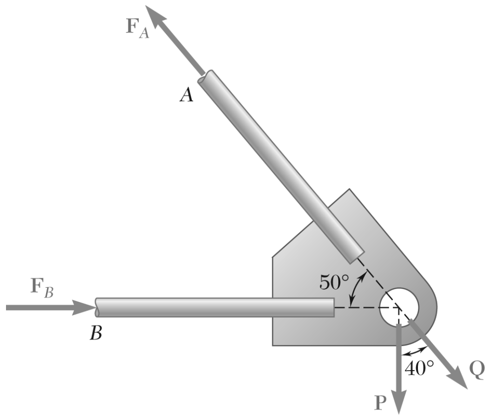
In the *x*-direction:

$$(650\text{ lb})\cos 50° + F_B - F_A\cos 50° = 0$$

Thus,

$$\begin{aligned}F_B &= F_A\cos 50° - (650\text{ lb})\cos 50° \\ &= (1302.70\text{ lb})\cos 50° - (650\text{ lb})\cos 50° \\ &= 419.55\text{ lb}\end{aligned}$$

$$F_B = 420\text{ lb} ◀$$

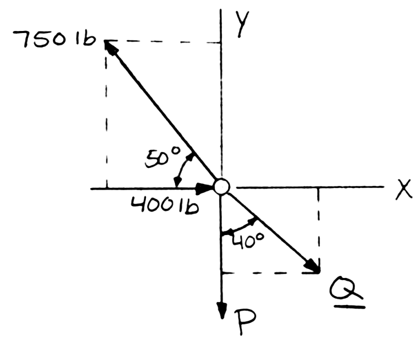


PROBLEM 2.56

Two forces **P** and **Q** are applied as shown to an aircraft connection. Knowing that the connection is in equilibrium and that the magnitudes of the forces exerted on rods *A* and *B* are $F_A = 750$ lb and $F_B = 400$ lb, determine the magnitudes of **P** and **Q**.

SOLUTION

Free-Body Diagram



Resolving the forces into *x*- and *y*-directions:

$$\mathbf{R} = \mathbf{P} + \mathbf{Q} + \mathbf{F}_A + \mathbf{F}_B = 0$$

Substituting components:

$$\begin{aligned}\mathbf{R} &= -P\mathbf{j} + Q\cos 50°\mathbf{i} - Q\sin 50°\mathbf{j}\\ &\quad -[(750\text{ lb})\cos 50°]\mathbf{i}\\ &\quad +[(750\text{ lb})\sin 50°]\mathbf{j} + (400\text{ lb})\mathbf{i}\end{aligned}$$

In the *x*-direction (one unknown force):

$$Q\cos 50° - [(750\text{ lb})\cos 50°] + 400\text{ lb} = 0$$

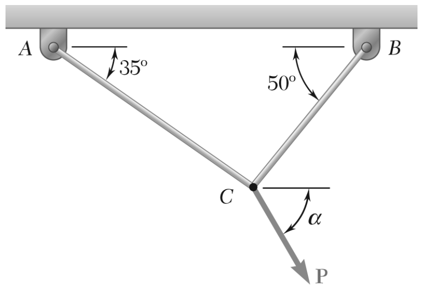
$$\begin{aligned}Q &= \frac{(750\text{ lb})\cos 50° - 400\text{ lb}}{\cos 50°}\\ &= 127.710\text{ lb}\end{aligned}$$

In the *y*-direction:

$$-P - Q\sin 50° + (750\text{ lb})\sin 50° = 0$$

$$\begin{aligned}P &= -Q\sin 50° + (750\text{ lb})\sin 50°\\ &= -(127.710\text{ lb})\sin 50° + (750\text{ lb})\sin 50°\\ &= 476.70\text{ lb}\end{aligned}$$

$P = 477$ lb; $Q = 127.7$ lb ◀

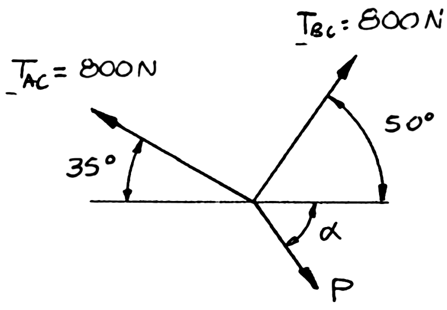


PROBLEM 2.57

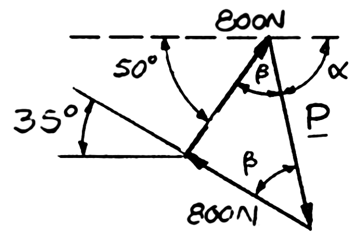
Two cables tied together at C are loaded as shown. Knowing that the maximum allowable tension in each cable is 800 N, determine (*a*) the magnitude of the largest force **P** that can be applied at C, (*b*) the corresponding value of α.

SOLUTION

Free-Body Diagram: *C*



Force Triangle



Force triangle is isosceles with

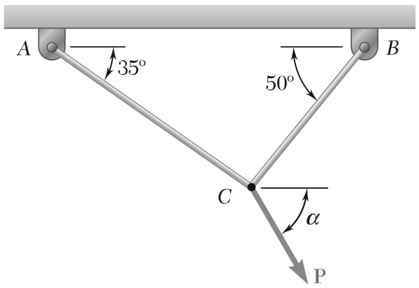
$$2\beta = 180° - 85°$$

$$\beta = 47.5°$$

(*a*) $$P = 2(800\text{ N})\cos 47.5° = 1081\text{ N}$$

Since $P > 0$, the solution is correct. $P = 1081\text{ N}$ ◀

(*b*) $$\alpha = 180° - 50° - 47.5° = 82.5°$$ $\alpha = 82.5°$ ◀

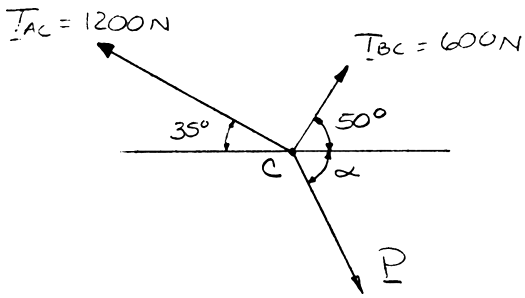


PROBLEM 2.58

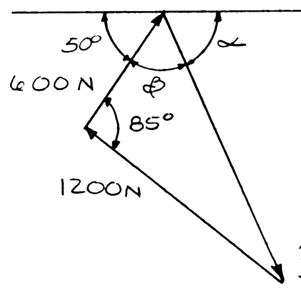
Two cables tied together at C are loaded as shown. Knowing that the maximum allowable tension is 1200 N in cable AC and 600 N in cable BC, determine (a) the magnitude of the largest force **P** that can be applied at C, (b) the corresponding value of α.

SOLUTION

Free-Body Diagram



Force Triangle



(a) Law of cosines: $P^2 = (1200 \text{ N})^2 + (600 \text{ N})^2 - 2(1200 \text{ N})(600 \text{ N})\cos 85°$

$$P = 1294.02 \text{ N}$$

Since $P > 1200$ N, the solution is correct.

$P = 1294$ N ◀

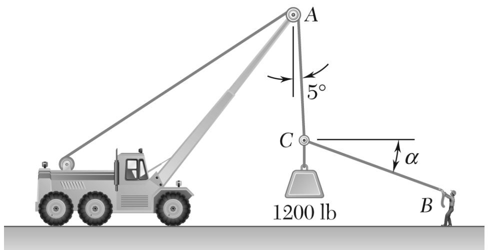
(b) Law of sines:

$$\frac{\sin\beta}{1200 \text{ N}} = \frac{\sin 85°}{1294.02 \text{ N}}$$

$$\beta = 67.5°$$

$$\alpha = 180° - 50° - 67.5°$$

$\alpha = 62.5°$ ◀



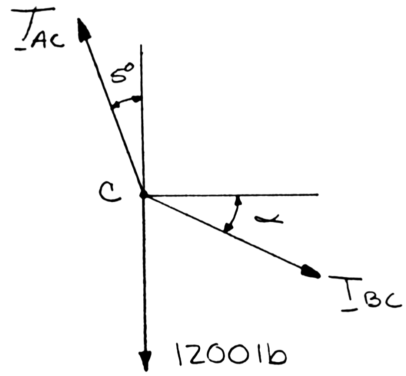
PROBLEM 2.59

For the situation described in Figure P2.45, determine (*a*) the value of α for which the tension in rope *BC* is as small as possible, (*b*) the corresponding value of the tension.

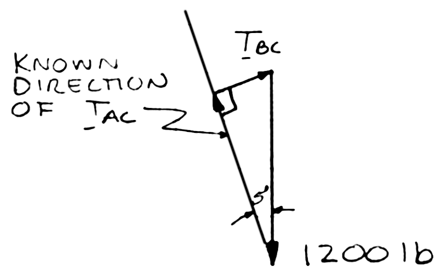
PROBLEM 2.45 Knowing that $\alpha = 20°$, determine the tension (*a*) in cable *AC*, (*b*) in rope *BC*.

SOLUTION

Free-Body Diagram



Force Triangle

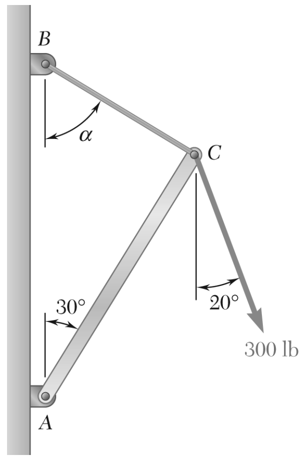


To be smallest, T_{BC} must be perpendicular to the direction of T_{AC}.

(*a*) Thus, $\alpha = 5°$ $\qquad$ $\alpha = 5.00°$ ◀

(*b*) $T_{BC} = (1200 \text{ lb})\sin 5°$ $\qquad$ $T_{BC} = 104.6 \text{ lb}$ ◀

PROBLEM 2.60

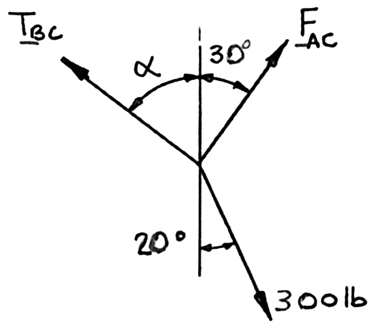


For the structure and loading of Problem 2.46, determine (*a*) the value of α for which the tension in cable *BC* is as small as possible, (*b*) the corresponding value of the tension.

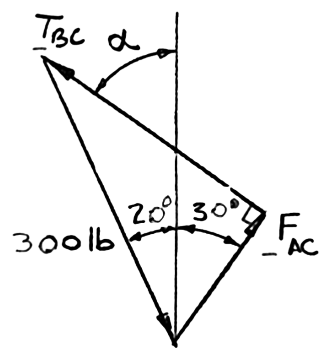
SOLUTION

T_{BC} must be perpendicular to F_{AC} to be as small as possible.

Free-Body Diagram: *C*



Force Triangle is a right triangle

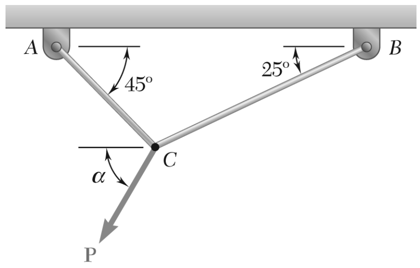


To be a minimum, T_{BC} must be perpendicular to F_{AC}.

(*a*) We observe: $\alpha = 90° - 30°$ $\alpha = 60.0°$ ◀

(*b*) $T_{BC} = (300 \text{ lb}) \sin 50°$

or $T_{BC} = 229.81 \text{ lb}$ $T_{BC} = 230 \text{ lb}$ ◀

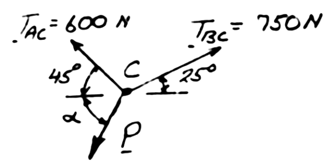


PROBLEM 2.61

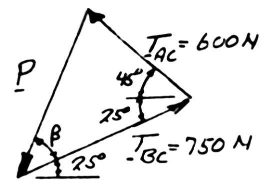
For the cables of Problem 2.48, it is known that the maximum allowable tension is 600 N in cable *AC* and 750 N in cable *BC*. Determine (*a*) the maximum force **P** that can be applied at *C*, (*b*) the corresponding value of α.

SOLUTION

Free-Body Diagram



Force Triangle



(*a*) Law of cosines

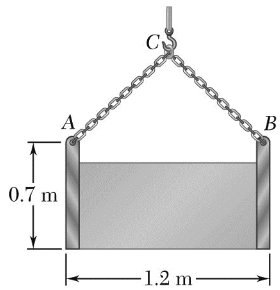
$$P^2 = (600)^2 + (750)^2 - 2(600)(750)\cos(25° + 45°)$$

$$P = 784.02 \text{ N} \qquad\qquad P = 784 \text{ N} ◀$$

(*b*) Law of sines

$$\frac{\sin\beta}{600 \text{ N}} = \frac{\sin(25° + 45°)}{784.02 \text{ N}}$$

$$\beta = 46.0° \qquad \therefore \quad \alpha = 46.0° + 25° \qquad\qquad \alpha = 71.0° ◀$$

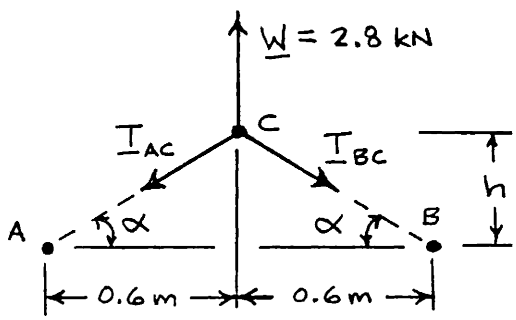


PROBLEM 2.62

A movable bin and its contents have a combined weight of 2.8 kN. Determine the shortest chain sling ACB that can be used to lift the loaded bin if the tension in the chain is not to exceed 5 kN.

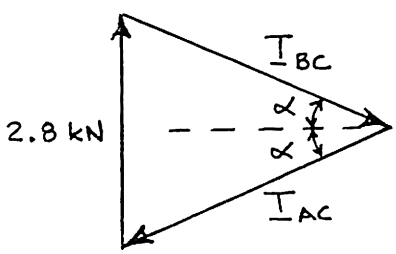
SOLUTION

Free-Body Diagram



$$\tan\alpha = \frac{h}{0.6\text{ m}} \qquad (1)$$

Isosceles Force Triangle



Law of sines: $$\sin\alpha = \frac{\frac{1}{2}(2.8\text{ kN})}{T_{AC}}$$

$$T_{AC} = 5\text{ kN}$$

$$\sin\alpha = \frac{\frac{1}{2}(2.8\text{ kN})}{5\text{ kN}}$$

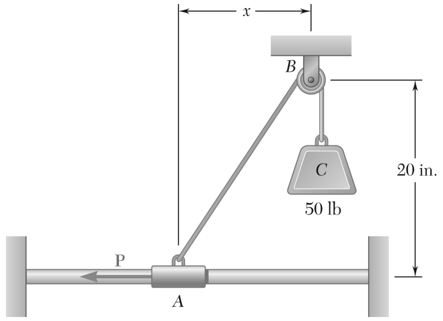
$$\alpha = 16.2602°$$

From Eq. (1): $\tan 16.2602° = \dfrac{h}{0.6\text{ m}}$ $\quad\therefore\quad h = 0.175000\text{ m}$

Half length of chain $= AC = \sqrt{(0.6\text{ m})^2 + (0.175\text{ m})^2}$

$= 0.625\text{ m}$

Total length: $= 2\times 0.625\text{ m}$ $\qquad$ 1.250 m ◀

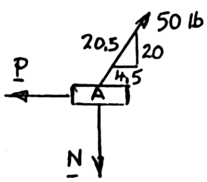


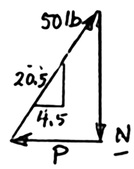
PROBLEM 2.63

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

(a) **Free Body: Collar A**



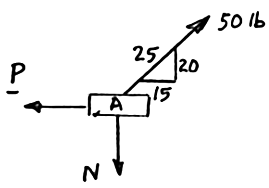


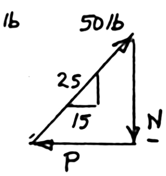
Force Triangle

$$\frac{P}{4.5} = \frac{50 \text{ lb}}{20.5}$$

$P = 10.98$ lb ◀

(b) **Free Body: Collar A**

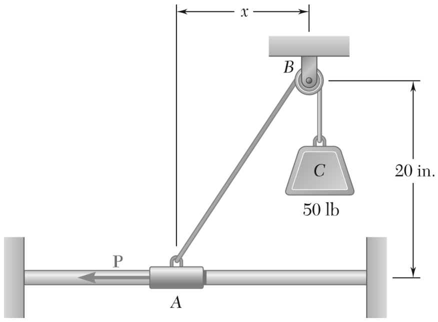




Force Triangle

$$\frac{P}{15} = \frac{50 \text{ lb}}{25}$$

$P = 30.0$ lb ◀

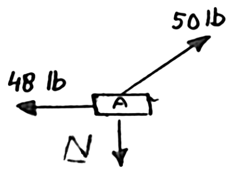


PROBLEM 2.64

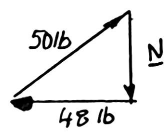
Collar A is connected as shown to a 50-lb load and can slide on a frictionless horizontal rod. Determine the distance x for which the collar is in equilibrium when $P = 48$ lb.

SOLUTION

Free Body: Collar *A*



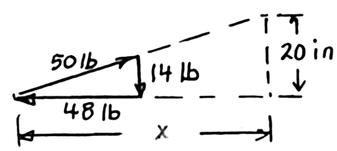
Force Triangle



$$N^2 = (50)^2 - (48)^2 = 196$$

$$N = 14.00 \text{ lb}$$

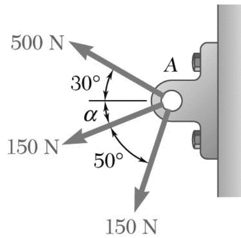
Similar Triangles



$$\frac{x}{20 \text{ in.}} = \frac{48 \text{ lb}}{14 \text{ lb}}$$

$x = 68.6$ in. ◀

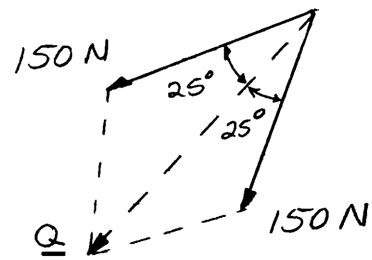
PROBLEM 2.65



Three forces are applied to a bracket as shown. The directions of the two 150-N forces may vary, but the angle between these forces is always 50°. Determine the range of values of α for which the magnitude of the resultant of the forces acting at A is less than 600 N.

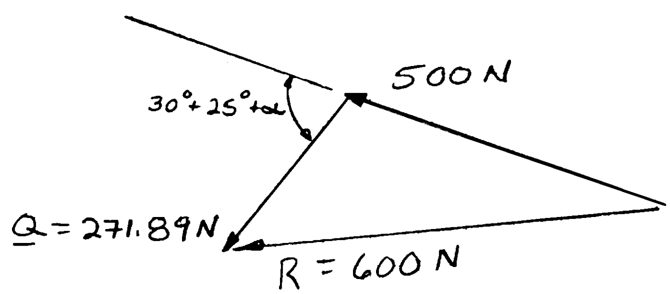
SOLUTION

Combine the two 150-N forces into a resultant force Q:



$$Q = 2(150 \text{ N})\cos 25°$$
$$= 271.89 \text{ N}$$

Equivalent loading at A:



Using the law of cosines:

$$(600 \text{ N})^2 = (500 \text{ N})^2 + (271.89 \text{ N})^2 + 2(500 \text{ N})(271.89 \text{ N})\cos(55° + \alpha)$$
$$\cos(55° + \alpha) = 0.132685$$

Two values for α: $55° + \alpha = 82.375$

$\alpha = 27.4°$

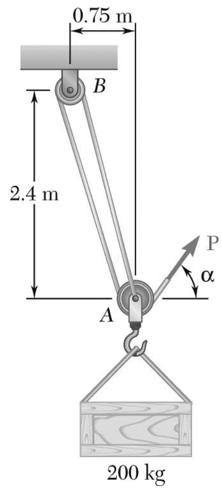
or $55° + \alpha = -82.375°$

$55° + \alpha = 360° - 82.375°$

$\alpha = 222.6°$

For $R < 600$ lb: $27.4° < \alpha < 222.6$ ◀

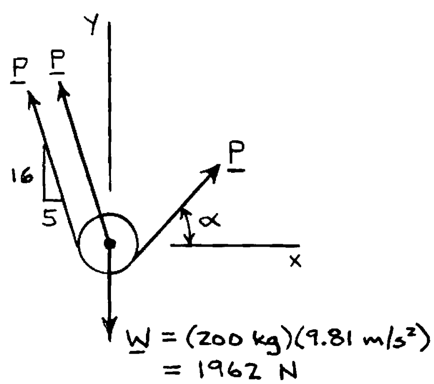
PROBLEM 2.66



A 200-kg crate is to be supported by the rope-and-pulley arrangement shown. Determine the magnitude and direction of the force **P** that must be exerted on the free end of the rope to maintain equilibrium. (*Hint:* The tension in the rope is the same on each side of a simple pulley. This can be proved by the methods of Ch. 4.)

SOLUTION

Free-Body Diagram: Pulley *A*



$$\xrightarrow{+} \Sigma F_x = 0: \quad -2P\left(\frac{5}{\sqrt{281}}\right) + P\cos\alpha = 0$$

$$\cos\alpha = 0.59655$$

$$\alpha = \pm 53.377°$$

For $\alpha = +53.377°$:

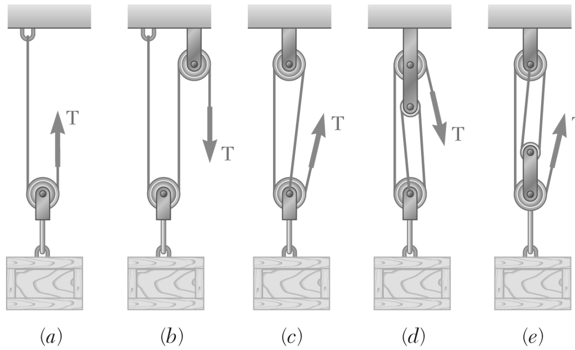
$$+\uparrow \Sigma F_y = 0: \quad 2P\left(\frac{16}{\sqrt{281}}\right) + P\sin 53.377° - 1962\text{ N} = 0$$

$\mathbf{P} = 724$ N $\measuredangle$ 53.4° ◀

For $\alpha = -53.377°$:

$$+\uparrow \Sigma F_y = 0: \quad 2P\left(\frac{16}{\sqrt{281}}\right) + P\sin(-53.377°) - 1962\text{ N} = 0$$

$\mathbf{P} = 1773$ ⦬ 53.4° ◀



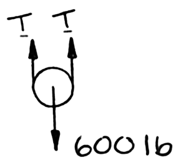
PROBLEM 2.67

A 600-lb crate is supported by several rope-and-pulley arrangements as shown. Determine for each arrangement the tension in the rope. (See the hint for Problem 2.66.)

SOLUTION

Free-Body Diagram of Pulley

(*a*)

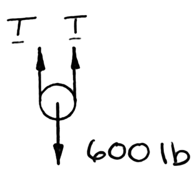


$$+\uparrow \Sigma F_y = 0: \quad 2T - (600 \text{ lb}) = 0$$

$$T = \frac{1}{2}(600 \text{ lb})$$

$$T = 300 \text{ lb} \blacktriangleleft$$

(*b*)

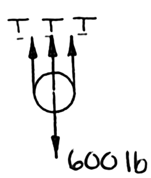


$$+\uparrow \Sigma F_y = 0: \quad 2T - (600 \text{ lb}) = 0$$

$$T = \frac{1}{2}(600 \text{ lb})$$

$$T = 300 \text{ lb} \blacktriangleleft$$

(*c*)

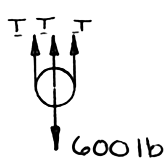


$$+\uparrow \Sigma F_y = 0: \quad 3T - (600 \text{ lb}) = 0$$

$$T = \frac{1}{3}(600 \text{ lb})$$

$$T = 200 \text{ lb} \blacktriangleleft$$

(*d*)

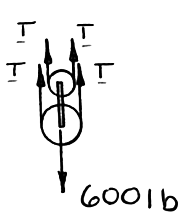


$$+\uparrow \Sigma F_y = 0: \quad 3T - (600 \text{ lb}) = 0$$

$$T = \frac{1}{3}(600 \text{ lb})$$

$$T = 200 \text{ lb} \blacktriangleleft$$

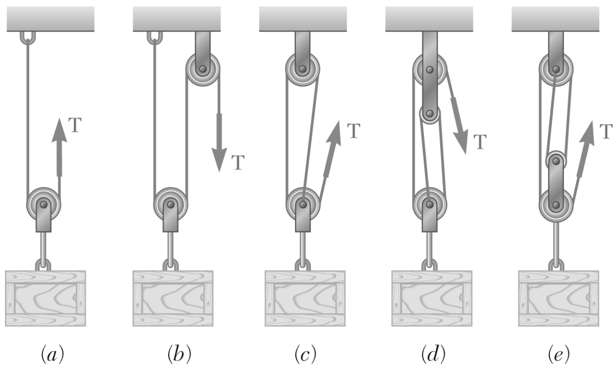
(*e*)



$$+\uparrow \Sigma F_y = 0: \quad 4T - (600 \text{ lb}) = 0$$

$$T = \frac{1}{4}(600 \text{ lb})$$

$$T = 150.0 \text{ lb} \blacktriangleleft$$



PROBLEM 2.68

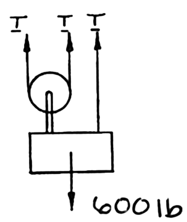
Solve Parts *b* and *d* of Problem 2.67, assuming that the free end of the rope is attached to the crate.

PROBLEM 2.67 A 600-lb crate is supported by several rope-and-pulley arrangements as shown. Determine for each arrangement the tension in the rope. (See the hint for Problem 2.66.)

SOLUTION

Free-Body Diagram of Pulley and Crate

(*b*)

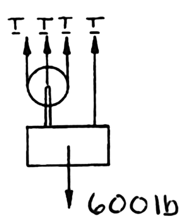


$$+\uparrow \Sigma F_y = 0: \quad 3T - (600 \text{ lb}) = 0$$

$$T = \frac{1}{3}(600 \text{ lb})$$

$$T = 200 \text{ lb} \blacktriangleleft$$

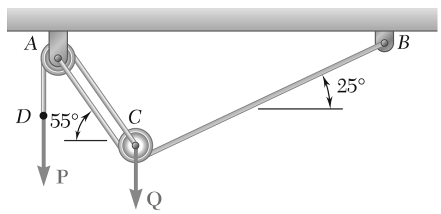
(*d*)



$$+\uparrow \Sigma F_y = 0: \quad 4T - (600 \text{ lb}) = 0$$

$$T = \frac{1}{4}(600 \text{ lb})$$

$$T = 150.0 \text{ lb} \blacktriangleleft$$

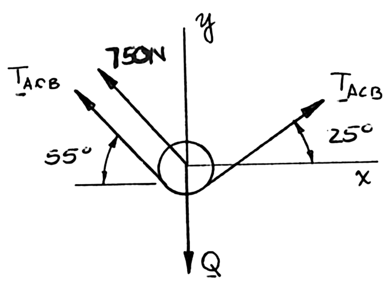


PROBLEM 2.69

A load **Q** is applied to the pulley C, which can roll on the cable ACB. The pulley is held in the position shown by a second cable CAD, which passes over the pulley A and supports a load **P**. Knowing that $P = 750$ N, determine (a) the tension in cable ACB, (b) the magnitude of load **Q**.

SOLUTION

Free-Body Diagram: Pulley *C*



(a) $\xrightarrow{+} \Sigma F_x = 0\text{:} \quad T_{ACB}(\cos 25° - \cos 55°) - (750 \text{ N})\cos 55° = 0$

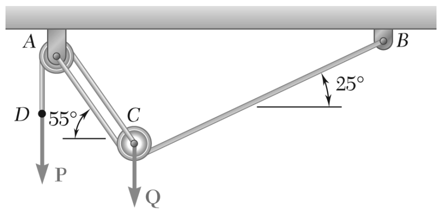
Hence: $\quad T_{ACB} = 1292.88 \text{ N}$

$T_{ACB} = 1293 \text{ N}$ ◀

(b) $+\!\uparrow \Sigma F_y = 0\text{:} \quad T_{ACB}(\sin 25° + \sin 55°) + (750 \text{ N})\sin 55° - Q = 0$

$(1292.88 \text{ N})(\sin 25° + \sin 55°) + (750 \text{ N})\sin 55° - Q = 0$

or $\quad Q = 2219.8 \text{ N} \qquad Q = 2220 \text{ N}$ ◀

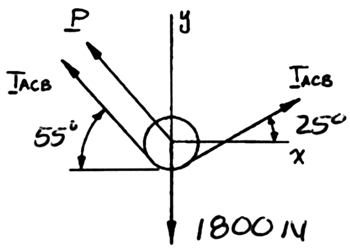


PROBLEM 2.70

An 1800-N load **Q** is applied to the pulley C, which can roll on the cable ACB. The pulley is held in the position shown by a second cable CAD, which passes over the pulley A and supports a load **P**. Determine (*a*) the tension in cable ACB, (*b*) the magnitude of load **P**.

SOLUTION

Free-Body Diagram: Pulley *C*



$$\xrightarrow{+} \Sigma F_x = 0: \quad T_{ACB}(\cos 25° - \cos 55°) - P\cos 55° = 0$$

or $$P = 0.58010T_{ACB} \qquad (1)$$

$$+\uparrow \Sigma F_y = 0: \quad T_{ACB}(\sin 25° + \sin 55°) + P\sin 55° - 1800 \text{ N} = 0$$

or $$1.24177T_{ACB} + 0.81915P = 1800 \text{ N} \qquad (2)$$

(*a*) Substitute Equation (1) into Equation (2):

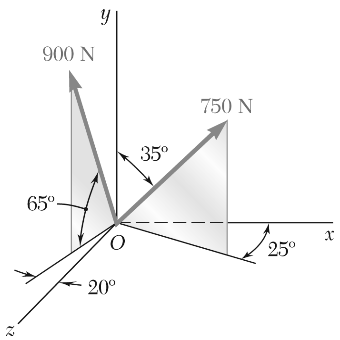
$$1.24177T_{ACB} + 0.81915(0.58010T_{ACB}) = 1800 \text{ N}$$

Hence: $$T_{ACB} = 1048.37 \text{ N}$$

$$T_{ACB} = 1048 \text{ N} \blacktriangleleft$$

(*b*) Using (1), $$P = 0.58010(1048.37 \text{ N}) = 608.16 \text{ N}$$

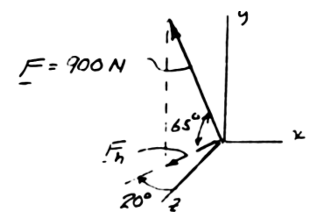
$$P = 608 \text{ N} \blacktriangleleft$$



PROBLEM 2.71

Determine (*a*) the *x*, *y*, and *z* components of the 900-N force, (*b*) the angles θ_x, θ_y, and θ_z that the force forms with the coordinate axes.

SOLUTION



$$F_h = F\cos 65^\circ$$
$$= (900\text{ N})\cos 65^\circ$$
$$F_h = 380.36\text{ N}$$

(*a*)
$$F_x = F_h \sin 20^\circ$$
$$= (380.36\text{ N})\sin 20^\circ$$
$$F_x = -130.091\text{ N}, \qquad F_x = -130.1\text{ N} \blacktriangleleft$$

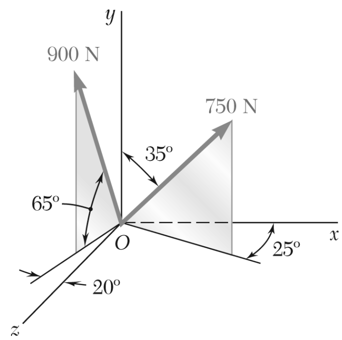
$$F_y = F\sin 65^\circ$$
$$= (900\text{ N})\sin 65^\circ$$
$$F_y = +815.68\text{ N}, \qquad F_y = +816\text{ N} \blacktriangleleft$$

$$F_z = F_h\cos 20^\circ$$
$$= (380.36\text{ N})\cos 20^\circ$$
$$F_z = +357.42\text{ N} \qquad F_z = +357\text{ N} \blacktriangleleft$$

(*b*)
$$\cos\theta_x = \frac{F_x}{F} = \frac{-130.091\text{ N}}{900\text{ N}} \qquad \theta_x = 98.3^\circ \blacktriangleleft$$

$$\cos\theta_y = \frac{F_y}{F} = \frac{+815.68\text{ N}}{900\text{ N}} \qquad \theta_y = 25.0^\circ \blacktriangleleft$$

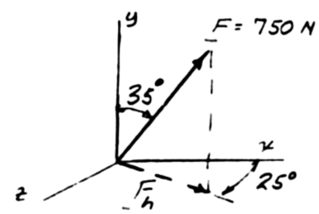
$$\cos\theta_z = \frac{F_z}{F} = \frac{+357.42\text{ N}}{900\text{ N}} \qquad \theta_z = 66.6^\circ \blacktriangleleft$$



PROBLEM 2.72

Determine (*a*) the *x*, *y*, and *z* components of the 750-N force, (*b*) the angles θ_x, θ_y, and θ_z that the force forms with the coordinate axes.

SOLUTION



$$F_h = F \sin 35^\circ$$
$$= (750 \text{ N})\sin 35^\circ$$
$$F_h = 430.18 \text{ N}$$

(*a*)

$$F_x = F_h \cos 25^\circ$$
$$= (430.18 \text{ N})\cos 25^\circ$$
$$F_x = +389.88 \text{ N}, \qquad F_x = +390 \text{ N} \blacktriangleleft$$

$$F_y = F \cos 35^\circ$$
$$= (750 \text{ N})\cos\ 35^\circ$$
$$F_y = +614.36 \text{ N}, \qquad F_y = +614 \text{ N} \blacktriangleleft$$

$$F_z = F_h \sin 25^\circ$$
$$= (430.18 \text{ N})\sin 25^\circ \qquad F_z = +181.8 \text{ N} \blacktriangleleft$$
$$F_z = +181.802 \text{ N}$$

(*b*)

$$\cos\,\theta_x = \frac{F_x}{F} = \frac{+389.88 \text{ N}}{750 \text{ N}} \qquad \theta_x = 58.7^\circ \blacktriangleleft$$

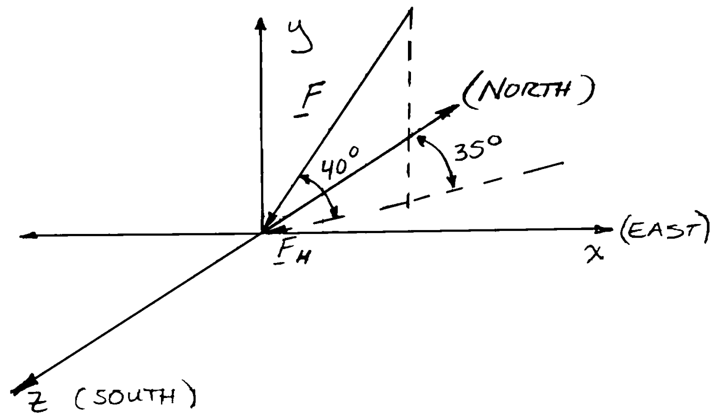
$$\cos\,\theta_y = \frac{F_y}{F} = \frac{+614.36 \text{ N}}{750 \text{ N}} \qquad \theta_y = 35.0^\circ \blacktriangleleft$$

$$\cos\,\theta_z = \frac{F_z}{F} = \frac{+181.802 \text{ N}}{750 \text{ N}} \qquad \theta_z = 76.0^\circ \blacktriangleleft$$

PROBLEM 2.73

A gun is aimed at a point A located 35° east of north. Knowing that the barrel of the gun forms an angle of 40° with the horizontal and that the maximum recoil force is 400 N, determine (a) the x, y, and z components of that force, (b) the values of the angles θ_x, θ_y, and θ_z defining the direction of the recoil force. (Assume that the x, y, and z axes are directed, respectively, east, up, and south.)

SOLUTION



Recoil force $F = 400 \text{ N}$

$$\therefore \quad F_H = (400 \text{ N})\cos 40° = 306.42 \text{ N}$$

(a)

$$F_x = -F_H \sin 35° = -(306.42 \text{ N})\sin 35° = -175.755 \text{ N}$$

$F_x = -175.8 \text{ N}$ ◀

$$F_y = -F \sin 40° = -(400 \text{ N})\sin 40° = -257.12 \text{ N}$$

$F_y = -257 \text{ N}$ ◀

$$F_z = +F_H \cos 35° = +(306.42 \text{ N})\cos 35° = +251.00 \text{ N}$$

$F_z = +251 \text{ N}$ ◀

(b)

$$\cos\theta_x = \frac{F_x}{F} = \frac{-175.755 \text{ N}}{400 \text{ N}}$$

$\theta_x = 116.1°$ ◀

$$\cos\theta_y = \frac{F_y}{F} = \frac{-257.12 \text{ N}}{400 \text{ N}}$$

$\theta_y = 130.0°$ ◀

$$\cos\theta_z = \frac{F_z}{F} = \frac{251.00 \text{ N}}{400 \text{ N}}$$

$\theta_z = 51.1°$ ◀

PROBLEM 2.74

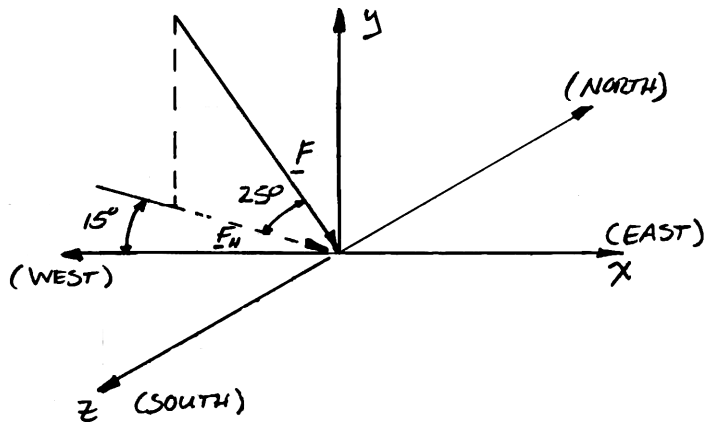
Solve Problem 2.73, assuming that point *A* is located 15° north of west and that the barrel of the gun forms an angle of 25° with the horizontal.

PROBLEM 2.73 A gun is aimed at a point *A* located 35° east of north. Knowing that the barrel of the gun forms an angle of 40° with the horizontal and that the maximum recoil force is 400 N, determine (*a*) the *x*, *y*, and *z* components of that force, (*b*) the values of the angles θ_x, θ_y, and θ_z defining the direction of the recoil force. (Assume that the *x*, *y*, and *z* axes are directed, respectively, east, up, and south.)

SOLUTION

Recoil force $F = 400 \text{ N}$

$$\therefore \quad F_H = (400 \text{ N})\cos 25° = 362.52 \text{ N}$$



(*a*)

$$F_x = +F_H \cos 15° = +(362.52 \text{ N})\cos 15° = +350.17 \text{ N}$$

$F_x = +350 \text{ N}$ ◀

$$F_y = -F \sin 25° = -(400 \text{ N})\sin 25° = -169.047 \text{ N}$$

$F_y = -169.0 \text{ N}$ ◀

$$F_z = +F_H \sin 15° = +(362.52 \text{ N})\sin 15° = +93.827 \text{ N}$$

$F_z = +93.8 \text{ N}$ ◀

(*b*)

$$\cos\theta_x = \frac{F_x}{F} = \frac{+350.17 \text{ N}}{400 \text{ N}}$$

$\theta_x = 28.9°$ ◀

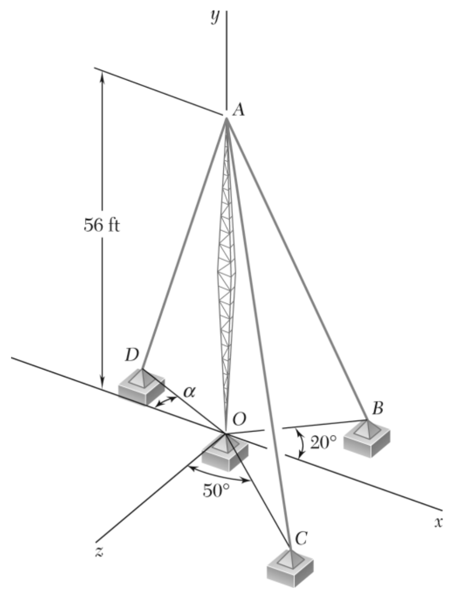
$$\cos\theta_y = \frac{F_y}{F} = \frac{-169.047 \text{ N}}{400 \text{ N}}$$

$\theta_y = 115.0°$ ◀

$$\cos\theta_z = \frac{F_z}{F} = \frac{+93.827 \text{ N}}{400 \text{ N}}$$

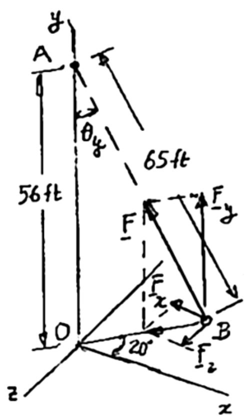
$\theta_z = 76.4°$ ◀

PROBLEM 2.75



Cable AB is 65 ft long, and the tension in that cable is 3900 lb. Determine (a) the x, y, and z components of the force exerted by the cable on the anchor B, (b) the angles θ_x, θ_y, and θ_z defining the direction of that force.

SOLUTION



From triangle AOB:
$$\cos\theta_y = \frac{56 \text{ ft}}{65 \text{ ft}} = 0.86154$$
$$\theta_y = 30.51°$$

(a)
$$F_x = -F\sin\theta_y\cos 20° = -(3900 \text{ lb})\sin 30.51°\cos 20°$$
$$F_x = -1861 \text{ lb} \blacktriangleleft$$

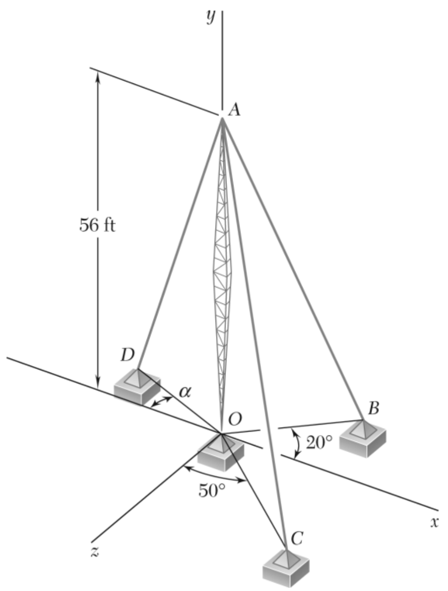
$$F_y = +F\cos\theta_y = (3900 \text{ lb})(0.86154) \qquad F_y = +3360 \text{ lb} \blacktriangleleft$$

$$F_z = +(3900 \text{ lb})\sin 30.51°\sin 20° \qquad F_z = +677 \text{ lb} \blacktriangleleft$$

(b)
$$\cos\theta_x = \frac{F_x}{F} = -\frac{1861 \text{ lb}}{3900 \text{ lb}} = -0.4771 \qquad \theta_x = 118.5° \blacktriangleleft$$

From above:
$$\theta_y = 30.51° \qquad \theta_y = 30.5° \blacktriangleleft$$

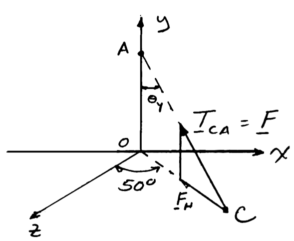
$$\cos\theta_z = \frac{F_z}{F} = +\frac{677 \text{ lb}}{3900 \text{ lb}} = +0.1736 \qquad \theta_z = 80.0° \blacktriangleleft$$



PROBLEM 2.76

Cable AC is 70 ft long, and the tension in that cable is 5250 lb. Determine (*a*) the *x*, *y*, and *z* components of the force exerted by the cable on the anchor C, (*b*) the angles θ_x, θ_y, and θ_z defining the direction of that force.

SOLUTION



In triangle *AOB*:

$$AC = 70 \text{ ft}$$
$$OA = 56 \text{ ft}$$
$$F = 5250 \text{ lb}$$

$$\cos\theta_y = \frac{56 \text{ ft}}{70 \text{ ft}}$$
$$\theta_y = 36.870°$$
$$F_H = F\sin\theta_y$$
$$= (5250 \text{ lb})\sin 36.870°$$
$$= 3150.0 \text{ lb}$$

(*a*) $F_x = -F_H \sin 50° = -(3150.0 \text{ lb})\sin 50° = -2413.04 \text{ lb}$ $\quad F_x = -2413 \text{ lb}$ ◀

$F_y = +F\cos\theta_y = +(5250 \text{ lb})\cos 36.870° = +4200.0 \text{ lb}$ $\quad F_y = +4200 \text{ lb}$ ◀

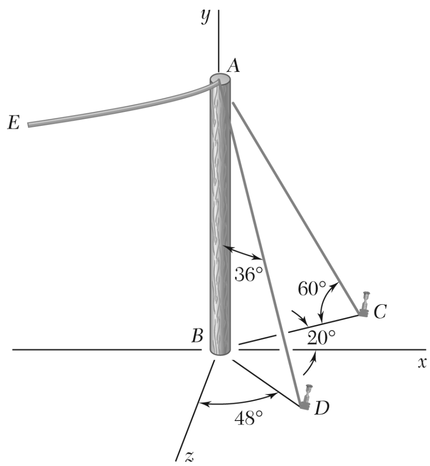
$F_z = -F_H \cos 50° = -3150\cos 50° = -2024.8 \text{ lb}$ $\quad F_z = -2025 \text{ lb}$ ◀

(*b*) $\cos\theta_x = \dfrac{F_x}{F} = \dfrac{-2413.04 \text{ lb}}{5250 \text{ lb}}$ $\quad \theta_x = 117.4°$ ◀

From above: $\theta_y = 36.870°$ $\quad \theta_y = 36.9°$ ◀

$\theta_z = \dfrac{F_z}{F} = \dfrac{-2024.8 \text{ lb}}{5250 \text{ lb}}$ $\quad \theta_z = 112.7°$ ◀

PROBLEM 2.77



The end of the coaxial cable AE is attached to the pole AB, which is strengthened by the guy wires AC and AD. Knowing that the tension in wire AC is 120 lb, determine (*a*) the components of the force exerted by this wire on the pole, (*b*) the angles θ_x, θ_y, and θ_z that the force forms with the coordinate axes.

SOLUTION

(*a*)

$$F_x = (120 \text{ lb})\cos 60^\circ \cos 20^\circ$$

$$F_x = 56.382 \text{ lb} \qquad F_x = +56.4 \text{ lb} \blacktriangleleft$$

$$F_y = -(120 \text{ lb})\sin 60^\circ$$

$$F_y = -103.923 \text{ lb} \qquad F_y = -103.9 \text{ lb} \blacktriangleleft$$

$$F_z = -(120 \text{ lb})\cos 60^\circ \sin 20^\circ$$

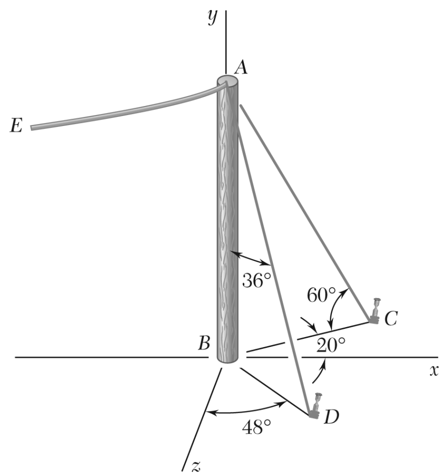
$$F_z = -20.521 \text{ lb} \qquad F_z = -20.5 \text{ lb} \blacktriangleleft$$

(*b*)

$$\cos\theta_x = \frac{F_x}{F} = \frac{56.382 \text{ lb}}{120 \text{ lb}} \qquad \theta_x = 62.0^\circ \blacktriangleleft$$

$$\cos\theta_y = \frac{F_y}{F} = \frac{-103.923 \text{ lb}}{120 \text{ lb}} \qquad \theta_y = 150.0^\circ \blacktriangleleft$$

$$\cos\theta_z = \frac{F_z}{F} = \frac{-20.52 \text{ lb}}{120 \text{ lb}} \qquad \theta_z = 99.8^\circ \blacktriangleleft$$



PROBLEM 2.78

The end of the coaxial cable *AE* is attached to the pole *AB*, which is strengthened by the guy wires *AC* and *AD*. Knowing that the tension in wire *AD* is 85 lb, determine (*a*) the components of the force exerted by this wire on the pole, (*b*) the angles θ_x, θ_y, and θ_z that the force forms with the coordinate axes.

SOLUTION

(*a*)

$$F_x = (85 \text{ lb})\sin 36° \sin 48°$$

$$= 37.129 \text{ lb} \qquad F_x = 37.1 \text{ lb} \blacktriangleleft$$

$$F_y = -(85 \text{ lb})\cos 36°$$

$$= -68.766 \text{ lb} \qquad F_y = -68.8 \text{ lb} \blacktriangleleft$$

$$F_z = (85 \text{ lb})\sin 36° \cos 48°$$

$$= 33.431 \text{ lb} \qquad F_z = 33.4 \text{ lb} \blacktriangleleft$$

(*b*)

$$\cos\theta_x = \frac{F_x}{F} = \frac{37.129 \text{ lb}}{85 \text{ lb}} \qquad \theta_x = 64.1° \blacktriangleleft$$

$$\cos\theta_y = \frac{F_y}{F} = \frac{-68.766 \text{ lb}}{85 \text{ lb}} \qquad \theta_y = 144.0° \blacktriangleleft$$

$$\cos\theta_z = \frac{F_z}{F} = \frac{33.431 \text{ lb}}{85 \text{ lb}} \qquad \theta_z = 66.8° \blacktriangleleft$$

PROBLEM 2.79

Determine the magnitude and direction of the force **F** = (690 lb)**i** + (300 lb)**j** – (580 lb)**k**.

SOLUTION

$$\mathbf{F} = (690\text{ N})\mathbf{i} + (300\text{ N})\mathbf{j} - (580\text{ N})\mathbf{k}$$

$$F = \sqrt{F_x^2 + F_y^2 + F_z^2}$$

$$= \sqrt{(690\text{ N})^2 + (300\text{ N})^2 + (-580\text{ N})^2}$$

$$= 950\text{ N} \qquad F = 950\text{ N} \blacktriangleleft$$

$$\cos\theta_x = \frac{F_x}{F} = \frac{690\text{ N}}{950\text{ N}} \qquad \theta_x = 43.4° \blacktriangleleft$$

$$\cos\theta_y = \frac{F_y}{F} = \frac{300\text{ N}}{950\text{ N}} \qquad \theta_y = 71.6° \blacktriangleleft$$

$$\cos\theta_z = \frac{F_z}{F} = \frac{-580\text{ N}}{950\text{ N}} \qquad \theta_z = 127.6° \blacktriangleleft$$

PROBLEM 2.80

Determine the magnitude and direction of the force $\mathbf{F} = (650\text{ N})\mathbf{i} - (320\text{ N})\mathbf{j} + (760\text{ N})\mathbf{k}$.

SOLUTION

$$\mathbf{F} = (650\text{ N})\mathbf{i} - (320\text{ N})\mathbf{j} + (760\text{ N})\mathbf{k}$$

$$F = \sqrt{F_x^2 + F_y^2 + F_z^2}$$

$$= \sqrt{(650\text{ N})^2 + (-320\text{ N})^2 + (760\text{ N})^2} \qquad F = 1050\text{ N} \blacktriangleleft$$

$$\cos\theta_x = \frac{F_x}{F} = \frac{650\text{ N}}{1050\text{ N}} \qquad \theta_x = 51.8° \blacktriangleleft$$

$$\cos\theta_y = \frac{F_y}{F} = \frac{-320\text{ N}}{1050\text{ N}} \qquad \theta_y = 107.7° \blacktriangleleft$$

$$\cos\theta_z = \frac{F_z}{F} = \frac{760\text{ N}}{1050\text{ N}} \qquad \theta_z = 43.6° \blacktriangleleft$$

PROBLEM 2.81

A force acts at the origin of a coordinate system in a direction defined by the angles $\theta_x = 75°$ and $\theta_z = 130°$. Knowing that the y component of the force is +300 lb, determine (a) the angle θ_y, (b) the other components and the magnitude of the force.

SOLUTION

$$\cos^2\theta_x + \cos^2\theta_y + \cos^2\theta_z = 1$$

$$\cos^2(75°) + \cos^2\theta_y + \cos^2(130°) = 1$$

$$\cos\theta_y = \pm 0.72100$$

(a) Since $F_y > 0$, we choose $\cos\theta_y = +0.72100$ $\quad\therefore\quad \theta_y = 43.9°$ ◀

(b)

$$F_y = F\cos\theta_y$$

$$300\text{ lb} = F(0.72100)$$

$$F = 416.09\text{ lb}$$ $F = 416\text{ lb}$ ◀

$$F_x = F\cos\theta_x = 416.09\text{ lb}\cos 75°$$ $F_x = +107.7\text{ lb}$ ◀

$$F_z = F\cos\theta_z = 416.09\text{ lb}\cos 130°$$ $F_z = -267\text{ lb}$ ◀

PROBLEM 2.82

A force acts at the origin of a coordinate system in a direction defined by the angles $\theta_y = 55°$ and $\theta_z = 45°$. Knowing that the x component of the force is −500 N, determine (*a*) the angle θ_x, (*b*) the other components and the magnitude of the force.

SOLUTION

$$\cos^2\theta_x + \cos^2\theta_y + \cos^2\theta_z = 1$$

$$\cos^2\theta_x + \cos^2 55° + \cos^2 45° = 1$$

$$\cos\theta_x = \pm 0.41353$$

(*a*) Since $F_y < 0$, we choose $\cos\theta_x = -0.41353$ $\qquad\therefore\ \theta_x = 114.4°$ ◀

(*b*)

$$F_x = F\cos\theta_x$$

$$-500\text{ N} = F(-0.41353)$$

$$F = 1209.10\text{ N}$$ $\qquad F = 1209.1\text{ N}$ ◀

$$F_y = F\cos\theta_y = 1209.10\text{ N}\cos 55°$$ $\qquad F_y = +694\text{ N}$ ◀

$$F_z = F\cos\theta_z = 1209.10\text{ N}\cos 45°$$ $\qquad F_z = +855\text{ N}$ ◀

PROBLEM 2.83

A force **F** of magnitude 230 N acts at the origin of a coordinate system. Knowing that $\theta_x = 32.5°$, $F_y = -60$ N, and $F_z > 0$, determine (*a*) the components F_x and F_z, (*b*) the angles θ_y and θ_z.

SOLUTION

(*a*) We have

$$F_x = F\cos\theta_x = (230\text{ N})\cos 32.5° \qquad F_x = -194.0\text{ N} \blacktriangleleft$$

Then:

$$F_x = 193.980\text{ N}$$

$$F^2 = F_x^2 + F_y^2 + F_z^2$$

So:

$$(230\text{ N})^2 = (193.980\text{ N})^2 + (-60\text{ N})^2 + F_z^2$$

Hence:

$$F_z = +\sqrt{(230\text{ N})^2 - (193.980\text{ N})^2 - (-60\text{ N})^2} \qquad F_z = 108.0\text{ N} \blacktriangleleft$$

(*b*)

$$F_z = 108.036\text{ N}$$

$$\cos\theta_y = \frac{F_y}{F} = \frac{-60\text{ N}}{230\text{ N}} = -0.26087 \qquad \theta_y = 105.1° \blacktriangleleft$$

$$\cos\theta_z = \frac{F_z}{F} = \frac{108.036\text{ N}}{230\text{ N}} = 0.46972 \qquad \theta_z = 62.0° \blacktriangleleft$$

PROBLEM 2.84

A force **F** of magnitude 210 N acts at the origin of a coordinate system. Knowing that $F_x = 80$ N, $\theta_z = 151.2°$, and $F_y < 0$, determine (*a*) the components F_y and F_z, (*b*) the angles θ_x and θ_y.

SOLUTION

(*a*)

$$F_z = F\cos\theta_z = (210 \text{ N})\cos 151.2°$$

$$= -184.024 \text{ N} \qquad F_z = -184.0 \text{ N} \blacktriangleleft$$

Then: $$F^2 = F_x^2 + F_y^2 + F_z^2$$

So: $$(210 \text{ N})^2 = (80 \text{ N})^2 + (F_y)^2 + (184.024 \text{ N})^2$$

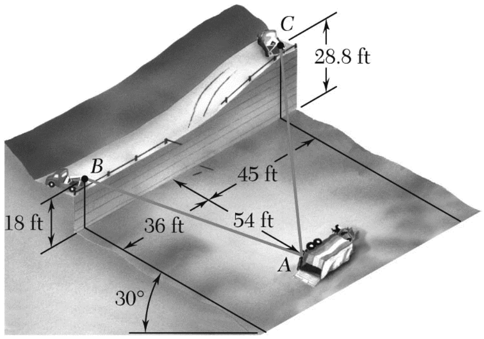
Hence: $$F_y = -\sqrt{(210 \text{ N})^2 - (80 \text{ N})^2 - (184.024 \text{ N})^2}$$

$$= -61.929 \text{ N} \qquad F_y = -62.0 \text{ lb} \blacktriangleleft$$

(*b*)

$$\cos\theta_x = \frac{F_x}{F} = \frac{80 \text{ N}}{210 \text{ N}} = 0.38095 \qquad \theta_x = 67.6° \blacktriangleleft$$

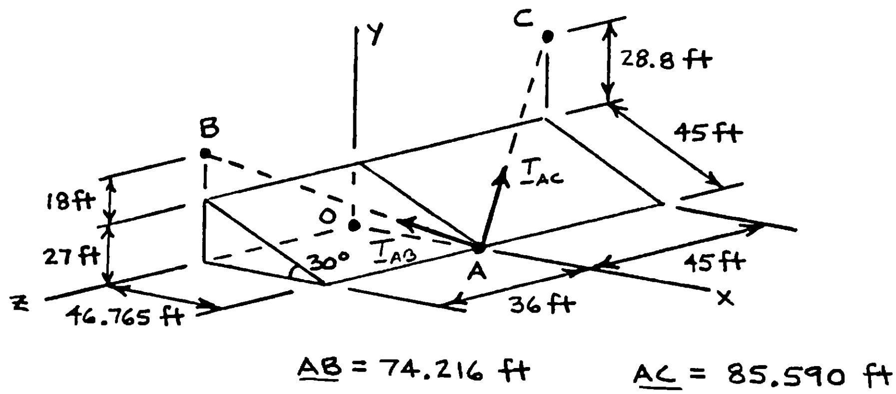
$$\cos\theta_y = \frac{F_y}{F} = \frac{61.929 \text{ N}}{210 \text{ N}} = -0.29490 \qquad \theta_y = 107.2° \blacktriangleleft$$



PROBLEM 2.85

In order to move a wrecked truck, two cables are attached at A and pulled by winches B and C as shown. Knowing that the tension in cable AB is 2 kips, determine the components of the force exerted at A by the cable.

SOLUTION



Cable AB:

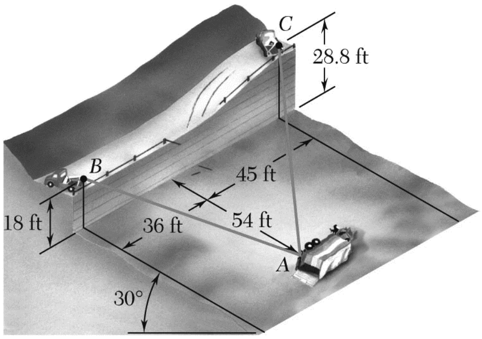
$$\boldsymbol{\lambda}_{AB} = \frac{\overrightarrow{AB}}{AB} = \frac{(-46.765\text{ ft})\mathbf{i} + (45\text{ ft})\mathbf{j} + (36\text{ ft})\mathbf{k}}{74.216\text{ ft}}$$

$$\mathbf{T}_{AB} = T_{AB}\,\boldsymbol{\lambda}_{AB} = \frac{-46.765\mathbf{i} + 45\mathbf{j} + 36\mathbf{k}}{74.216}$$

$(T_{AB})_x = -1.260$ kips ◀

$(T_{AB})_y = +1.213$ kips ◀

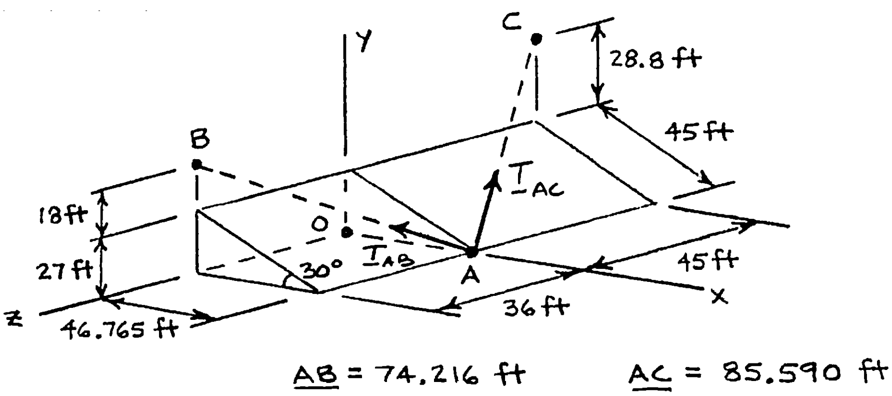
$(T_{AB})_z = +0.970$ kips ◀



PROBLEM 2.86

In order to move a wrecked truck, two cables are attached at A and pulled by winches B and C as shown. Knowing that the tension in cable AC is 1.5 kips, determine the components of the force exerted at A by the cable.

SOLUTION



Cable AB:

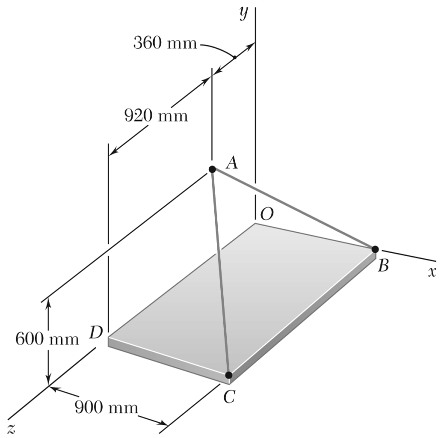
$$\boldsymbol{\lambda}_{AC} = \frac{\overrightarrow{AC}}{AC} = \frac{(-46.765\text{ ft})\mathbf{i} + (55.8\text{ ft})\mathbf{j} + (-45\text{ ft})\mathbf{k}}{85.590\text{ ft}}$$

$$\mathbf{T}_{AC} = T_{AC}\,\boldsymbol{\lambda}_{AC} = (1.5\text{ kips})\frac{-46.765\mathbf{i} + 55.8\mathbf{j} - 45\mathbf{k}}{85.590}$$

$$(T_{AC})_x = -0.820\text{ kips} \blacktriangleleft$$

$$(T_{AC})_y = +0.978\text{ kips} \blacktriangleleft$$

$$(T_{AC})_z = -0.789\text{ kips} \blacktriangleleft$$



PROBLEM 2.87

Knowing that the tension in cable AB is 1425 N, determine the components of the force exerted on the plate at B.

SOLUTION

$$\overrightarrow{BA} = -(900\text{ mm})\mathbf{i} + (600\text{ mm})\mathbf{j} + (360\text{ mm})\mathbf{k}$$

$$BA = \sqrt{(900\text{ mm})^2 + (600\text{ mm})^2 + (360\text{ mm})^2}$$

$$= 1140\text{ mm}$$

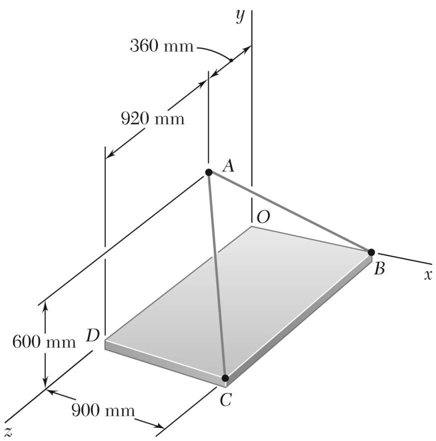
$$\mathbf{T}_{BA} = T_{BA}\boldsymbol{\lambda}_{BA}$$

$$= T_{BA}\frac{\overrightarrow{BA}}{BA}$$

$$\mathbf{T}_{BA} = \frac{1425\text{ N}}{1140\text{ mm}}[-(900\text{ mm})\mathbf{i} + (600\text{ mm})\mathbf{j} + (360\text{ mm})\mathbf{k}]$$

$$= -(1125\text{ N})\mathbf{i} + (750\text{ N})\mathbf{j} + (450\text{ N})\mathbf{k}$$

$$(T_{BA})_x = -1125\text{ N}, \quad (T_{BA})_y = 750\text{ N}, \quad (T_{BA})_z = 450\text{ N} \blacktriangleleft$$



PROBLEM 2.88

Knowing that the tension in cable AC is 2130 N, determine the components of the force exerted on the plate at C.

SOLUTION

$$\overrightarrow{CA} = -(900 \text{ mm})\mathbf{i} + (600 \text{ mm})\mathbf{j} - (920 \text{ mm})\mathbf{k}$$

$$CA = \sqrt{(900 \text{ mm})^2 + (600 \text{ mm})^2 + (920 \text{ mm})^2}$$

$$= 1420 \text{ mm}$$

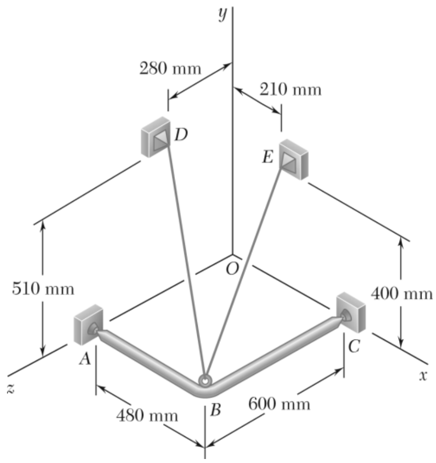
$$\mathbf{T}_{CA} = T_{CA}\boldsymbol{\lambda}_{CA}$$

$$= T_{CA}\frac{\overrightarrow{CA}}{CA}$$

$$\mathbf{T}_{CA} = \frac{2130 \text{ N}}{1420 \text{ mm}}[-(900 \text{ mm})\mathbf{i} + (600 \text{ mm})\mathbf{j} - (920 \text{ mm})\mathbf{k}]$$

$$= -(1350 \text{ N})\mathbf{i} + (900 \text{ N})\mathbf{j} - (1380 \text{ N})\mathbf{k}$$

$$(T_{CA})_x = -1350 \text{ N}, \quad (T_{CA})_y = 900 \text{ N}, \quad (T_{CA})_z = -1380 \text{ N} \blacktriangleleft$$



PROBLEM 2.89

A frame ABC is supported in part by cable DBE that 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

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

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

$$= 770\text{ mm}$$

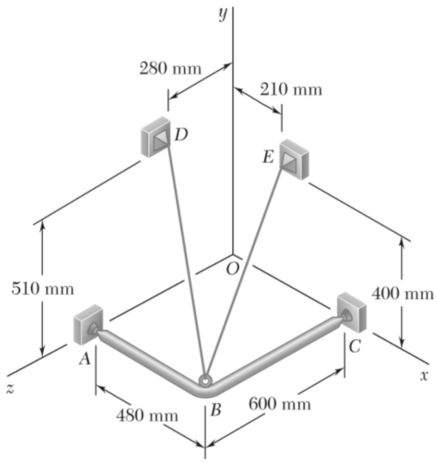
$$\mathbf{F} = F\boldsymbol{\lambda}_{DB}$$

$$= F\frac{\overrightarrow{DB}}{DB}$$

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

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

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



PROBLEM 2.90

For the frame and cable of Problem 2.89, determine the components of the force exerted by the cable on the support at *E*.

PROBLEM 2.89 A frame *ABC* is supported in part by cable *DBE* that 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

$$\overrightarrow{EB} = (270\text{ mm})\mathbf{i} - (400\text{ mm})\mathbf{j} + (600\text{ mm})\mathbf{k}$$

$$EB = \sqrt{(270\text{ mm})^2 + (400\text{ mm})^2 + (600\text{ mm})^2}$$

$$= 770\text{ mm}$$

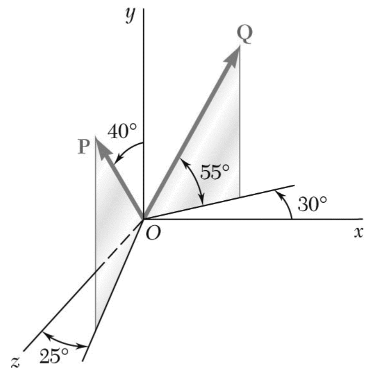
$$\mathbf{F} = F\boldsymbol{\lambda}_{EB}$$

$$= F\frac{\overrightarrow{EB}}{EB}$$

$$= \frac{385\text{ N}}{770\text{ mm}}[(270\text{ mm})\mathbf{i} - (400\text{ mm})\mathbf{j} + (600\text{ mm})\mathbf{k}]$$

$$\mathbf{F} = (135\text{ N})\mathbf{i} - (200\text{ N})\mathbf{j} + (300\text{ N})\mathbf{k}$$

$$F_x = +135.0\text{ N}, \quad F_y = -200\text{ N}, \quad F_z = +300\text{ N} \blacktriangleleft$$



PROBLEM 2.91

Find the magnitude and direction of the resultant of the two forces shown knowing that $P = 600$ N and $Q = 450$ N.

SOLUTION

$$\begin{aligned}
\mathbf{P} &= (600\text{ N})[\sin 40°\sin 25°\mathbf{i} + \cos 40°\mathbf{j} + \sin 40°\cos 25°\mathbf{k}] \\
&= (162.992\text{ N})\mathbf{i} + (459.63\text{ N})\mathbf{j} + (349.54\text{ N})\mathbf{k} \\
\mathbf{Q} &= (450\text{ N})[\cos 55°\cos 30°\mathbf{i} + \sin 55°\mathbf{j} - \cos 55°\sin 30°\mathbf{k}] \\
&= (223.53\text{ N})\mathbf{i} + (368.62\text{ N})\mathbf{j} - (129.055\text{ N})\mathbf{k} \\
\mathbf{R} &= \mathbf{P} + \mathbf{Q} \\
&= (386.52\text{ N})\mathbf{i} + (828.25\text{ N})\mathbf{j} + (220.49\text{ N})\mathbf{k} \\
R &= \sqrt{(386.52\text{ N})^2 + (828.25\text{ N})^2 + (220.49\text{ N})^2} \\
&= 940.22\text{ N}
\end{aligned}$$

$R = 940$ N ◀

$$\cos\theta_x = \frac{R_x}{R} = \frac{386.52\text{ N}}{940.22\text{ N}}$$

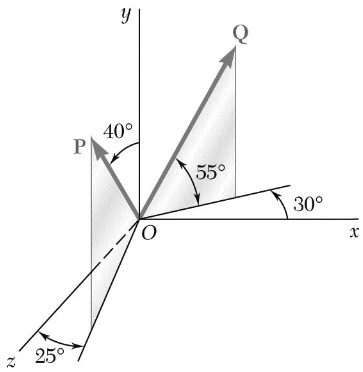
$\theta_x = 65.7°$ ◀

$$\cos\theta_y = \frac{R_y}{R} = \frac{828.25\text{ N}}{940.22\text{ N}}$$

$\theta_y = 28.2°$ ◀

$$\cos\theta_z = \frac{R_z}{R} = \frac{220.49\text{ N}}{940.22\text{ N}}$$

$\theta_z = 76.4°$ ◀



PROBLEM 2.92

Find the magnitude and direction of the resultant of the two forces shown knowing that $P = 450$ N and $Q = 600$ N.

SOLUTION

$$\begin{aligned}
\mathbf{P} &= (450\text{ N})[\sin 40° \sin 25° \mathbf{i} + \cos 40° \mathbf{j} + \sin 40° \cos 25° \mathbf{k}] \\
&= (122.244\text{ N})\mathbf{i} + (344.72\text{ N})\mathbf{j} + (262.154\text{ N})\mathbf{k} \\
\mathbf{Q} &= (600\text{ N})[\cos 55° \cos 30° \mathbf{i} + \sin 55° \mathbf{j} - \cos 55° \sin 30° \mathbf{k}] \\
&= (298.04\text{ N})\mathbf{i} + (491.49\text{ N})\mathbf{j} - (172.073\text{ N})\mathbf{k} \\
\mathbf{R} &= \mathbf{P} + \mathbf{Q} \\
&= (420.28\text{ N})\mathbf{i} + (836.21\text{ N})\mathbf{j} + (90.081\text{ N})\mathbf{k} \\
R &= \sqrt{(420.28\text{ N})^2 + (836.21\text{ N})^2 + (90.081\text{ N})^2} \\
&= 940.21\text{ N}
\end{aligned}$$

$R = 940$ N ◀

$$\cos\theta_x = \frac{R_x}{R} = \frac{420.28}{940.21}$$

$\theta_x = 63.4°$ ◀

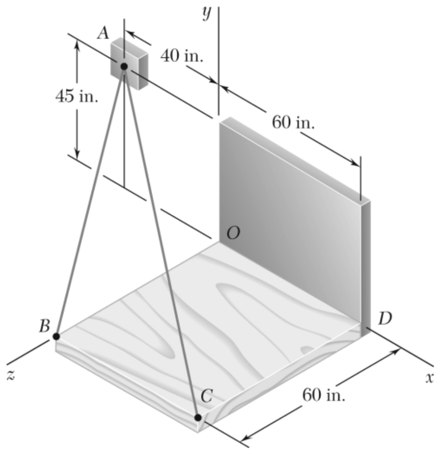
$$\cos\theta_y = \frac{R_y}{R} = \frac{836.21}{940.21}$$

$\theta_y = 27.2°$ ◀

$$\cos\theta_z = \frac{R_z}{R} = \frac{90.081}{940.21}$$

$\theta_z = 84.5°$ ◀

PROBLEM 2.93



Knowing that the tension is 425 lb in cable AB and 510 lb in cable AC, determine the magnitude and direction of the resultant of the forces exerted at A by the two cables.

SOLUTION

$$\overrightarrow{AB} = (40\text{ in.})\mathbf{i} - (45\text{ in.})\mathbf{j} + (60\text{ in.})\mathbf{k}$$

$$AB = \sqrt{(40\text{ in.})^2 + (45\text{ in.})^2 + (60\text{ in.})^2} = 85\text{ in.}$$

$$\overrightarrow{AC} = (100\text{ in.})\mathbf{i} - (45\text{ in.})\mathbf{j} + (60\text{ in.})\mathbf{k}$$

$$AC = \sqrt{(100\text{ in.})^2 + (45\text{ in.})^2 + (60\text{ in.})^2} = 125\text{ in.}$$

$$\mathbf{T}_{AB} = T_{AB}\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = (425\text{ lb})\left[\frac{(40\text{ in.})\mathbf{i} - (45\text{ in.})\mathbf{j} + (60\text{ in.})\mathbf{k}}{85\text{ in.}}\right]$$

$$\mathbf{T}_{AB} = (200\text{ lb})\mathbf{i} - (225\text{ lb})\mathbf{j} + (300\text{ lb})\mathbf{k}$$

$$\mathbf{T}_{AC} = T_{AC}\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = (510\text{ lb})\left[\frac{(100\text{ in.})\mathbf{i} - (45\text{ in.})\mathbf{j} + (60\text{ in.})\mathbf{k}}{125\text{ in.}}\right]$$

$$\mathbf{T}_{AC} = (408\text{ lb})\mathbf{i} - (183.6\text{ lb})\mathbf{j} + (244.8\text{ lb})\mathbf{k}$$

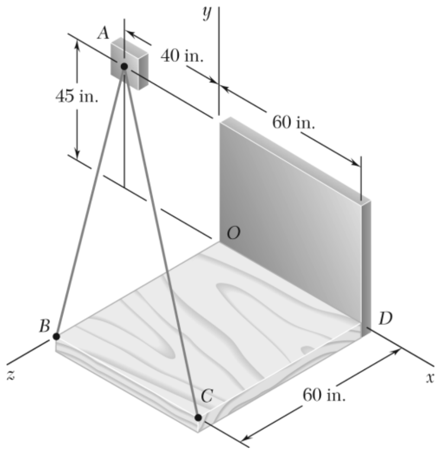
$$\mathbf{R} = \mathbf{T}_{AB} + \mathbf{T}_{AC} = (608)\mathbf{i} - (408.6\text{ lb})\mathbf{j} + (544.8\text{ lb})\mathbf{k}$$

Then: $R = 912.92\text{ lb}$ $\qquad R = 913\text{ lb}$ ◀

and $\cos\theta_x = \dfrac{608\text{ lb}}{912.92\text{ lb}} = 0.66599$ $\qquad \theta_x = 48.2°$ ◀

$\cos\theta_y = \dfrac{408.6\text{ lb}}{912.92\text{ lb}} = -0.44757$ $\qquad \theta_y = 116.6°$ ◀

$\cos\theta_z = \dfrac{544.8\text{ lb}}{912.92\text{ lb}} = 0.59677$ $\qquad \theta_z = 53.4°$ ◀



PROBLEM 2.94

Knowing that the tension is 510 lb in cable AB and 425 lb in cable AC, determine the magnitude and direction of the resultant of the forces exerted at A by the two cables.

SOLUTION

$$\overrightarrow{AB} = (40 \text{ in.})\mathbf{i} - (45 \text{ in.})\mathbf{j} + (60 \text{ in.})\mathbf{k}$$

$$AB = \sqrt{(40 \text{ in.})^2 + (45 \text{ in.})^2 + (60 \text{ in.})^2} = 85 \text{ in.}$$

$$\overrightarrow{AC} = (100 \text{ in.})\mathbf{i} - (45 \text{ in.})\mathbf{j} + (60 \text{ in.})\mathbf{k}$$

$$AC = \sqrt{(100 \text{ in.})^2 + (45 \text{ in.})^2 + (60 \text{ in.})^2} = 125 \text{ in.}$$

$$\mathbf{T}_{AB} = T_{AB}\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = (510 \text{ lb})\left[\frac{(40 \text{ in.})\mathbf{i} - (45 \text{ in.})\mathbf{j} + (60 \text{ in.})\mathbf{k}}{85 \text{ in.}}\right]$$

$$\mathbf{T}_{AB} = (240 \text{ lb})\mathbf{i} - (270 \text{ lb})\mathbf{j} + (360 \text{ lb})\mathbf{k}$$

$$\mathbf{T}_{AC} = T_{AC}\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = (425 \text{ lb})\left[\frac{(100 \text{ in.})\mathbf{i} - (45 \text{ in.})\mathbf{j} + (60 \text{ in.})\mathbf{k}}{125 \text{ in.}}\right]$$

$$\mathbf{T}_{AC} = (340 \text{ lb})\mathbf{i} - (153 \text{ lb})\mathbf{j} + (204 \text{ lb})\mathbf{k}$$

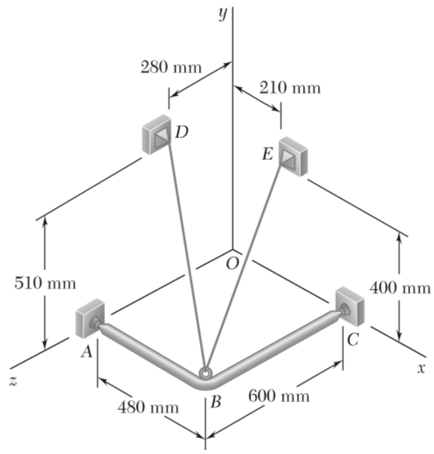
$$\mathbf{R} = \mathbf{T}_{AB} + \mathbf{T}_{AC} = (580 \text{ lb})\mathbf{i} - (423 \text{ lb})\mathbf{j} + (564 \text{ lb})\mathbf{k}$$

Then: $R = 912.92 \text{ lb}$ $\qquad R = 913 \text{ lb}$ ◀

and $\cos\theta_x = \dfrac{580 \text{ lb}}{912.92 \text{ lb}} = 0.63532$ $\qquad \theta_x = 50.6°$ ◀

$$\cos\theta_y = \frac{-423 \text{ lb}}{912.92 \text{ lb}} = -0.46335 \qquad \theta_y = 117.6° \blacktriangleleft$$

$$\cos\theta_z = \frac{564 \text{ lb}}{912.92 \text{ lb}} = 0.61780 \qquad \theta_z = 51.8° \blacktriangleleft$$



PROBLEM 2.95

For the frame of Problem 2.89, 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.

PROBLEM 2.89 A frame *ABC* is supported in part by cable *DBE* that 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

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

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

$$\mathbf{F}_{BD} = T_{BD}\boldsymbol{\lambda}_{BD} = T_{BD}\frac{\overrightarrow{BD}}{BD}$$

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

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

$$\overrightarrow{BE} = -(270\text{ mm})\mathbf{i} + (400\text{ mm})\mathbf{j} - (600\text{ mm})\mathbf{k}$$

$$BE = \sqrt{(270\text{ mm})^2 + (400\text{ mm})^2 + (600\text{ mm})^2} = 770\text{ mm}$$

$$\mathbf{F}_{BE} = T_{BE}\boldsymbol{\lambda}_{BE} = T_{BE}\frac{\overrightarrow{BE}}{BE}$$

$$= \frac{(385\text{ N})}{(770\text{ mm})}[-(270\text{ mm})\mathbf{i} + (400\text{ mm})\mathbf{j} - (600\text{ mm})\mathbf{k}]$$

$$= -(135\text{ N})\mathbf{i} + (200\text{ N})\mathbf{j} - (300\text{ N})\mathbf{k}$$

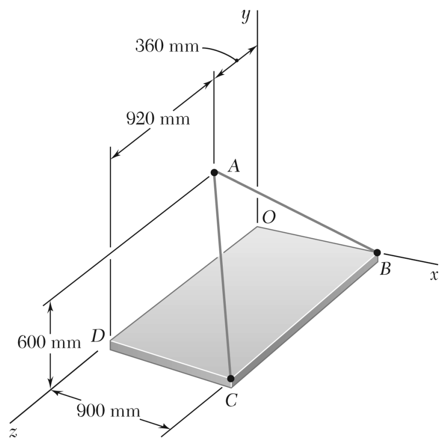
$$\mathbf{R} = \mathbf{F}_{BD} + \mathbf{F}_{BE} = -(375\text{ N})\mathbf{i} + (455\text{ N})\mathbf{j} - (460\text{ N})\mathbf{k}$$

$$R = \sqrt{(375\text{ N})^2 + (455\text{ N})^2 + (460\text{ N})^2} = 747.83\text{ N}$$ $R = 748\text{ N}$ ◀

$$\cos\theta_x = \frac{-375\text{ N}}{747.83\text{ N}}$$ $\theta_x = 120.1°$ ◀

$$\cos\theta_y = \frac{455\text{ N}}{747.83\text{ N}}$$ $\theta_y = 52.5°$ ◀

$$\cos\theta_z = \frac{-460\text{ N}}{747.83\text{ N}}$$ $\theta_z = 128.0°$ ◀



PROBLEM 2.96

For the cables of Problem 2.87, knowing that the tension is 1425 N in cable *AB* and 2130 N in cable *AC*, determine the magnitude and direction of the resultant of the forces exerted at *A* by the two cables.

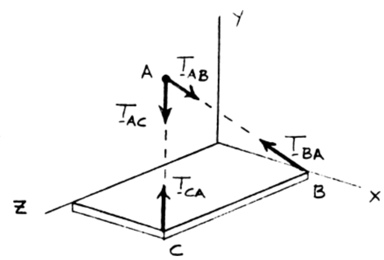
SOLUTION

$$T_{AB} = -T_{BA} \quad \text{(use results of Problem 2.87)}$$

$$(T_{AB})_x = +1125 \text{ N} \quad (T_{AB})_y = -750 \text{ N} \quad (T_{AB})_z = -450 \text{ N}$$

$$T_{AC} = -T_{CA} \quad \text{(use results of Problem 2.88)}$$

$$(T_{AC})_x = +1350 \text{ N} \quad (T_{AC})_y = -900 \text{ N} \quad (T_{AC})_z = +1380 \text{ N}$$



Resultant:

$$R_x = \Sigma F_x = +1125 + 1350 = +2475 \text{ N}$$

$$R_y = \Sigma F_y = -750 - 900 = -1650 \text{ N}$$

$$R_z = \Sigma F_z = -450 + 1380 = +930 \text{ N}$$

$$R = \sqrt{R_x^2 + R_y^2 + R_z^2}$$

$$= \sqrt{(+2475)^2 + (-1650)^2 + (+930)^2}$$

$$= 3116.6 \text{ N}$$

$R = 3120$ N ◀

$$\cos\theta_x = \frac{R_x}{R} = \frac{+2475}{3116.6}$$

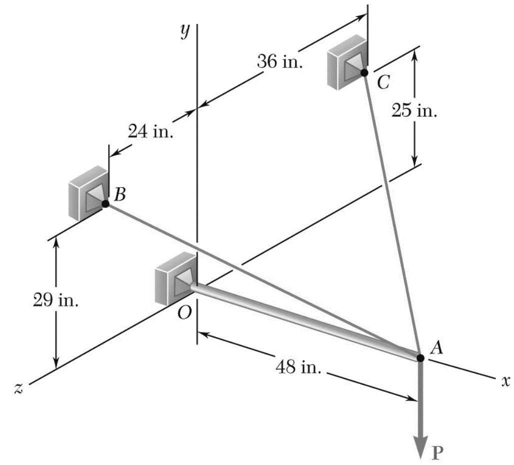
$\theta_x = 37.4°$ ◀

$$\cos\theta_y = \frac{R_y}{R} = \frac{-1650}{3116.6}$$

$\theta_y = 122.0°$ ◀

$$\cos\theta_z = \frac{R_z}{R} = \frac{+930}{3116.6}$$

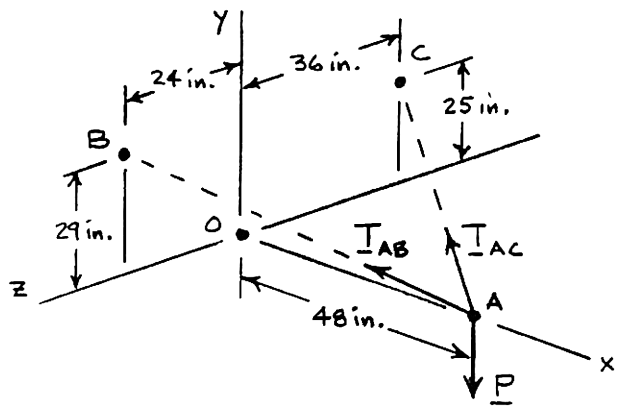
$\theta_z = 72.6°$ ◀



PROBLEM 2.97

The boom OA carries a load $\mathbf{P}$ and is supported by two cables as shown. Knowing that the tension in cable AB is 183 lb and that the resultant of the load $\mathbf{P}$ and of the forces exerted at A by the two cables must be directed along OA, determine the tension in cable AC.

SOLUTION



Cable AB: $T_{AB} = 183 \text{ lb}$

$$\mathbf{T}_{AB} = T_{AB}\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = (183 \text{ lb})\frac{(-48 \text{ in.})\mathbf{i} + (29 \text{ in.})\mathbf{j} + (24 \text{ in.})\mathbf{k}}{61 \text{ in.}}$$

$$\mathbf{T}_{AB} = -(144 \text{ lb})\mathbf{i} + (87 \text{ lb})\mathbf{j} + (72 \text{ lb})\mathbf{k}$$

Cable AC: $$\mathbf{T}_{AC} = T_{AC}\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = T_{AC}\frac{(-48 \text{ in.})\mathbf{i} + (25 \text{ in.})\mathbf{j} + (-36 \text{ in.})\mathbf{k}}{65 \text{ in.}}$$

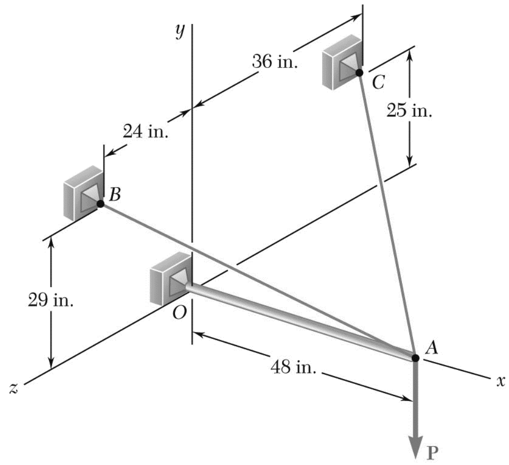
$$\mathbf{T}_{AC} = -\frac{48}{65}T_{AC}\mathbf{i} + \frac{25}{65}T_{AC}\mathbf{j} - \frac{36}{65}T_{AC}\mathbf{k}$$

Load P: $\mathbf{P} = P\mathbf{j}$

For resultant to be directed along OA, i.e., x-axis

$$R_z = 0: \quad \Sigma F_z = (72 \text{ lb}) - \frac{36}{65}T'_{AC} = 0$$

$T_{AC} = 130.0 \text{ lb}$ ◀



PROBLEM 2.98

For the boom and loading of Problem. 2.97, determine the magnitude of the load **P**.

PROBLEM 2.97 The boom *OA* carries a load **P** and is supported by two cables as shown. Knowing that the tension in cable *AB* is 183 lb and that the resultant of the load **P** and of the forces exerted at *A* by the two cables must be directed along *OA*, determine the tension in cable *AC*.

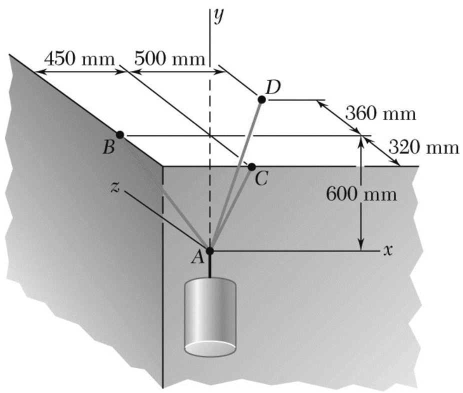
SOLUTION

See Problem 2.97. Since resultant must be directed along *OA*, i.e., the *x*-axis, we write

$$R_y = 0: \quad \Sigma F_y = (87\text{ lb}) + \frac{25}{65}T_{AC} - P = 0$$

$T_{AC} = 130.0\text{ lb}$ from Problem 2.97.

Then $$(87\text{ lb}) + \frac{25}{65}(130.0\text{ lb}) - P = 0$$ $P = 137.0\text{ lb}$ ◀

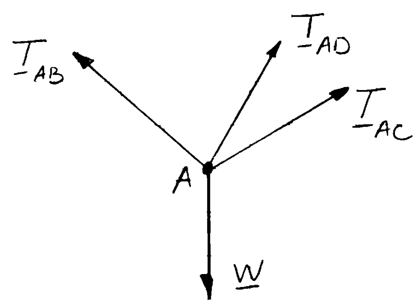


PROBLEM 2.99

A container is supported by three cables that are attached to a ceiling as shown. Determine the weight W of the container, knowing that the tension in cable AB is 6 kN.

SOLUTION

Free-Body Diagram at A:



The forces applied at A are: $\mathbf{T}_{AB}, \mathbf{T}_{AC}, \mathbf{T}_{AD},$ and $\mathbf{W}$

where $\mathbf{W} = W\mathbf{j}$. To express the other forces in terms of the unit vectors **i**, **j**, **k**, we write

$$\overrightarrow{AB} = -(450 \text{ mm})\mathbf{i} + (600 \text{ mm})\mathbf{j} \qquad AB = 750 \text{ mm}$$

$$\overrightarrow{AC} = +(600 \text{ mm})\mathbf{j} - (320 \text{ mm})\mathbf{k} \qquad AC = 680 \text{ mm}$$

$$\overrightarrow{AD} = +(500 \text{ mm})\mathbf{i} + (600 \text{ mm})\mathbf{j} + (360 \text{ mm})\mathbf{k} \qquad AD = 860 \text{ mm}$$

and

$$\mathbf{T}_{AB} = \boldsymbol{\lambda}_{AB} T_{AB} = T_{AB} \frac{\overrightarrow{AB}}{AB} = T_{AB} \frac{(-450 \text{ mm})\mathbf{i} + (600 \text{ mm})\mathbf{j}}{750 \text{ mm}}$$

$$= \left(-\frac{45}{75}\mathbf{i} + \frac{60}{75}\mathbf{j}\right) T_{AB}$$

$$\mathbf{T}_{AC} = \boldsymbol{\lambda}_{AC} T_{AC} = T_{AC} \frac{\overrightarrow{AC}}{AC} = T_{AC} \frac{(600 \text{ mm})\mathbf{i} - (320 \text{ mm})\mathbf{j}}{680 \text{ mm}}$$

$$= \left(\frac{60}{68}\mathbf{j} - \frac{32}{68}\mathbf{k}\right) T_{AC}$$

$$\mathbf{T}_{AD} = \boldsymbol{\lambda}_{AD} T_{AD} = T_{AD} \frac{\overrightarrow{AD}}{AD} = T_{AD} \frac{(500 \text{ mm})\mathbf{i} + (600 \text{ mm})\mathbf{j} + (360 \text{ mm})\mathbf{k}}{860 \text{ mm}}$$

$$= \left(\frac{50}{86}\mathbf{i} + \frac{60}{86}\mathbf{j} + \frac{36}{86}\mathbf{k}\right) T_{AD}$$

PROBLEM 2.99 (Continued)

Equilibrium condition: $\Sigma F = 0$: $\therefore$ $\mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{T}_{AD} + \mathbf{W} = 0$

Substituting the expressions obtained for $\mathbf{T}_{AB}, \mathbf{T}_{AC}$, and $\mathbf{T}_{AD}$; factoring **i**, **j**, and **k**; and equating each of the coefficients to zero gives the following equations:

From **i**: $$-\frac{45}{75}T_{AB} + \frac{50}{86}T_{AD} = 0 \qquad (1)$$

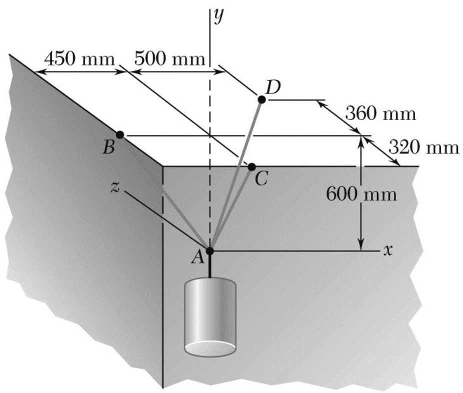
From **j**: $$\frac{60}{75}T_{AB} + \frac{60}{68}T_{AC} + \frac{60}{86}T_{AD} - W = 0 \qquad (2)$$

From **k**: $$-\frac{32}{68}T_{AC} + \frac{36}{86}T_{AD} = 0 \qquad (3)$$

Setting $T_{AB} = 6\text{ kN}$ in (1) and (2), and solving the resulting set of equations gives

$$T_{AC} = 6.1920\text{ kN}$$
$$T_{AC} = 5.5080\text{ kN}$$

$W = 13.98\text{ kN}$ ◀



PROBLEM 2.100

A container is supported by three cables that are attached to a ceiling as shown. Determine the weight W of the container, knowing that the tension in cable AD is 4.3 kN.

SOLUTION

See Problem 2.99 for the figure and analysis leading to the following set of linear algebraic equations:

$$-\frac{45}{75}T_{AB}+\frac{50}{86}T_{AD}=0 \qquad (1)$$

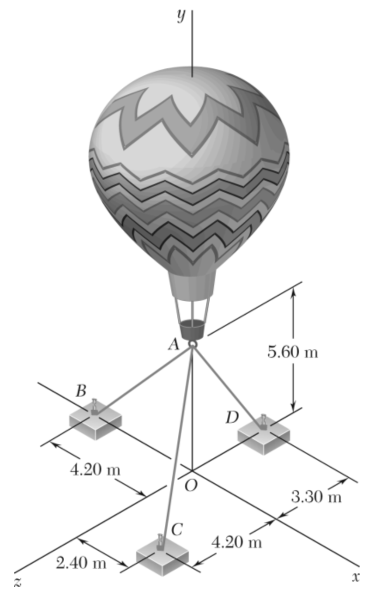
$$\frac{60}{75}T_{AB}+\frac{60}{68}T_{AC}+\frac{60}{86}T_{AD}-W=0 \qquad (2)$$

$$-\frac{32}{68}T_{AC}+\frac{36}{86}T_{AD}=0 \qquad (3)$$

Setting $T_{AD}=4.3\text{ kN}$ into the above equations gives

$$T_{AB}=4.1667\text{ kN}$$
$$T_{AC}=3.8250\text{ kN}$$

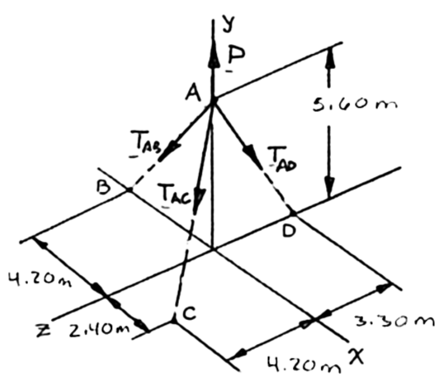
$W=9.71\text{ kN}$ ◀



PROBLEM 2.101

Three cables are used to tether a balloon as shown. Determine the vertical force **P** exerted by the balloon at A knowing that the tension in cable AD is 481 N.

SOLUTION



The forces applied at A are: $\mathbf{T}_{AB}, \mathbf{T}_{AC}, \mathbf{T}_{AD}$, and $\mathbf{P}$

where $\mathbf{P} = P\mathbf{j}$. To express the other forces in terms of the unit vectors **i**, **j**, **k**, we write

$$\overrightarrow{AB} = -(4.20\text{ m})\mathbf{i} - (5.60\text{ m})\mathbf{j} \qquad AB = 7.00\text{ m}$$
$$\overrightarrow{AC} = (2.40\text{ m})\mathbf{i} - (5.60\text{ m})\mathbf{j} + (4.20\text{ m})\mathbf{k} \qquad AC = 7.40\text{ m}$$
$$\overrightarrow{AD} = -(5.60\text{ m})\mathbf{j} - (3.30\text{ m})\mathbf{k} \qquad AD = 6.50\text{ m}$$

and

$$\mathbf{T}_{AB} = T_{AB}\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = (-0.6\mathbf{i} - 0.8\mathbf{j})T_{AB}$$
$$\mathbf{T}_{AC} = T_{AC}\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = (0.32432\mathbf{i} - 0.75676\mathbf{j} + 0.56757\mathbf{k})T_{AC}$$
$$\mathbf{T}_{AD} = T_{AD}\boldsymbol{\lambda}_{AD} = T_{AD}\frac{\overrightarrow{AD}}{AD} = (-0.86154\mathbf{j} - 0.50769\mathbf{k})T_{AD}$$

PROBLEM 2.101 (Continued)

Equilibrium condition: $\Sigma F = 0$: $\mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{T}_{AD} + P\mathbf{j} = 0$

Substituting the expressions obtained for $\mathbf{T}_{AB}$, $\mathbf{T}_{AC}$, and $\mathbf{T}_{AD}$ and factoring **i**, **j**, and **k**:

$$(-0.6T_{AB} + 0.32432T_{AC})\mathbf{i} + (-0.8T_{AB} - 0.75676T_{AC} - 0.86154T_{AD} + P)\mathbf{j}$$
$$+ (0.56757T_{AC} - 0.50769T_{AD})\mathbf{k} = 0$$

Equating to zero the coefficients of **i**, **j**, **k**:

$$-0.6T_{AB} + 0.32432T_{AC} = 0 \quad (1)$$

$$-0.8T_{AB} - 0.75676T_{AC} - 0.86154T_{AD} + P = 0 \quad (2)$$

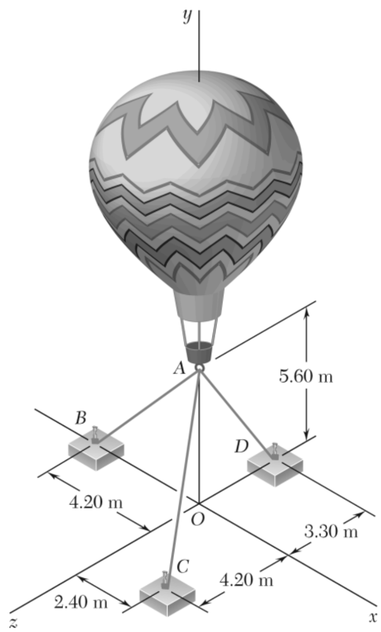
$$0.56757T_{AC} - 0.50769T_{AD} = 0 \quad (3)$$

Setting $T_{AD} = 481$ N in (2) and (3), and solving the resulting set of equations gives

$$T_{AC} = 430.26 \text{ N}$$
$$T_{AD} = 232.57 \text{ N}$$

$\mathbf{P} = 926 \text{ N} \uparrow$ ◀

PROBLEM 2.102



Three cables are used to tether a balloon as shown. Knowing that the balloon exerts an 800-N vertical force at A, determine the tension in each cable.

SOLUTION

See Problem 2.101 for the figure and analysis leading to the linear algebraic Equations (1), (2), and (3).

$$-0.6T_{AB} + 0.32432T_{AC} = 0 \quad (1)$$

$$-0.8T_{AB} - 0.75676T_{AC} - 0.86154T_{AD} + P = 0 \quad (2)$$

$$0.56757T_{AC} - 0.50769T_{AD} = 0 \quad (3)$$

From Eq. (1): $T_{AB} = 0.54053T_{AC}$

From Eq. (3): $T_{AD} = 1.11795T_{AC}$

Substituting for T_{AB} and T_{AD} in terms of T_{AC} into Eq. (2) gives

$$-0.8(0.54053T_{AC}) - 0.75676T_{AC} - 0.86154(1.11795T_{AC}) + P = 0$$

$$2.1523T_{AC} = P; \quad P = 800 \text{ N}$$

$$T_{AC} = \frac{800 \text{ N}}{2.1523}$$

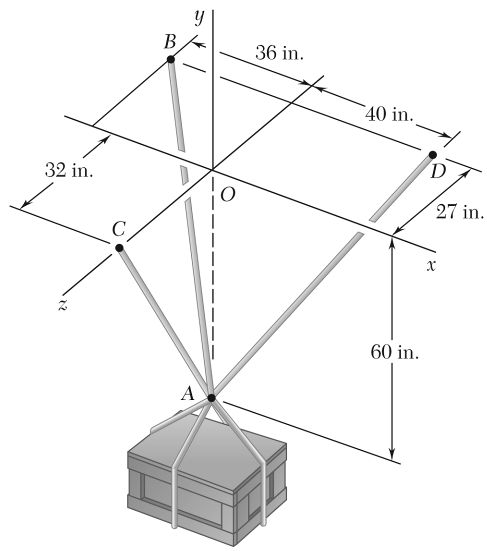
$$= 371.69 \text{ N}$$

Substituting into expressions for T_{AB} and T_{AD} gives

$$T_{AB} = 0.54053(371.69 \text{ N})$$

$$T_{AD} = 1.11795(371.69 \text{ N})$$

$$T_{AB} = 201 \text{ N}, \quad T_{AC} = 372 \text{ N}, \quad T_{AD} = 416 \text{ N} \blacktriangleleft$$



PROBLEM 2.103

A crate is supported by three cables as shown. Determine the weight of the crate knowing that the tension in cable AB is 750 lb.

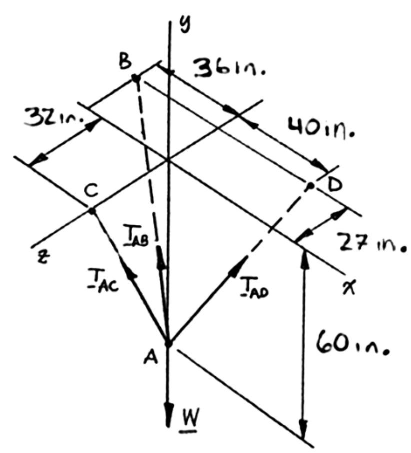
SOLUTION

The forces applied at A are:

$$\mathbf{T}_{AB}, \mathbf{T}_{AC}, \mathbf{T}_{AD} \text{ and } \mathbf{W}$$

where $\mathbf{P} = P\mathbf{j}$. To express the other forces in terms of the unit vectors $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$, we write

$$\overrightarrow{AB} = -(36 \text{ in.})\mathbf{i} + (60 \text{ in.})\mathbf{j} - (27 \text{ in.})\mathbf{k}$$
$$AB = 75 \text{ in.}$$
$$\overrightarrow{AC} = (60 \text{ in.})\mathbf{j} + (32 \text{ in.})\mathbf{k}$$
$$AC = 68 \text{ in.}$$
$$\overrightarrow{AD} = (40 \text{ in.})\mathbf{i} + (60 \text{ in.})\mathbf{j} - (27 \text{ in.})\mathbf{k}$$
$$AD = 77 \text{ in.}$$



and

$$\mathbf{T}_{AB} = T_{AB}\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB}$$
$$= (-0.48\mathbf{i} + 0.8\mathbf{j} - 0.36\mathbf{k})T_{AB}$$
$$\mathbf{T}_{AC} = T_{AC}\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC}$$
$$= (0.88235\mathbf{j} + 0.47059\mathbf{k})T_{AC}$$
$$\mathbf{T}_{AD} = T_{AD}\boldsymbol{\lambda}_{AD} = T_{AD}\frac{\overrightarrow{AD}}{AD}$$
$$= (0.51948\mathbf{i} + 0.77922\mathbf{j} - 0.35065\mathbf{k})T_{AD}$$

Equilibrium Condition with $\mathbf{W} = -W\mathbf{j}$

$$\Sigma F = 0: \quad \mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{T}_{AD} - W\mathbf{j} = 0$$

Substituting the expressions obtained for $\mathbf{T}_{AB}$, $\mathbf{T}_{AC}$, and $\mathbf{T}_{AD}$ and factoring **i**, **j**, and **k**:

$$(-0.48T_{AB} + 0.51948T_{AD})\mathbf{i} + (0.8T_{AB} + 0.88235T_{AC} + 0.77922T_{AD} - W)\mathbf{j}$$
$$+(-0.36T_{AB} + 0.47059T_{AC} - 0.35065T_{AD})\mathbf{k} = 0$$

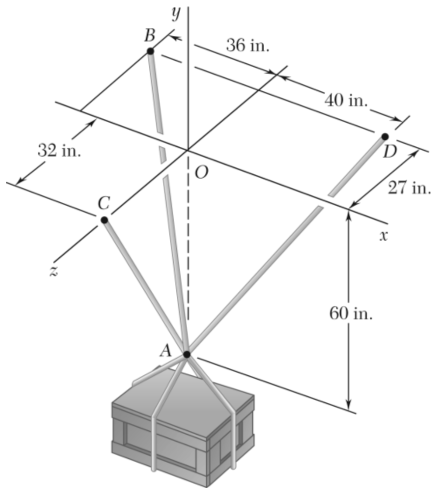
Equating to zero the coefficients of **i**, **j**, **k**:

$$-0.48T_{AB} + 0.51948T_{AD} = 0$$
$$0.8T_{AB} + 0.88235T_{AC} + 0.77922T_{AD} - W = 0$$
$$-0.36T_{AB} + 0.47059T_{AC} - 0.35065T_{AD} = 0$$

Substituting $T_{AB} = 750$ lb in Equations (1), (2), and (3) and solving the resulting set of equations, using conventional algorithms for solving linear algebraic equations, gives:

$$T_{AC} = 1090.1 \text{ lb}$$
$$T_{AD} = 693 \text{ lb}$$

$W = 2100$ lb ◀



PROBLEM 2.104

A crate is supported by three cables as shown. Determine the weight of the crate knowing that the tension in cable *AD* is 616 lb.

SOLUTION

See Problem 2.103 for the figure and the analysis leading to the linear algebraic Equations (1), (2), and (3) below:

$$-0.48T_{AB} + 0.51948T_{AD} = 0 \tag{1}$$

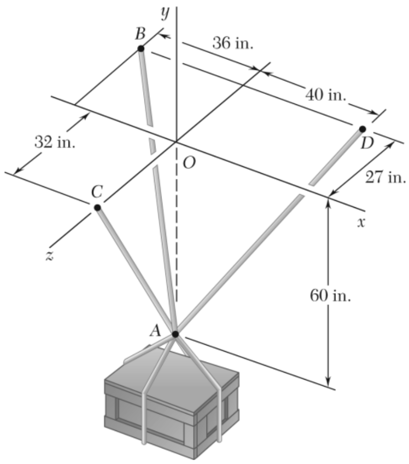
$$0.8T_{AB} + 0.88235T_{AC} + 0.77922T_{AD} - W = 0 \tag{2}$$

$$-0.36T_{AB} + 0.47059T_{AC} - 0.35065T_{AD} = 0 \tag{3}$$

Substituting $T_{AD} = 616 \text{ lb}$ in Equations (1), (2), and (3) above, and solving the resulting set of equations using conventional algorithms, gives:

$$T_{AB} = 667.67 \text{ lb}$$
$$T_{AC} = 969.00 \text{ lb}$$

$W = 1868 \text{ lb}$ ◀



PROBLEM 2.105

A crate is supported by three cables as shown. Determine the weight of the crate knowing that the tension in cable AC is 544 lb.

SOLUTION

See Problem 2.103 for the figure and the analysis leading to the linear algebraic Equations (1), (2), and (3) below:

$$-0.48T_{AB} + 0.51948T_{AD} = 0 \quad (1)$$

$$0.8T_{AB} + 0.88235T_{AC} + 0.77922T_{AD} - W = 0 \quad (2)$$

$$-0.36T_{AB} + 0.47059T_{AC} - 0.35065T_{AD} = 0 \quad (3)$$

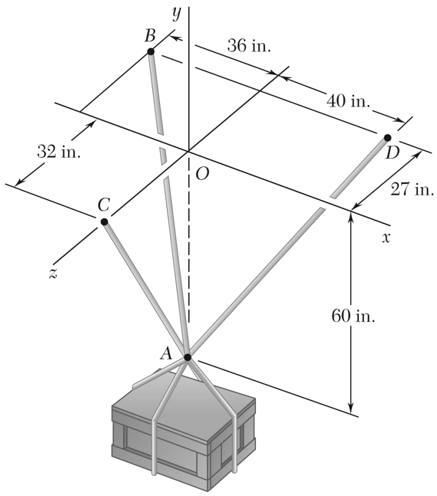
Substituting $T_{AC} = 544 \text{ lb}$ in Equations (1), (2), and (3) above, and solving the resulting set of equations using conventional algorithms, gives:

$$T_{AB} = 374.27 \text{ lb}$$

$$T_{AD} = 345.82 \text{ lb}$$

$W = 1049 \text{ lb}$ ◀

PROBLEM 2.106



A 1600-lb crate is supported by three cables as shown. Determine the tension in each cable.

SOLUTION

See Problem 2.103 for the figure and the analysis leading to the linear algebraic Equations (1), (2), and (3) below:

$$-0.48T_{AB} + 0.51948T_{AD} = 0 \tag{1}$$

$$0.8T_{AB} + 0.88235T_{AC} + 0.77922T_{AD} - W = 0 \tag{2}$$

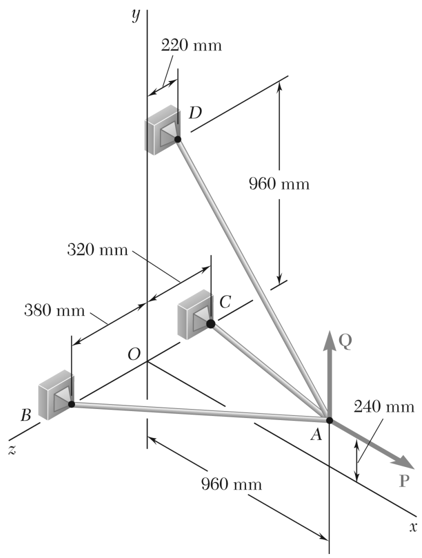
$$-0.36T_{AB} + 0.47059T_{AC} - 0.35065T_{AD} = 0 \tag{3}$$

Substituting $W = 1600$ lb in Equations (1), (2), and (3) above, and solving the resulting set of equations using conventional algorithms, gives

$T_{AB} = 571$ lb ◀

$T_{AC} = 830$ lb ◀

$T_{AD} = 528$ lb ◀



PROBLEM 2.107

Three cables are connected at A, where the forces **P** and **Q** are applied as shown. Knowing that $Q = 0$, find the value of P for which the tension in cable AD is 305 N.

SOLUTION

$$\Sigma \mathbf{F}_A = 0: \quad \mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{T}_{AD} + \mathbf{P} = 0 \quad \text{where} \quad \mathbf{P} = P\mathbf{i}$$

$$\overrightarrow{AB} = -(960 \text{ mm})\mathbf{i} - (240 \text{ mm})\mathbf{j} + (380 \text{ mm})\mathbf{k} \qquad AB = 1060 \text{ mm}$$

$$\overrightarrow{AC} = -(960 \text{ mm})\mathbf{i} - (240 \text{ mm})\mathbf{j} - (320 \text{ mm})\mathbf{k} \qquad AC = 1040 \text{ mm}$$

$$\overrightarrow{AD} = -(960 \text{ mm})\mathbf{i} + (720 \text{ mm})\mathbf{j} - (220 \text{ mm})\mathbf{k} \qquad AD = 1220 \text{ mm}$$

$$\mathbf{T}_{AB} = T_{AB}\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = T_{AB}\left(-\frac{48}{53}\mathbf{i} - \frac{12}{53}\mathbf{j} + \frac{19}{53}\mathbf{k}\right)$$

$$\mathbf{T}_{AC} = T_{AC}\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = T_{AC}\left(-\frac{12}{13}\mathbf{i} - \frac{3}{13}\mathbf{j} - \frac{4}{13}\mathbf{k}\right)$$

$$\mathbf{T}_{AD} = T_{AD}\boldsymbol{\lambda}_{AD} = \frac{305 \text{ N}}{1220 \text{ mm}}[(-960 \text{ mm})\mathbf{i} + (720 \text{ mm})\mathbf{j} - (220 \text{ mm})\mathbf{k}]$$

$$= -(240 \text{ N})\mathbf{i} + (180 \text{ N})\mathbf{j} - (55 \text{ N})\mathbf{k}$$

Substituting into $\Sigma \mathbf{F}_A = 0$, factoring $\mathbf{i}, \mathbf{j}, \mathbf{k}$, and setting each coefficient equal to ϕ gives:

$$\mathbf{i}: \quad P = \frac{48}{53}T_{AB} + \frac{12}{13}T_{AC} + 240 \text{ N} \qquad (1)$$

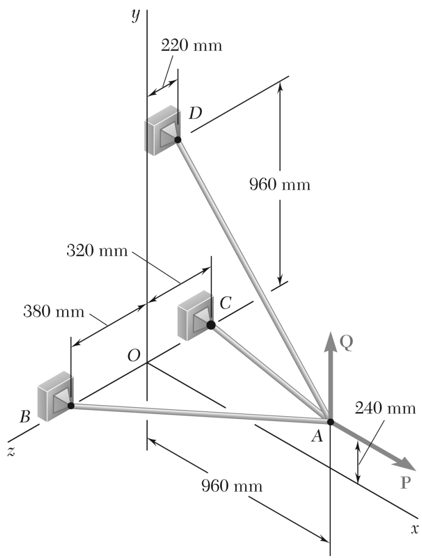
$$\mathbf{j}: \quad \frac{12}{53}T_{AB} + \frac{3}{13}T_{AC} = 180 \text{ N} \qquad (2)$$

$$\mathbf{k}: \quad \frac{19}{53}T_{AB} - \frac{4}{13}T_{AC} = 55 \text{ N} \qquad (3)$$

Solving the system of linear equations using conventional algorithms gives:

$$T_{AB} = 446.71 \text{ N}$$
$$T_{AC} = 341.71 \text{ N}$$

$P = 960 \text{ N}$ ◀



PROBLEM 2.108

Three cables are connected at A, where the forces **P** and **Q** are applied as shown. Knowing that $P = 1200$ N, determine the values of Q for which cable AD is taut.

SOLUTION

We assume that $T_{AD} = 0$ and write $\qquad \Sigma\mathbf{F}_A = 0\colon \quad \mathbf{T}_{AB} + \mathbf{T}_{AC} + Q\mathbf{j} + (1200\text{ N})\mathbf{i} = 0$

$$\overrightarrow{AB} = -(960\text{ mm})\mathbf{i} - (240\text{ mm})\mathbf{j} + (380\text{ mm})\mathbf{k} \quad AB = 1060\text{ mm}$$

$$\overrightarrow{AC} = -(960\text{ mm})\mathbf{i} - (240\text{ mm})\mathbf{j} - (320\text{ mm})\mathbf{k} \quad AC = 1040\text{ mm}$$

$$\mathbf{T}_{AB} = T_{AB}\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = \left(-\frac{48}{53}\mathbf{i} - \frac{12}{53}\mathbf{j} + \frac{19}{53}\mathbf{k}\right)T_{AB}$$

$$\mathbf{T}_{AC} = T_{AC}\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = \left(-\frac{12}{13}\mathbf{i} - \frac{3}{13}\mathbf{j} - \frac{4}{13}\mathbf{k}\right)T_{AC}$$

Substituting into $\Sigma\mathbf{F}_A = 0$, factoring $\mathbf{i}, \mathbf{j}, \mathbf{k}$, and setting each coefficient equal to ϕ gives:

$$\mathbf{i}\colon \quad -\frac{48}{53}T_{AB} - \frac{12}{13}T_{AC} + 1200\text{ N} = 0 \tag{1}$$

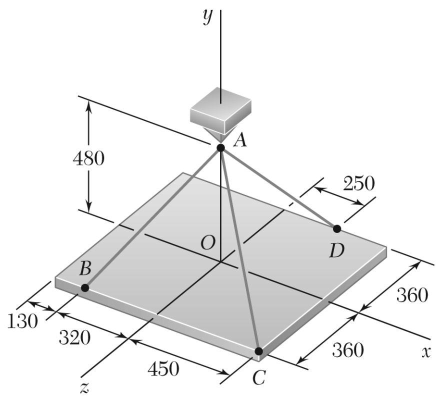
$$\mathbf{j}\colon \quad -\frac{12}{53}T_{AB} - \frac{3}{13}T_{AC} + Q = 0 \tag{2}$$

$$\mathbf{k}\colon \quad \frac{19}{53}T_{AB} - \frac{4}{13}T_{AC} = 0 \tag{3}$$

Solving the resulting system of linear equations using conventional algorithms gives:

$$T_{AB} = 605.71\text{ N}$$
$$T_{AC} = 705.71\text{ N}$$
$$Q = 300.00\text{ N} \qquad\qquad 0 \le Q < 300\text{ N} \blacktriangleleft$$

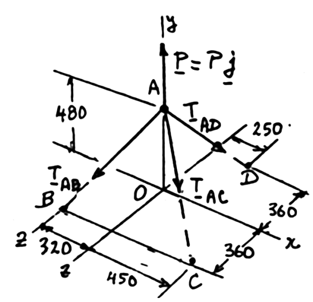
Note: This solution assumes that Q is directed upward as shown $(Q \ge 0)$, if negative values of Q are considered, cable AD remains taut, but AC becomes slack for $Q = -460$ N.

 Dimensions in mm	**PROBLEM 2.109** A rectangular plate is supported by three cables as shown. Knowing that the tension in cable AC is 60 N, determine the weight of the plate.

SOLUTION

We note that the weight of the plate is equal in magnitude to the force **P** exerted by the support on Point A.

Free Body A:



Dimensions in mm

$$\Sigma F = 0: \quad \mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{T}_{AD} + P\mathbf{j} = 0$$

We have:

$$\overrightarrow{AB} = -(320 \text{ mm})\mathbf{i} - (480 \text{ mm})\mathbf{j} + (360 \text{ mm})\mathbf{k} \qquad AB = 680 \text{ mm}$$

$$\overrightarrow{AC} = (450 \text{ mm})\mathbf{i} - (480 \text{ mm})\mathbf{j} + (360 \text{ mm})\mathbf{k} \qquad AC = 750 \text{ mm}$$

$$\overrightarrow{AD} = (250 \text{ mm})\mathbf{i} - (480 \text{ mm})\mathbf{j} - (360 \text{ mm})\mathbf{k} \qquad AD = 650 \text{ mm}$$

Thus:

$$\mathbf{T}_{AB} = T_{AB}\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = \left(-\frac{8}{17}\mathbf{i} - \frac{12}{17}\mathbf{j} + \frac{9}{17}\mathbf{k}\right)T_{AB}$$

$$\mathbf{T}_{AC} = T_{AC}\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = (0.6\mathbf{i} - 0.64\mathbf{j} + 0.48\mathbf{k})T_{AC}$$

$$\mathbf{T}_{AD} = T_{AD}\boldsymbol{\lambda}_{AD} = T_{AD}\frac{\overrightarrow{AD}}{AD} = \left(\frac{5}{13}\mathbf{i} - \frac{9.6}{13}\mathbf{j} - \frac{7.2}{13}\mathbf{k}\right)T_{AD}$$

Substituting into the Eq. $\Sigma F = 0$ and factoring $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$:

$$\left(-\frac{8}{17}T_{AB} + 0.6T_{AC} + \frac{5}{13}T_{AD}\right)\mathbf{i}$$

$$+\left(-\frac{12}{17}T_{AB} - 0.64T_{AC} - \frac{9.6}{13}T_{AD} + P\right)\mathbf{j}$$

$$+\left(\frac{9}{17}T_{AB} + 0.48T_{AC} - \frac{7.2}{13}T_{AD}\right)\mathbf{k} = 0$$

PROBLEM 2.109 (Continued)

Setting the coefficient of **i**, **j**, **k** equal to zero:

$$\mathbf{i}: \quad -\frac{8}{17}T_{AB} + 0.6T_{AC} + \frac{5}{13}T_{AD} = 0 \tag{1}$$

$$\mathbf{j}: \quad -\frac{12}{7}T_{AB} - 0.64T_{AC} - \frac{9.6}{13}T_{AD} + P = 0 \tag{2}$$

$$\mathbf{k}: \quad \frac{9}{17}T_{AB} + 0.48T_{AC} - \frac{7.2}{13}T_{AD} = 0 \tag{3}$$

Making $T_{AC} = 60$ N in (1) and (3):

$$-\frac{8}{17}T_{AB} + 36\text{ N} + \frac{5}{13}T_{AD} = 0 \tag{1′}$$

$$\frac{9}{17}T_{AB} + 28.8\text{ N} - \frac{7.2}{13}T_{AD} = 0 \tag{3′}$$

Multiply (1′) by 9, (3′) by 8, and add:

$$554.4\text{ N} - \frac{12.6}{13}T_{AD} = 0 \quad T_{AD} = 572.0\text{ N}$$

Substitute into (1′) and solve for T_{AB}:

$$T_{AB} = \frac{17}{8}\left(36 + \frac{5}{13}\times 572\right) \qquad T_{AB} = 544.0\text{ N}$$

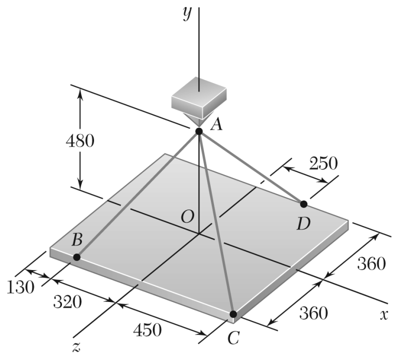
Substitute for the tensions in Eq. (2) and solve for P:

$$P = \frac{12}{17}(544\text{ N}) + 0.64(60\text{ N}) + \frac{9.6}{13}(572\text{ N})$$

$$= 844.8\text{ N}$$

Weight of plate $= P = 845$ N ◀

PROBLEM 2.110



Dimensions in mm

A rectangular plate is supported by three cables as shown. Knowing that the tension in cable AD is 520 N, determine the weight of the plate.

SOLUTION

See Problem 2.109 for the figure and the analysis leading to the linear algebraic Equations (1), (2), and (3) below:

$$-\frac{8}{17}T_{AB}+0.6T_{AC}+\frac{5}{13}T_{AD}=0 \tag{1}$$

$$-\frac{12}{17}T_{AB}+0.64T_{AC}-\frac{9.6}{13}T_{AD}+P=0 \tag{2}$$

$$\frac{9}{17}T_{AB}+0.48T_{AC}-\frac{7.2}{13}T_{AD}=0 \tag{3}$$

Making $T_{AD}=520\text{ N}$ in Eqs. (1) and (3):

$$-\frac{8}{17}T_{AB}+0.6T_{AC}+200\text{ N}=0 \tag{1′}$$

$$\frac{9}{17}T_{AB}+0.48T_{AC}-288\text{ N}=0 \tag{3′}$$

Multiply (1′) by 9, (3′) by 8, and add:

$$9.24T_{AC}-504\text{ N}=0 \quad T_{AC}=54.5455\text{ N}$$

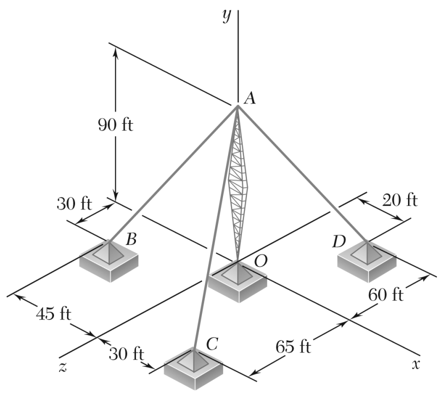
Substitute into (1′) and solve for T_{AB}:

$$T_{AB}=\frac{17}{8}(0.6\times 54.5455+200) \quad T_{AB}=494.545\text{ N}$$

Substitute for the tensions in Eq. (2) and solve for P:

$$P=\frac{12}{17}(494.545\text{ N})+0.64(54.5455\text{ N})+\frac{9.6}{13}(520\text{ N})$$
$$=768.00\text{ N}$$

Weight of plate $=P=768\text{ N}$ ◀

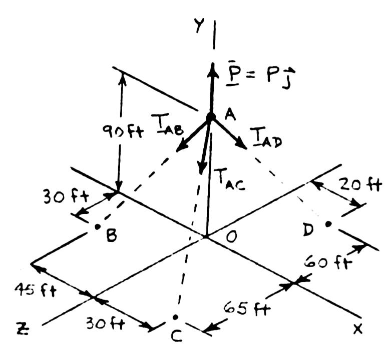


PROBLEM 2.111

A transmission tower is held by three guy wires attached to a pin at *A* and anchored by bolts at *B*, *C*, and *D*. If the tension in wire *AB* is 630 lb, determine the vertical force **P** exerted by the tower on the pin at *A*.

SOLUTION

Free Body A:



$$\Sigma\mathbf{F} = 0: \quad \mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{T}_{AD} + P\mathbf{j} = 0$$

$$\overrightarrow{AB} = -45\mathbf{i} - 90\mathbf{j} + 30\mathbf{k} \quad AB = 105 \text{ ft}$$

$$\overrightarrow{AC} = 30\mathbf{i} - 90\mathbf{j} + 65\mathbf{k} \quad AC = 115 \text{ ft}$$

$$\overrightarrow{AD} = 20\mathbf{i} - 90\mathbf{j} - 60\mathbf{k} \quad AD = 110 \text{ ft}$$

We write

$$\mathbf{T}_{AB} = T_{AB}\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = \left(-\frac{3}{7}\mathbf{i} - \frac{6}{7}\mathbf{j} + \frac{2}{7}\mathbf{k}\right)T_{AB}$$

$$\mathbf{T}_{AC} = T_{AC}\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = \left(\frac{6}{23}\mathbf{i} - \frac{18}{23}\mathbf{j} + \frac{13}{23}\mathbf{k}\right)T_{AC}$$

$$\mathbf{T}_{AD} = T_{AD}\boldsymbol{\lambda}_{AD} = T_{AD}\frac{\overrightarrow{AD}}{AD} = \left(\frac{2}{11}\mathbf{i} - \frac{9}{11}\mathbf{j} - \frac{6}{11}\mathbf{k}\right)T_{AD}$$

Substituting into the Eq. $\Sigma\mathbf{F} = 0$ and factoring $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$:

$$\left(-\frac{3}{7}T_{AB} + \frac{6}{23}T_{AC} + \frac{2}{11}T_{AD}\right)\mathbf{i} + \left(-\frac{6}{7}T_{AB} - \frac{18}{23}T_{AC} - \frac{9}{11}T_{AD} + P\right)\mathbf{j} + \left(\frac{2}{7}T_{AB} + \frac{13}{23}T_{AC} - \frac{6}{11}T_{AD}\right)\mathbf{k} = 0$$

Setting the coefficients of $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$, equal to zero:

$$\mathbf{i}: \quad -\frac{3}{7}T_{AB} + \frac{6}{23}T_{AC} + \frac{2}{11}T_{AD} = 0 \tag{1}$$

$$\mathbf{j}: \quad -\frac{6}{7}T_{AB} - \frac{18}{23}T_{AC} - \frac{9}{11}T_{AD} + P = 0 \tag{2}$$

$$\mathbf{k}: \quad \frac{2}{7}T_{AB} + \frac{13}{23}T_{AC} - \frac{6}{11}T_{AD} = 0 \tag{3}$$

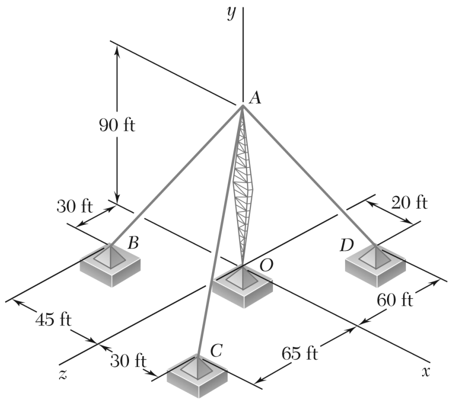
Set $T_{AB} = 630$ lb in Eqs. (1) – (3):

$$-270 \text{ lb} + \frac{6}{23}T_{AC} + \frac{2}{11}T_{AD} = 0 \tag{1$'$}$$

$$-540 \text{ lb} - \frac{18}{23}T_{AC} - \frac{9}{11}T_{AD} + P = 0 \tag{2$'$}$$

$$180 \text{ lb} + \frac{13}{23}T_{AC} - \frac{6}{11}T_{AD} = 0 \tag{3$'$}$$

Solving, $T_{AC} = 467.42$ lb $\quad T_{AD} = 814.35$ lb $\quad P = 1572.10$ lb $\qquad P = 1572$ lb ◀



PROBLEM 2.112

A transmission tower is held by three guy wires attached to a pin at A and anchored by bolts at B, C, and D. If the tension in wire AC is 920 lb, determine the vertical force **P** exerted by the tower on the pin at A.

SOLUTION

See Problem 2.111 for the figure and the analysis leading to the linear algebraic Equations (1), (2), and (3) below:

$$-\frac{3}{7}T_{AB} + \frac{6}{23}T_{AC} + \frac{2}{11}T_{AD} = 0 \tag{1}$$

$$-\frac{6}{7}T_{AB} - \frac{18}{23}T_{AC} - \frac{9}{11}T_{AD} + P = 0 \tag{2}$$

$$\frac{2}{7}T_{AB} + \frac{13}{23}T_{AC} - \frac{6}{11}T_{AD} = 0 \tag{3}$$

Substituting for $T_{AC} = 920\text{ lb}$ in Equations (1), (2), and (3) above and solving the resulting set of equations using conventional algorithms gives:

$$-\frac{3}{7}T_{AB} + 240\text{ lb} + \frac{2}{11}T_{AD} = 0 \tag{1$'$}$$

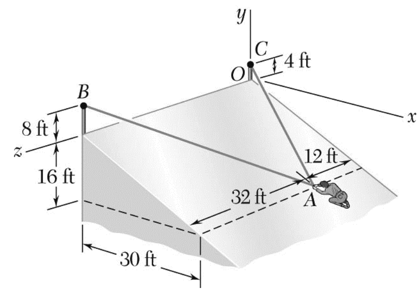
$$-\frac{6}{7}T_{AB} - 720\text{ lb} - \frac{9}{11}T_{AD} + P = 0 \tag{2$'$}$$

$$\frac{2}{7}T_{AB} + 520\text{ lb} - \frac{6}{11}T_{AD} = 0 \tag{3$'$}$$

Solving,

$$T_{AB} = 1240.00\text{ lb}$$
$$T_{AD} = 1602.86\text{ lb}$$
$$P = 3094.3\text{ lb}$$

$P = 3090\text{ lb}$ ◀

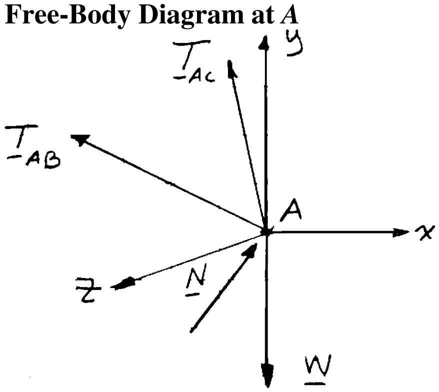


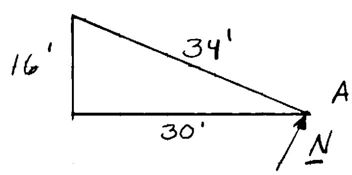
PROBLEM 2.113

In trying to move across a slippery icy surface, a 180-lb man uses two ropes AB and AC. Knowing that the force exerted on the man by the icy surface is perpendicular to that surface, determine the tension in each rope.

SOLUTION

Free-Body Diagram at A





$$\mathbf{N} = N\left(\frac{16}{34}\mathbf{i} + \frac{30}{34}\mathbf{j}\right)$$

and $\mathbf{W} = W\,\mathbf{j} = -(180\text{ lb})\mathbf{j}$

$$\mathbf{T}_{AC} = T_{AC}\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = T_{AC}\frac{(-30\text{ ft})\mathbf{i} + (20\text{ ft})\mathbf{j} - (12\text{ ft})\mathbf{k}}{38\text{ ft}}$$

$$= T_{AC}\left(-\frac{15}{19}\mathbf{i} + \frac{10}{19}\mathbf{j} - \frac{6}{19}\mathbf{k}\right)$$

$$\mathbf{T}_{AB} = T_{AB}\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = T_{AB}\frac{(-30\text{ ft})\mathbf{i} + (24\text{ ft})\mathbf{j} + (32\text{ ft})\mathbf{k}}{50\text{ ft}}$$

$$= T_{AB}\left(-\frac{15}{25}\mathbf{i} + \frac{12}{25}\mathbf{j} + \frac{16}{25}\mathbf{k}\right)$$

Equilibrium condition: $\Sigma\mathbf{F} = 0$

$$\mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{N} + \mathbf{W} = 0$$

PROBLEM 2.113 (Continued)

Substituting the expressions obtained for $\mathbf{T}_{AB}, \mathbf{T}_{AC}, \mathbf{N},$ and $\mathbf{W}$; factoring **i**, **j**, and **k**; and equating each of the coefficients to zero gives the following equations:

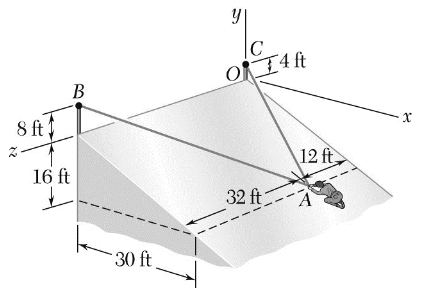
From **i**:
$$-\frac{15}{25}T_{AB} - \frac{15}{19}T_{AC} + \frac{16}{34}N = 0 \qquad (1)$$

From **j**:
$$\frac{12}{25}T_{AB} + \frac{10}{19}T_{AC} + \frac{30}{34}N - (180\text{ lb}) = 0 \qquad (2)$$

From **k**:
$$\frac{16}{25}T_{AB} - \frac{6}{19}T_{AC} = 0 \qquad (3)$$

Solving the resulting set of equations gives:

$$T_{AB} = 31.7\text{ lb};\ T_{AC} = 64.3\text{ lb} \blacktriangleleft$$



PROBLEM 2.114

Solve Problem 2.113, assuming that a friend is helping the man at A by pulling on him with a force $\mathbf{P} = -(60 \text{ lb})\mathbf{k}$.

PROBLEM 2.113 In trying to move across a slippery icy surface, a 180-lb man uses two ropes AB and AC. Knowing that the force exerted on the man by the icy surface is perpendicular to that surface, determine the tension in each rope.

SOLUTION

Refer to Problem 2.113 for the figure and analysis leading to the following set of equations, Equation (3) being modified to include the additional force $\mathbf{P} = (-60 \text{ lb})\mathbf{k}$.

$$-\frac{15}{25}T_{AB} - \frac{15}{19}T_{AC} + \frac{16}{34}N = 0 \tag{1}$$

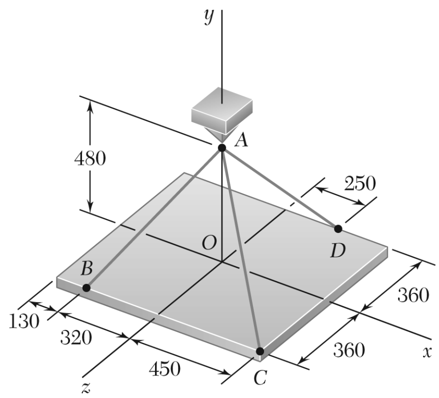
$$\frac{12}{25}T_{AB} + \frac{10}{19}T_{AC} + \frac{30}{34}N - (180 \text{ lb}) = 0 \tag{2}$$

$$\frac{16}{25}T_{AB} - \frac{6}{19}T_{AC} - (60 \text{ lb}) = 0 \tag{3}$$

Solving the resulting set of equations simultaneously gives:

$$T_{AB} = 99.0 \text{ lb} \blacktriangleleft$$

$$T_{AC} = 10.55 \text{ lb} \blacktriangleleft$$



Dimensions in mm

PROBLEM 2.115

For the rectangular plate of Problems 2.109 and 2.110, determine the tension in each of the three cables knowing that the weight of the plate is 792 N.

SOLUTION

See Problem 2.109 for the figure and the analysis leading to the linear algebraic Equations (1), (2), and (3) below. Setting $P = 792$ N gives:

$$-\frac{8}{17}T_{AB} + 0.6T_{AC} + \frac{5}{13}T_{AD} = 0 \qquad (1)$$

$$-\frac{12}{17}T_{AB} - 0.64T_{AC} - \frac{9.6}{13}T_{AD} + 792 \text{ N} = 0 \qquad (2)$$

$$\frac{9}{17}T_{AB} + 0.48T_{AC} - \frac{7.2}{13}T_{AD} = 0 \qquad (3)$$

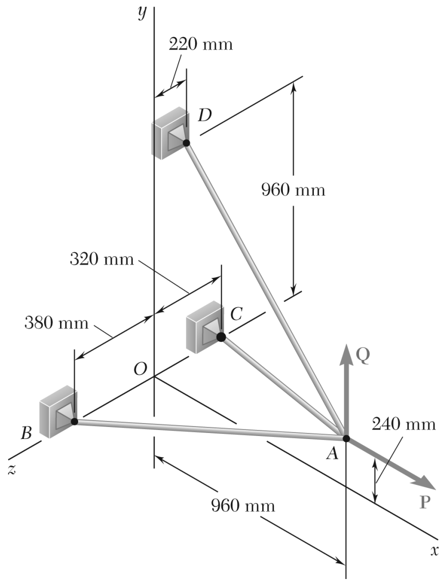
Solving Equations (1), (2), and (3) by conventional algorithms gives

$T_{AB} = 510.00$ N $\qquad T_{AB} = 510$ N ◀

$T_{AC} = 56.250$ N $\qquad T_{AC} = 56.2$ N ◀

$T_{AD} = 536.25$ N $\qquad T_{AD} = 536$ N ◀

PROBLEM 2.116



For the cable system of Problems 2.107 and 2.108, determine the tension in each cable knowing that $P = 2880$ N and $Q = 0$.

SOLUTION

$$\Sigma \mathbf{F}_A = 0: \quad \mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{T}_{AD} + \mathbf{P} + \mathbf{Q} = 0$$

Where $\quad \mathbf{P} = P\mathbf{i}$ and $\mathbf{Q} = Q\mathbf{j}$

$$\overrightarrow{AB} = -(960 \text{ mm})\mathbf{i} - (240 \text{ mm})\mathbf{j} + (380 \text{ mm})\mathbf{k} \quad AB = 1060 \text{ mm}$$

$$\overrightarrow{AC} = -(960 \text{ mm})\mathbf{i} - (240 \text{ mm})\mathbf{j} - (320 \text{ mm})\mathbf{k} \quad AC = 1040 \text{ mm}$$

$$\overrightarrow{AD} = -(960 \text{ mm})\mathbf{i} + (720 \text{ mm})\mathbf{j} - (220 \text{ mm})\mathbf{k} \quad AD = 1220 \text{ mm}$$

$$\mathbf{T}_{AB} = T_{AB}\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = T_{AB}\left(-\frac{48}{53}\mathbf{i} - \frac{12}{53}\mathbf{j} + \frac{19}{53}\mathbf{k}\right)$$

$$\mathbf{T}_{AC} = T_{AC}\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = T_{AC}\left(-\frac{12}{13}\mathbf{i} - \frac{3}{13}\mathbf{j} - \frac{4}{13}\mathbf{k}\right)$$

$$\mathbf{T}_{AD} = T_{AD}\boldsymbol{\lambda}_{AD} = T_{AD}\frac{\overrightarrow{AD}}{AD} = T_{AD}\left(-\frac{48}{61}\mathbf{i} + \frac{36}{61}\mathbf{j} - \frac{11}{61}\mathbf{k}\right)$$

Substituting into $\Sigma \mathbf{F}_A = 0$, setting $P = (2880 \text{ N})\mathbf{i}$ and $Q = 0$, and setting the coefficients of $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$ equal to 0, we obtain the following three equilibrium equations:

$$\mathbf{i}: \quad -\frac{48}{53}T_{AB} - \frac{12}{13}T_{AC} - \frac{48}{61}T_{AD} + 2880 \text{ N} = 0 \qquad (1)$$

$$\mathbf{j}: \quad -\frac{12}{53}T_{AB} - \frac{3}{13}T_{AC} + \frac{36}{61}T_{AD} = 0 \qquad (2)$$

$$\mathbf{k}: \quad \frac{19}{53}T_{AB} - \frac{4}{13}T_{AC} - \frac{11}{61}T_{AD} = 0 \qquad (3)$$

PROBLEM 2.116 (Continued)

Solving the system of linear equations using conventional algorithms gives:

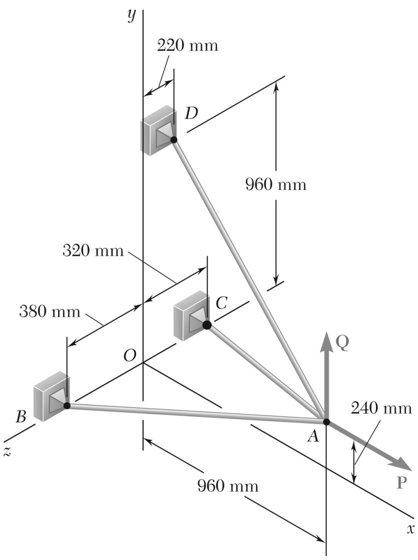
$$T_{AB} = 1340.14 \text{ N}$$
$$T_{AC} = 1025.12 \text{ N}$$
$$T_{AD} = 915.03 \text{ N}$$

$T_{AB} = 1340 \text{ N}$ ◀

$T_{AC} = 1025 \text{ N}$ ◀

$T_{AD} = 915 \text{ N}$ ◀

PROBLEM 2.117



For the cable system of Problems 2.107 and 2.108, determine the tension in each cable knowing that $P = 2880$ N and $Q = 576$ N.

SOLUTION

See Problem 2.116 for the analysis leading to the linear algebraic Equations (1), (2), and (3) below:

$$-\frac{48}{53}T_{AB} - \frac{12}{13}T_{AC} - \frac{48}{61}T_{AD} + P = 0 \qquad (1)$$

$$-\frac{12}{53}T_{AB} - \frac{3}{13}T_{AC} + \frac{36}{61}T_{AD} + Q = 0 \qquad (2)$$

$$\frac{19}{53}T_{AB} - \frac{4}{13}T_{AC} - \frac{11}{61}T_{AD} = 0 \qquad (3)$$

Setting $P = 2880$ N and $Q = 576$ N gives:

$$-\frac{48}{53}T_{AB} - \frac{12}{13}T_{AC} - \frac{48}{61}T_{AD} + 2880 \text{ N} = 0 \qquad (1')$$

$$-\frac{12}{53}T_{AB} - \frac{3}{13}T_{AC} + \frac{36}{61}T_{AD} + 576 \text{ N} = 0 \qquad (2')$$

$$\frac{19}{53}T_{AB} - \frac{4}{13}T_{AC} - \frac{11}{61}T_{AD} = 0 \qquad (3')$$

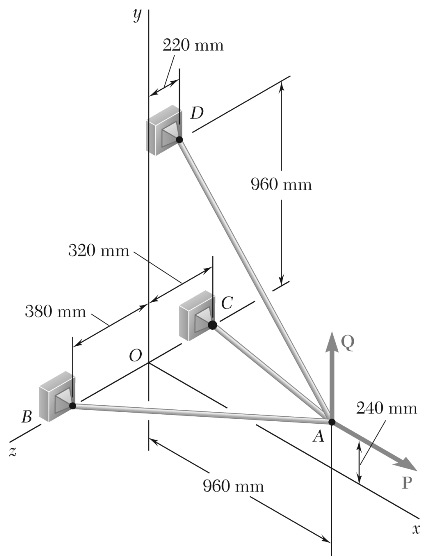
Solving the resulting set of equations using conventional algorithms gives:

$$T_{AB} = 1431.00 \text{ N}$$
$$T_{AC} = 1560.00 \text{ N}$$
$$T_{AD} = 183.010 \text{ N}$$

$T_{AB} = 1431$ N ◀

$T_{AC} = 1560$ N ◀

$T_{AD} = 183.0$ N ◀



PROBLEM 2.118

For the cable system of Problems 2.107 and 2.108, determine the tension in each cable knowing that $P = 2880$ N and $Q = -576$ N. (**Q** is directed downward).

SOLUTION

See Problem 2.116 for the analysis leading to the linear algebraic Equations (1), (2), and (3) below:

$$-\frac{48}{53}T_{AB} - \frac{12}{13}T_{AC} - \frac{48}{61}T_{AD} + P = 0 \qquad (1)$$

$$-\frac{12}{53}T_{AB} - \frac{3}{13}T_{AC} + \frac{36}{61}T_{AD} + Q = 0 \qquad (2)$$

$$\frac{19}{53}T_{AB} - \frac{4}{13}T_{AC} - \frac{11}{61}T_{AD} = 0 \qquad (3)$$

Setting $P = 2880$ N and $Q = -576$ N gives:

$$-\frac{48}{53}T_{AB} - \frac{12}{13}T_{AC} - \frac{48}{61}T_{AD} + 2880\text{ N} = 0 \qquad (1')$$

$$-\frac{12}{53}T_{AB} - \frac{3}{13}T_{AC} + \frac{36}{61}T_{AD} - 576\text{ N} = 0 \qquad (2')$$

$$\frac{19}{53}T_{AB} - \frac{4}{13}T_{AC} - \frac{11}{61}T_{AD} = 0 \qquad (3')$$

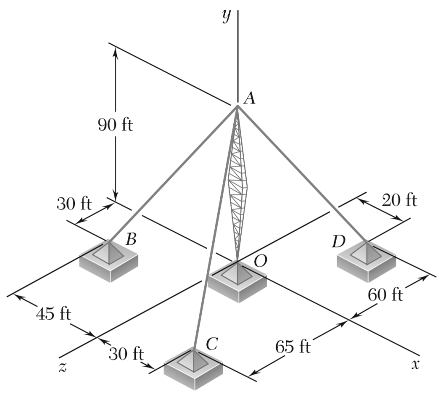
Solving the resulting set of equations using conventional algorithms gives:

$$T_{AB} = 1249.29\text{ N}$$
$$T_{AC} = 490.31\text{ N}$$
$$T_{AD} = 1646.97\text{ N}$$

$T_{AB} = 1249$ N ◀

$T_{AC} = 490$ N ◀

$T_{AD} = 1647$ N ◀



PROBLEM 2.119

For the transmission tower of Problems 2.111 and 2.112, determine the tension in each guy wire knowing that the tower exerts on the pin at A an upward vertical force of 2100 lb.

SOLUTION

See Problem 2.111 for the figure and the analysis leading to the linear algebraic Equations (1), (2), and (3) below:

$$-\frac{3}{7}T_{AB} + \frac{6}{23}T_{AC} + \frac{2}{11}T_{AD} = 0 \tag{1}$$

$$-\frac{6}{7}T_{AB} - \frac{18}{23}T_{AC} - \frac{9}{11}T_{AD} + P = 0 \tag{2}$$

$$\frac{2}{7}T_{AB} + \frac{13}{23}T_{AC} - \frac{6}{11}T_{AD} = 0 \tag{3}$$

Substituting for $P = 2100$ lb in Equations (1), (2), and (3) above and solving the resulting set of equations using conventional algorithms gives:

$$-\frac{3}{7}T_{AB} + \frac{6}{23}T_{AC} + \frac{2}{11}T_{AD} = 0 \tag{1′}$$

$$-\frac{6}{7}T_{AB} - \frac{18}{23}T_{AC} - \frac{9}{11}T_{AD} + 2100 \text{ lb} = 0 \tag{2′}$$

$$\frac{2}{7}T_{AB} + \frac{13}{23}T_{AC} - \frac{6}{11}T_{AD} = 0 \tag{3′}$$

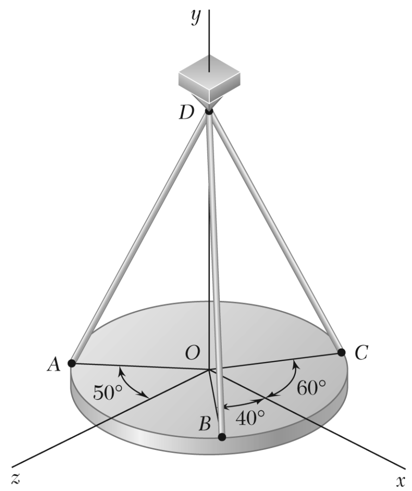
$$T_{AB} = 841.55 \text{ lb}$$
$$T_{AC} = 624.38 \text{ lb}$$
$$T_{AD} = 1087.81 \text{ lb}$$

$T_{AB} = 842$ lb ◀

$T_{AC} = 624$ lb ◀

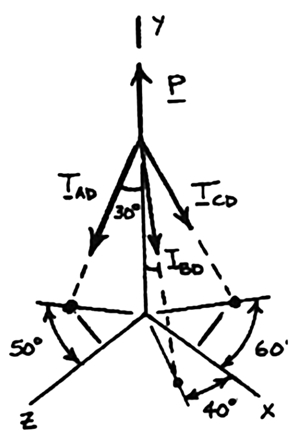
$T_{AD} = 1088$ lb ◀

PROBLEM 2.120



A horizontal circular plate weighing 60 lb is suspended as shown from three wires that are attached to a support at *D* and form 30° angles with the vertical. Determine the tension in each wire.

SOLUTION



$\Sigma F_x = 0$:

$$-T_{AD}(\sin 30°)(\sin 50°) + T_{BD}(\sin 30°)(\cos 40°) + T_{CD}(\sin 30°)(\cos 60°) = 0$$

Dividing through by $\sin 30°$ and evaluating:

$$-0.76604T_{AD} + 0.76604T_{BD} + 0.5T_{CD} = 0 \quad (1)$$

$\Sigma F_y = 0$: $\quad -T_{AD}(\cos 30°) - T_{BD}(\cos 30°) - T_{CD}(\cos 30°) + 60 \text{ lb} = 0$

or $$T_{AD} + T_{BD} + T_{CD} = 69.282 \text{ lb} \quad (2)$$

$\Sigma F_z = 0$: $\quad T_{AD}\sin 30°\cos 50° + T_{BD}\sin 30°\sin 40° - T_{CD}\sin 30°\sin 60° = 0$

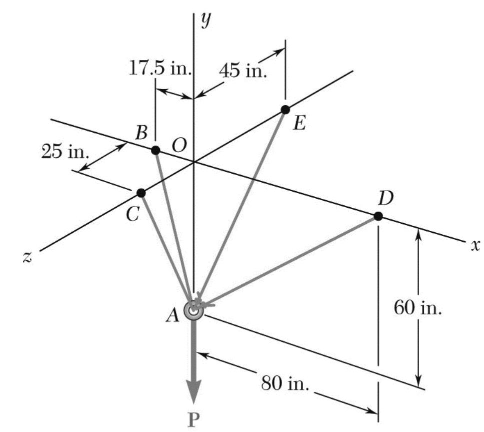
or $$0.64279T_{AD} + 0.64279T_{BD} - 0.86603T_{CD} = 0 \quad (3)$$

Solving Equations (1), (2), and (3) simultaneously:

$T_{AD} = 29.5 \text{ lb}$ ◀

$T_{BD} = 10.25 \text{ lb}$ ◀

$T_{CD} = 29.5 \text{ lb}$ ◀

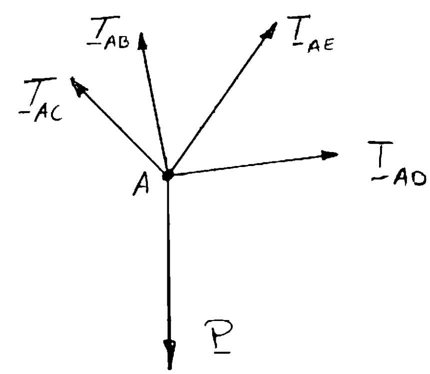


PROBLEM 2.121

Cable *BAC* passes through a frictionless ring *A* and is attached to fixed supports at *B* and *C*, while cables *AD* and *AE* are both tied to the ring and are attached, respectively, to supports at *D* and *E*. Knowing that a 200-lb vertical load **P** is applied to ring *A*, determine the tension in each of the three cables.

SOLUTION

Free Body Diagram at *A*:



Since T_{BAC} = tension in cable *BAC*, it follows that

$$T_{AB} = T_{AC} = T_{BAC}$$

$$\mathbf{T}_{AB} = T_{BAC}\boldsymbol{\lambda}_{AB} = T_{BAC}\frac{(-17.5\text{ in.})\mathbf{i} + (60\text{ in.})\mathbf{j}}{62.5\text{ in.}} = T_{BAC}\left(\frac{-17.5}{62.5}\mathbf{i} + \frac{60}{62.5}\mathbf{j}\right)$$

$$\mathbf{T}_{AC} = T_{BAC}\boldsymbol{\lambda}_{AC} = T_{BAC}\frac{(60\text{ in.})\mathbf{i} + (25\text{ in.})\mathbf{k}}{65\text{ in.}} = T_{BAC}\left(\frac{60}{65}\mathbf{j} + \frac{25}{65}\mathbf{k}\right)$$

$$\mathbf{T}_{AD} = T_{AD}\boldsymbol{\lambda}_{AD} = T_{AD}\frac{(80\text{ in.})\mathbf{i} + (60\text{ in.})\mathbf{j}}{100\text{ in.}} = T_{AD}\left(\frac{4}{5}\mathbf{i} + \frac{3}{5}\mathbf{j}\right)$$

$$\mathbf{T}_{AE} = T_{AE}\boldsymbol{\lambda}_{AE} = T_{AE}\frac{(60\text{ in.})\mathbf{j} - (45\text{ in.})\mathbf{k}}{75\text{ in.}} = T_{AE}\left(\frac{4}{5}\mathbf{j} - \frac{3}{5}\mathbf{k}\right)$$

PROBLEM 2.121 (Continued)

Substituting into $\Sigma\mathbf{F}_A = 0$, setting $\mathbf{P} = (-200\text{ lb})\mathbf{j}$, and setting the coefficients of $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$ equal to ϕ, we obtain the following three equilibrium equations:

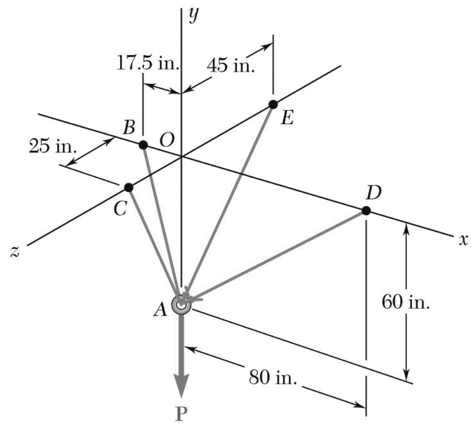
From $\quad \mathbf{i}: \quad -\dfrac{17.5}{62.5}T_{BAC} + \dfrac{4}{5}T_{AD} = 0 \qquad (1)$

From $\quad \mathbf{j}: \quad \left(\dfrac{60}{62.5} + \dfrac{60}{65}\right)T_{BAC} + \dfrac{3}{5}T_{AD} + \dfrac{4}{5}T_{AE} - 200\text{ lb} = 0 \qquad (2)$

From $\quad \mathbf{k}: \quad \dfrac{25}{65}T_{BAC} - \dfrac{3}{5}T_{AE} = 0 \qquad (3)$

Solving the system of linear equations using convential acgorithms gives:

$T_{BAC} = 76.7\text{ lb}; \; T_{AD} = 26.9\text{ lb}; \; T_{AE} = 49.2\text{ lb}$ ◀



PROBLEM 2.122

Knowing that the tension in cable *AE* of Prob. 2.121 is 75 lb, determine (*a*) the magnitude of the load **P**, (*b*) the tension in cables *BAC* and *AD*.

PROBLEM 2.121 Cable *BAC* passes through a frictionless ring *A* and is attached to fixed supports at *B* and *C*, while cables *AD* and *AE* are both tied to the ring and are attached, respectively, to supports at *D* and *E*. Knowing that a 200-lb vertical load **P** is applied to ring *A*, determine the tension in each of the three cables.

SOLUTION

Refer to the solution to Problem 2.121 for the figure and analysis leading to the following set of equilibrium equations, Equation (2) being modified to include $P\mathbf{j}$ as an unknown quantity:

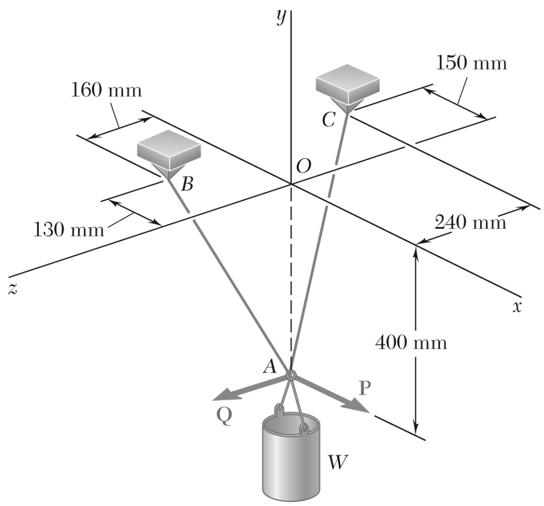
$$-\frac{17.5}{62.5}T_{BAC} + \frac{4}{5}T_{AD} = 0 \qquad (1)$$

$$\left(\frac{60}{62.5} + \frac{60}{65}\right)T_{BAC} + \frac{3}{5}T_{AD} + \frac{4}{5}T_{AE} - P = 0 \qquad (2)$$

$$\frac{25}{65}T_{BAC} - \frac{3}{5}T_{AE} = 0 \qquad (3)$$

Substituting for $T_{AE} = 75\text{ lb}$ and solving simultaneously gives:

$$P = 305\text{ lb};\ T_{BAC} = 117.0\text{ lb};\ T_{AD} = 40.9\text{ lb} \blacktriangleleft$$

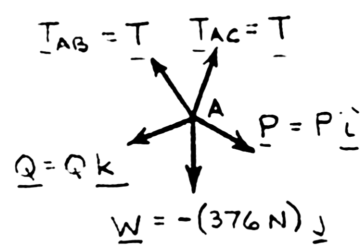


PROBLEM 2.123

A container of weight W is suspended from ring A. Cable BAC passes through the ring and is attached to fixed supports at B and C. Two forces $\mathbf{P} = P\mathbf{i}$ and $\mathbf{Q} = Q\mathbf{k}$ are applied to the ring to maintain the container in the position shown. Knowing that $W = 376\text{ N}$, determine P and Q. (*Hint:* The tension is the same in both portions of cable BAC.)

SOLUTION

Free-Body A:



$$\mathbf{T}_{AB} = T\boldsymbol{\lambda}_{AB}$$

$$= T\frac{\overrightarrow{AB}}{AB}$$

$$= T\frac{(-130\text{ mm})\mathbf{i} + (400\text{ mm})\mathbf{j} + (160\text{ mm})\mathbf{k}}{450\text{ mm}}$$

$$= T\left(-\frac{13}{45}\mathbf{i} + \frac{40}{45}\mathbf{j} + \frac{16}{45}\mathbf{k}\right)$$

$$\mathbf{T}_{AC} = T\boldsymbol{\lambda}_{AC}$$

$$= T\frac{\overrightarrow{AC}}{AC}$$

$$= T\frac{(-150\text{ mm})\mathbf{i} + (400\text{ mm})\mathbf{j} + (-240\text{ mm})\mathbf{k}}{490\text{ mm}}$$

$$= T\left(-\frac{15}{49}\mathbf{i} + \frac{40}{49}\mathbf{j} - \frac{24}{49}\mathbf{k}\right)$$

$$\Sigma F = 0: \quad \mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{Q} + \mathbf{P} + \mathbf{W} = 0$$

Setting coefficients of **i**, **j**, **k** equal to zero:

$$\mathbf{i}: \quad -\frac{13}{45}T - \frac{15}{49}T + P = 0 \qquad 0.59501T = P \tag{1}$$

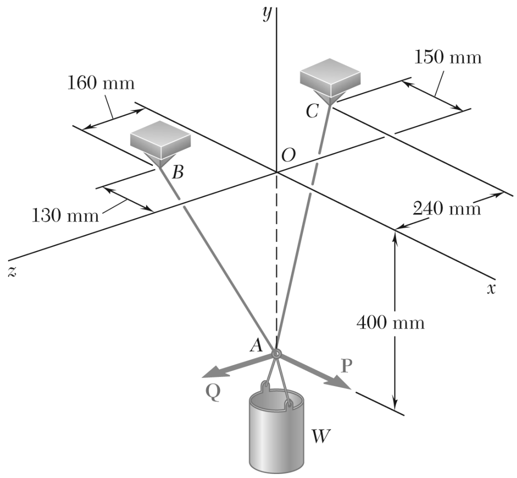
$$\mathbf{j}: \quad +\frac{40}{45}T + \frac{40}{49}T - W = 0 \qquad 1.70521T = W \tag{2}$$

$$\mathbf{k}: \quad +\frac{16}{45}T - \frac{24}{49}T + Q = 0 \qquad 0.134240T = Q \tag{3}$$

Data: $W = 376\text{ N} \quad 1.70521T = 376\text{ N} \quad T = 220.50\text{ N}$

$0.59501(220.50\text{ N}) = P$ $\qquad P = 131.2\text{ N}$ ◀

$0.134240(220.50\text{ N}) = Q$ $\qquad Q = 29.6\text{ N}$ ◀



PROBLEM 2.124

For the system of Problem 2.123, determine W and Q knowing that $P = 164$ N.

PROBLEM 2.123 A container of weight W is suspended from ring A. Cable BAC passes through the ring and is attached to fixed supports at B and C. Two forces $\mathbf{P} = P\mathbf{i}$ and $\mathbf{Q} = Q\mathbf{k}$ are applied to the ring to maintain the container in the position shown. Knowing that $W = 376$ N, determine P and Q. (*Hint:* The tension is the same in both portions of cable BAC.)

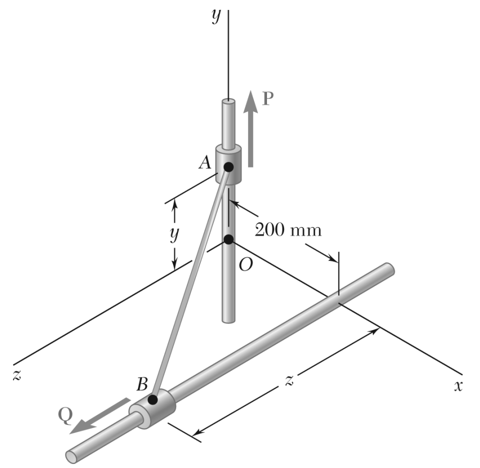
SOLUTION

Refer to Problem 2.123 for the figure and analysis resulting in Equations (1), (2), and (3) for P, W, and Q in terms of T below. Setting $P = 164$ N we have:

Eq. (1): $\quad 0.59501T = 164 \text{ N} \quad T = 275.63 \text{ N}$

Eq. (2): $\quad 1.70521(275.63 \text{ N}) = W \quad W = 470 \text{ N}$ ◀

Eq. (3): $\quad 0.134240(275.63 \text{ N}) = Q \quad Q = 37.0 \text{ N}$ ◀



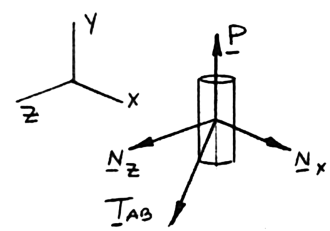
PROBLEM 2.125

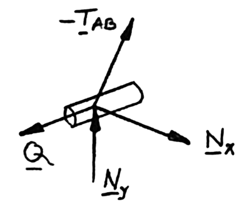
Collars A and B are connected by a 525-mm-long wire and can slide freely on frictionless rods. If a force $\mathbf{P} = (341\text{ N})\mathbf{j}$ is applied to collar A, determine (a) the tension in the wire when $y = 155$ mm, (b) the magnitude of the force $\mathbf{Q}$ required to maintain the equilibrium of the system.

SOLUTION

For both Problems 2.125 and 2.126:

Free-Body Diagrams of Collars:





$$(AB)^2 = x^2 + y^2 + z^2$$

Here $$(0.525\text{ m})^2 = (0.20\text{ m})^2 + y^2 + z^2$$

or $$y^2 + z^2 = 0.23563\text{ m}^2$$

Thus, when y given, z is determined,

Now
$$\boldsymbol{\lambda}_{AB} = \frac{\overline{AB}}{AB}$$
$$= \frac{1}{0.525\text{ m}}(0.20\mathbf{i} - y\mathbf{j} + z\mathbf{k})\text{m}$$
$$= 0.38095\mathbf{i} - 1.90476y\mathbf{j} + 1.90476z\mathbf{k}$$

Where y and z are in units of meters, m.

From the F.B. Diagram of collar A: $\quad \Sigma\mathbf{F} = 0: \quad N_x\mathbf{i} + N_z\mathbf{k} + P\mathbf{j} + T_{AB}\lambda_{AB} = 0$

Setting the $\mathbf{j}$ coefficient to zero gives $\quad P - (1.90476y)T_{AB} = 0$

With $$P = 341\text{ N}$$
$$T_{AB} = \frac{341\text{ N}}{1.90476y}$$

Now, from the free body diagram of collar B: $\quad \Sigma\mathbf{F} = 0: \quad N_x\mathbf{i} + N_y\mathbf{j} + Q\mathbf{k} - T_{AB}\boldsymbol{\lambda}_{AB} = 0$

Setting the $\mathbf{k}$ coefficient to zero gives $\quad Q - T_{AB}(1.90476z) = 0$

And using the above result for T_{AB}, we have $\quad Q = T_{AB}z = \dfrac{341\text{ N}}{(1.90476)y}(1.90476z) = \dfrac{(341\text{ N})(z)}{y}$

PROBLEM 2.125 (Continued)

Then from the specifications of the problem, $y = 155\text{ mm} = 0.155\text{ m}$

$$z^2 = 0.23563\text{ m}^2 - (0.155\text{ m})^2$$
$$z = 0.46\text{ m}$$

and

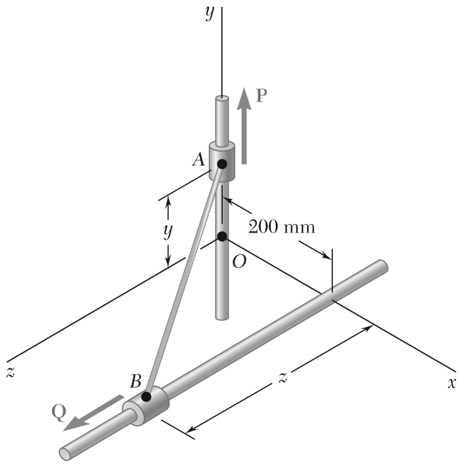
(*a*)
$$T_{AB} = \frac{341\text{ N}}{0.155(1.90476)}$$
$$= 1155.00\text{ N}$$

or $T_{AB} = 1155\text{ N}$ ◀

and

(*b*)
$$Q = \frac{341\text{ N}(0.46\text{ m})(0.866)}{(0.155\text{ m})}$$
$$= (1012.00\text{ N})$$

or $Q = 1012\text{ N}$ ◀



PROBLEM 2.126

Solve Problem 2.125 assuming that $y = 275$ mm.

PROBLEM 2.125 Collars A and B are connected by a 525-mm-long wire and can slide freely on frictionless rods. If a force $\mathbf{P} = (341 \text{ N})\mathbf{j}$ is applied to collar A, determine (a) the tension in the wire when $y = 155$ mm, (b) the magnitude of the force $\mathbf{Q}$ required to maintain the equilibrium of the system.

SOLUTION

From the analysis of Problem 2.125, particularly the results:

$$y^2 + z^2 = 0.23563 \text{ m}^2$$

$$T_{AB} = \frac{341 \text{ N}}{1.90476 y}$$

$$Q = \frac{341 \text{ N}}{y} z$$

With $y = 275 \text{ mm} = 0.275 \text{ m}$, we obtain:

$$z^2 = 0.23563 \text{ m}^2 - (0.275 \text{ m})^2$$

$$z = 0.40 \text{ m}$$

and

(a) $$T_{AB} = \frac{341 \text{ N}}{(1.90476)(0.275 \text{ m})} = 651.00$$

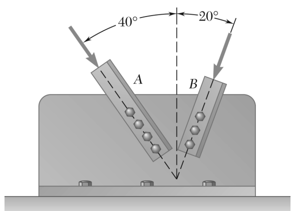
or $T_{AB} = 651 \text{ N}$ ◀

and

(b) $$Q = \frac{341 \text{ N}(0.40 \text{ m})}{(0.275 \text{ m})}$$

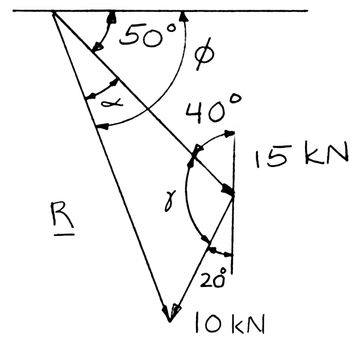
or $Q = 496 \text{ N}$ ◀

PROBLEM 2.127



Two structural members A and B are bolted to a bracket as shown. Knowing that both members are in compression and that the force is 15 kN in member A and 10 kN in member B, determine by trigonometry the magnitude and direction of the resultant of the forces applied to the bracket by members A and B.

SOLUTION



Using the force triangle and the laws of cosines and sines,

we have $\quad \gamma = 180° - (40° + 20°)$

$$= 120°$$

Then

$$R^2 = (15 \text{ kN})^2 + (10 \text{ kN})^2 - 2(15 \text{ kN})(10 \text{ kN})\cos 120°$$

$$= 475 \text{ kN}^2$$

$$R = 21.794 \text{ kN}$$

and

$$\frac{10 \text{ kN}}{\sin\alpha} = \frac{21.794 \text{ kN}}{\sin 120°}$$

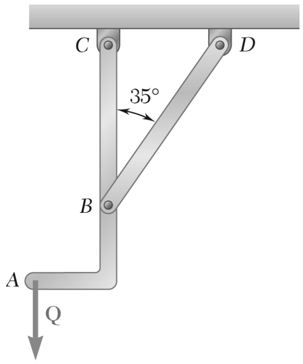
$$\sin\alpha = \left(\frac{10 \text{ kN}}{21.794 \text{ kN}}\right)\sin 120°$$

$$= 0.39737$$

$$\alpha = 23.414$$

Hence: $\quad \phi = \alpha + 50° = 73.414$

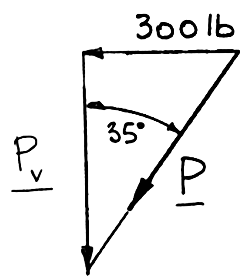
R = 21.8 kN ⦪ 73.4° ◀



PROBLEM 2.128

Member *BD* exerts on member *ABC* a force **P** directed along line *BD*. Knowing that **P** must have a 300-lb horizontal component, determine (*a*) the magnitude of the force **P**, (*b*) its vertical component.

SOLUTION

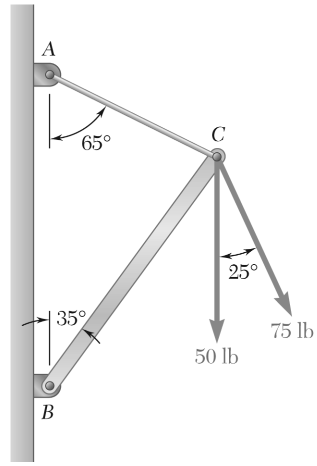


(*a*) $P\sin 35° = 300 \text{ lb}$

$$P = \frac{300 \text{ lb}}{\sin 35°} \qquad P = 523 \text{ lb} \blacktriangleleft$$

(*b*) Vertical component $P_v = P\cos 35°$

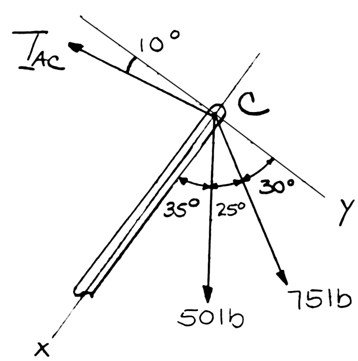
$$= (523 \text{ lb})\cos 35° \qquad P_v = 428 \text{ lb} \blacktriangleleft$$



PROBLEM 2.129

Determine (*a*) the required tension in cable *AC*, knowing that the resultant of the three forces exerted at Point *C* of boom *BC* must be directed along *BC*, (*b*) the corresponding magnitude of the resultant.

SOLUTION



Using the *x* and *y* axes shown:

$$R_x = \Sigma F_x = T_{AC}\sin 10° + (50\text{ lb})\cos 35° + (75\text{ lb})\cos 60°$$
$$= T_{AC}\sin 10° + 78.458\text{ lb} \tag{1}$$

$$R_y = \Sigma F_y = (50\text{ lb})\sin 35° + (75\text{ lb})\sin 60° - T_{AC}\cos 10°$$
$$R_y = 93.631\text{ lb} - T_{AC}\cos 10° \tag{2}$$

(*a*) Set $R_y = 0$ in Eq. (2):

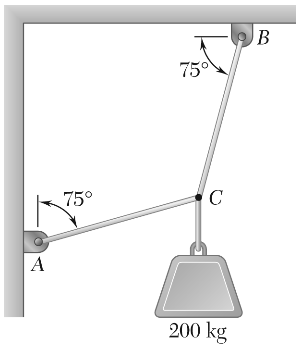
$$93.631\text{ lb} - T_{AC}\cos 10° = 0$$
$$T_{AC} = 95.075\text{ lb}$$

$T_{AC} = 95.1\text{ lb}$ ◀

(*b*) Substituting for T_{AC} in Eq. (1):

$$R_x = (95.075\text{ lb})\sin 10° + 78.458\text{ lb}$$
$$= 94.968\text{ lb}$$
$$R = R_x$$

$R = 95.0\text{ lb}$ ◀

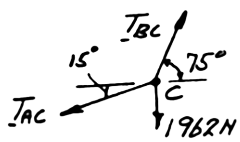


PROBLEM 2.130

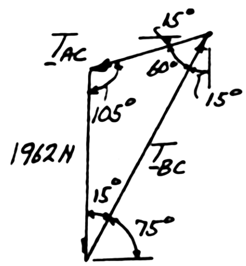
Two cables are tied together at C and are loaded as shown. Determine the tension (a) in cable AC, (b) in cable BC.

SOLUTION

Free-Body Diagram



Force Triangle



$$\begin{aligned} W &= \text{mg} \\ &= (200\text{ kg})(9.81\text{ m/s}^2) \\ &= 1962\text{ N} \end{aligned}$$

Law of sines:

$$\frac{T_{AC}}{\sin 15°} = \frac{T_{BC}}{\sin 105°} = \frac{1962\text{ N}}{\sin 60°}$$

(a)

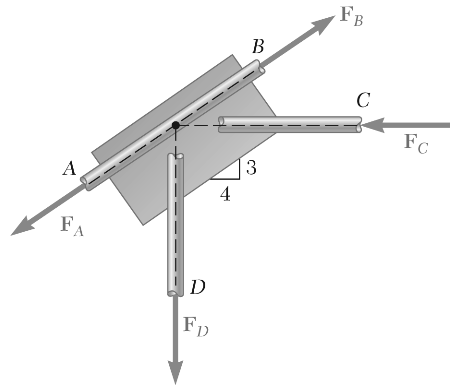
$$T_{AC} = \frac{(1962\text{ N})\ \sin 15°}{\sin 60°}$$

$T_{AC} = 586\text{ N}$ ◀

(b)

$$T_{BC} = \frac{(1962\text{ N})\sin 105°}{\sin 60°}$$

$T_{BC} = 2190\text{ N}$ ◀

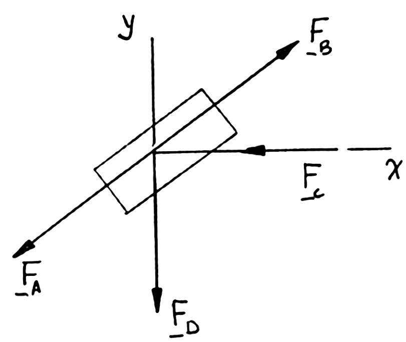


PROBLEM 2.131

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 $\quad F_A = 8$ kN

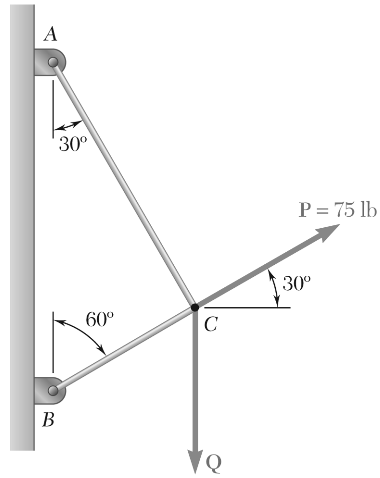
$F_B = 16$ kN

$$F_C = \frac{4}{5}(16 \text{ kN}) - \frac{4}{5}(8 \text{ kN}) \qquad F_C = 6.40 \text{ kN} \blacktriangleleft$$

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

With F_A and F_B as above:

$$F_D = \frac{3}{5}(16 \text{ kN}) - \frac{3}{5}(8 \text{ kN}) \qquad F_D = 4.80 \text{ kN} \blacktriangleleft$$

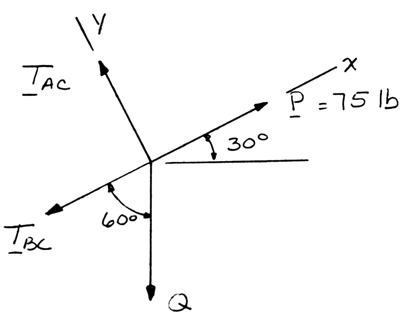


PROBLEM 2.132

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

Free-Body Diagram



$$\Sigma F_x = 0: \quad -T_{BC} - Q\cos 60° + 75 \text{ lb} = 0$$

$$T_{BC} = 75 \text{ lb} - Q \cos 60° \qquad (1)$$

$$\Sigma F_y = 0: \quad T_{AC} - Q\sin 60° = 0$$

$$T_{AC} = Q\sin 60° \qquad (2)$$

Requirement: $T_{AC} \le 60$ lb:

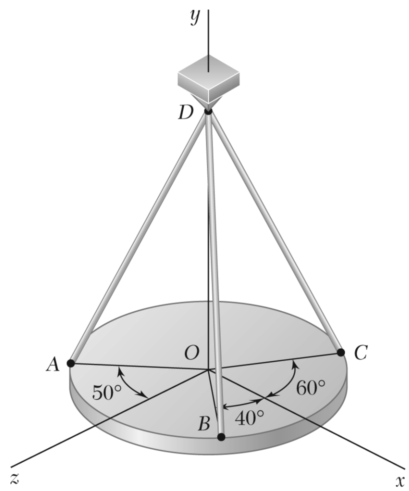
From Eq. (2): $Q\sin 60° \le 60$ lb

$Q \le 69.3$ lb

Requirement: $T_{BC} \le 60$ lb:

From Eq. (1): $75 \text{ lb} - Q\sin 60° \le 60$ lb

$Q \ge 30.0$ lb $\qquad 30.0 \text{ lb} \le Q \le 69.3 \text{ lb}$ ◀



PROBLEM 2.133

A horizontal circular plate is suspended as shown from three wires that are attached to a support at *D* and form 30° angles with the vertical. Knowing that the *x* component of the force exerted by wire *AD* on the plate is 110.3 N, determine (*a*) the tension in wire *AD*, (*b*) the angles θ_x, θ_y, and θ_z that the force exerted at *A* forms with the coordinate axes.

SOLUTION

(*a*)

$$F_x = F \sin 30° \sin 50° = 110.3 \text{ N} \quad \text{(Given)}$$

$$F = \frac{110.3 \text{ N}}{\sin 30° \sin 50°} = 287.97 \text{ N}$$

$F = 288 \text{ N}$ ◀

(*b*)

$$\cos\theta_x = \frac{F_x}{F} = \frac{110.3 \text{ N}}{287.97 \text{ N}} = 0.38303$$

$\theta_x = 67.5°$ ◀

$$F_y = F \cos 30° = 249.39$$

$$\cos\theta_y = \frac{F_y}{F} = \frac{249.39 \text{ N}}{287.97 \text{ N}} = 0.86603$$

$\theta_y = 30.0°$ ◀

$$\begin{aligned} F_z &= -F \sin 30° \cos 50° \\ &= -(287.97 \text{ N}) \sin 30° \cos 50° \\ &= -92.552 \text{ N} \end{aligned}$$

$$\cos\theta_z = \frac{F_z}{F} = \frac{-92.552 \text{ N}}{287.97 \text{ N}} = -0.32139$$

$\theta_z = 108.7°$ ◀

PROBLEM 2.134

A force acts at the origin of a coordinate system in a direction defined by the angles $\theta_y = 55°$ and $\theta_z = 45°$. Knowing that the x component of the force is −500 lb, determine (*a*) the angle θ_x, (*b*) the other components and the magnitude of the force.

SOLUTION

(*a*) We have

$$(\cos\theta_x)^2 + (\cos\theta_y)^2 + (\cos\theta_z)^2 = 1 \Rightarrow (\cos\theta_y)^2 = 1 - (\cos\theta_y)^2 - (\cos\theta_z)^2$$

Since $F_x < 0,$ we must have $\cos\theta_x < 0.$

Thus, taking the negative square root, from above, we have

$$\cos\theta_x = -\sqrt{1-(\cos 55)^2 - (\cos 45)^2} = 0.41353 \qquad \theta_x = 114.4° \blacktriangleleft$$

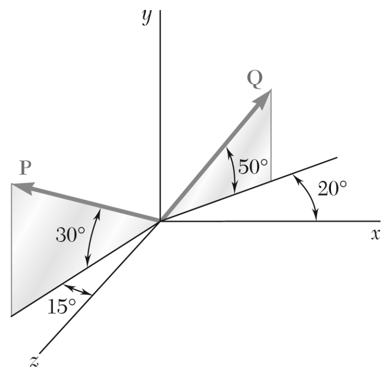
(*b*) Then

$$F = \frac{F_x}{\cos\theta_x} = \frac{500 \text{ lb}}{0.41353} = 1209.10 \text{ lb} \qquad F = 1209 \text{ lb} \blacktriangleleft$$

and

$$F_y = F\cos\theta_y = (1209.10 \text{ lb})\cos 55° \qquad F_y = 694 \text{ lb} \blacktriangleleft$$

$$F_z = F\cos\theta_z = (1209.10 \text{ lb})\cos 45° \qquad F_z = 855 \text{ lb} \blacktriangleleft$$



PROBLEM 2.135

Find the magnitude and direction of the resultant of the two forces shown knowing that $P = 300$ N and $Q = 400$ N.

SOLUTION

$$\begin{aligned}
\mathbf{P} &= (300\text{ N})[-\cos 30°\sin 15°\mathbf{i} + \sin 30°\mathbf{j} + \cos 30°\cos 15°\mathbf{k}] \\
&= -(67.243\text{ N})\mathbf{i} + (150\text{ N})\mathbf{j} + (250.95\text{ N})\mathbf{k} \\
\mathbf{Q} &= (400\text{ N})[\cos 50°\cos 20°\mathbf{i} + \sin 50°\mathbf{j} - \cos 50°\sin 20°\mathbf{k}] \\
&= (400\text{ N})[0.60402\mathbf{i} + 0.76604\mathbf{j} - 0.21985] \\
&= (241.61\text{ N})\mathbf{i} + (306.42\text{ N})\mathbf{j} - (87.939\text{ N})\mathbf{k} \\
\mathbf{R} &= \mathbf{P} + \mathbf{Q} \\
&= (174.367\text{ N})\mathbf{i} + (456.42\text{ N})\mathbf{j} + (163.011\text{ N})\mathbf{k} \\
R &= \sqrt{(174.367\text{ N})^2 + (456.42\text{ N})^2 + (163.011\text{ N})^2} \\
&= 515.07\text{ N}
\end{aligned}$$

$R = 515$ N ◀

$$\cos\theta_x = \frac{R_x}{R} = \frac{174.367\text{ N}}{515.07\text{ N}} = 0.33853$$

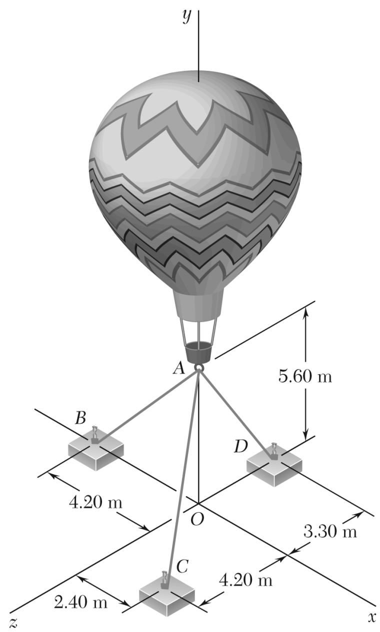
$\theta_x = 70.2°$ ◀

$$\cos\theta_y = \frac{R_y}{R} = \frac{456.42\text{ N}}{515.07\text{ N}} = 0.88613$$

$\theta_y = 27.6°$ ◀

$$\cos\theta_z = \frac{R_z}{R} = \frac{163.011\text{ N}}{515.07\text{ N}} = 0.31648$$

$\theta_z = 71.5°$ ◀



PROBLEM 2.136

Three cables are used to tether a balloon as shown. Determine the vertical force **P** exerted by the balloon at A knowing that the tension in cable AC is 444 N.

SOLUTION

See Problem 2.101 for the figure and the analysis leading to the linear algebraic Equations (1), (2), and (3) below:

$$-0.6T_{AB} + 0.32432T_{AC} = 0 \qquad (1)$$

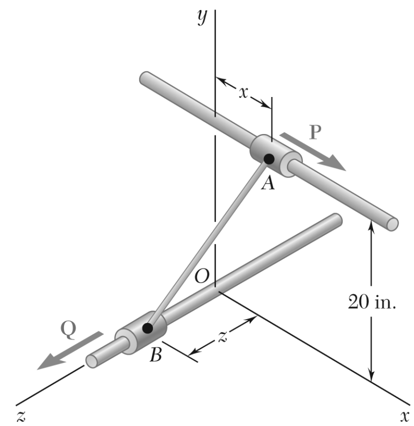
$$-0.8T_{AB} - 0.75676T_{AC} - 0.86154T_{AD} + P = 0 \qquad (2)$$

$$0.56757T_{AC} - 0.50769T_{AD} = 0 \qquad (3)$$

Substituting $T_{AC} = 444$ N in Equations (1), (2), and (3) above, and solving the resulting set of equations using conventional algorithms gives

$$T_{AB} = 240 \text{ N}$$
$$T_{AD} = 496.36 \text{ N}$$

$\mathbf{P} = 956 \text{ N} \uparrow$ ◀



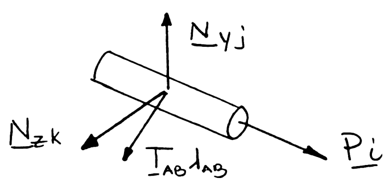
PROBLEM 2.137

Collars A and B are connected by a 25-in.-long wire and can slide freely on frictionless rods. If a 60-lb force **Q** is applied to collar B as shown, determine (a) the tension in the wire when $x = 9$ in., (b) the corresponding magnitude of the force **P** required to maintain the equilibrium of the system.

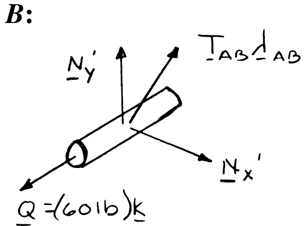
SOLUTION

Free-Body Diagrams of Collars:

***A*:**



***B*:**



$$\boldsymbol{\lambda}_{AB} = \frac{\overrightarrow{AB}}{AB} = \frac{-x\mathbf{i} - (20\text{ in.})\mathbf{j} + z\mathbf{k}}{25\text{ in.}}$$

Collar A: $\quad \Sigma\mathbf{F} = 0\colon \quad P\mathbf{i} + N_y\mathbf{j} + N_z\mathbf{k} + T_{AB}\boldsymbol{\lambda}_{AB} = 0$

Substitute for $\boldsymbol{\lambda}_{AB}$ and set coefficient of **i** equal to zero:

$$P - \frac{T_{AB}x}{25\text{ in.}} = 0 \qquad (1)$$

Collar B: $\quad \Sigma\mathbf{F} = 0\colon \quad (60\text{ lb})\mathbf{k} + N'_x\mathbf{i} + N'_y\mathbf{j} - T_{AB}\boldsymbol{\lambda}_{AB} = 0$

Substitute for $\boldsymbol{\lambda}_{AB}$ and set coefficient of **k** equal to zero:

$$60\text{ lb} - \frac{T_{AB}z}{25\text{ in.}} = 0 \qquad (2)$$

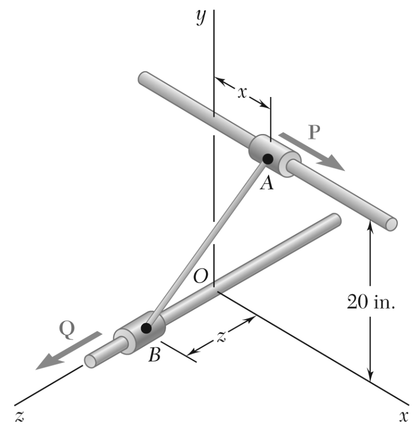
(a) $\quad x = 9$ in. $\quad (9\text{ in.})^2 + (20\text{ in.})^2 + z^2 = (25\text{ in.})^2$

$$z = 12\text{ in.}$$

From Eq. (2): $\quad \dfrac{60\text{ lb} - T_{AB}(12\text{ in.})}{25\text{ in.}} \qquad T_{AB} = 125.0\text{ lb} ◀$

(b) From Eq. (1): $\quad P = \dfrac{(125.0\text{ lb})(9\text{ in.})}{25\text{ in.}} \qquad P = 45.0\text{ lb} ◀$

PROBLEM 2.138



Collars A and B are connected by a 25-in.-long wire and can slide freely on frictionless rods. Determine the distances x and z for which the equilibrium of the system is maintained when $P = 120$ lb and $Q = 60$ lb.

SOLUTION

See Problem 2.137 for the diagrams and analysis leading to Equations (1) and (2) below:

$$P = \frac{T_{AB}x}{25 \text{ in.}} = 0 \qquad (1)$$

$$60 \text{ lb} - \frac{T_{AB}z}{25 \text{ in.}} = 0 \qquad (2)$$

For $P = 120$ lb, Eq. (1) yields $\quad T_{AB}x = (25 \text{ in.})(20 \text{ lb}) \qquad (1')$

From Eq. (2): $\quad T_{AB}z = (25 \text{ in.})(60 \text{ lb}) \qquad (2')$

Dividing Eq. (1′) by (2′), $\quad \dfrac{x}{z} = 2 \qquad (3)$

Now write $\quad x^2 + z^2 + (20 \text{ in.})^2 = (25 \text{ in.})^2 \qquad (4)$

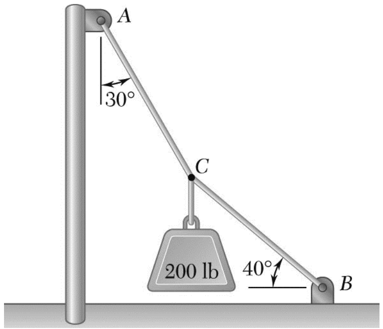
Solving (3) and (4) simultaneously,

$$4z^2 + z^2 + 400 = 625$$
$$z^2 = 45$$
$$z = 6.7082 \text{ in.}$$

From Eq. (3): $\quad x = 2z = 2(6.7082 \text{ in.})$

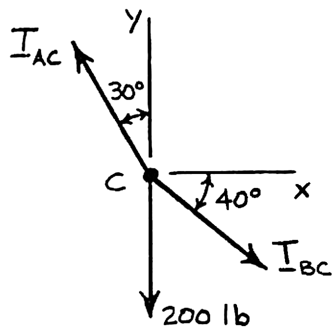
$$= 13.4164 \text{ in.}$$

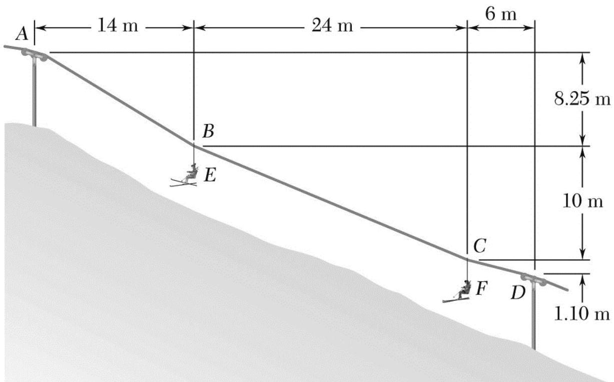
$x = 13.42$ in., $\quad z = 6.71$ in. ◀

	**PROBLEM 2F1** Two cables are tied together at *C* and loaded as shown. Draw the free-body diagram needed to determine the tension in *AC* and *BC*.

SOLUTION

Free-Body Diagram of Point *C*:



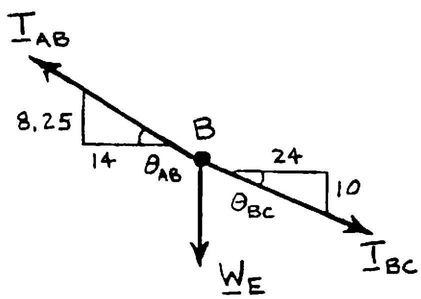


PROBLEM 2.F2

A chairlift has been stopped in the position shown. Knowing that each chair weighs 250 N and that the skier in chair *E* weighs 765 N, draw the free-body diagrams needed to determine the weight of the skier in chair *F*.

SOLUTION

Free-Body Diagram of Point *B*:



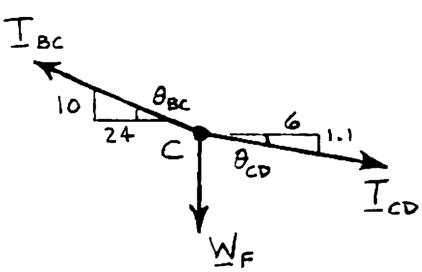
$$W_E = 250 \text{ N} + 765 \text{ N} = 1015 \text{ N}$$

$$\theta_{AB} = \tan^{-1}\frac{8.25}{14} = 30.510°$$

$$\theta_{BC} = \tan^{-1}\frac{10}{24} = 22.620°$$

Use this free body to determine T_{AB} and T_{BC}.

Free-Body Diagram of Point *C*:

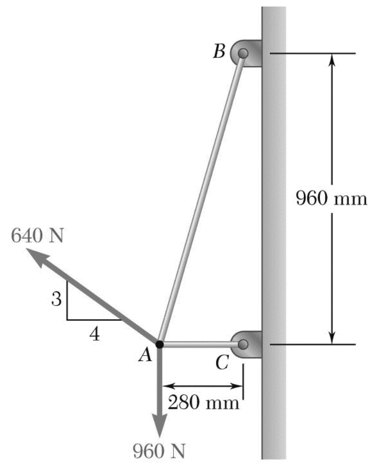


$$\theta_{CD} = \tan^{-1}\frac{1.1}{6} = 10.3889°$$

Use this free body to determine T_{CD} and W_F.

Then weight of skier W_S is found by

$$W_S = W_F - 250 \text{ N} \blacktriangleleft$$

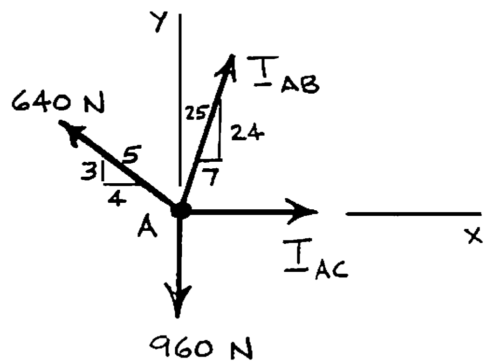


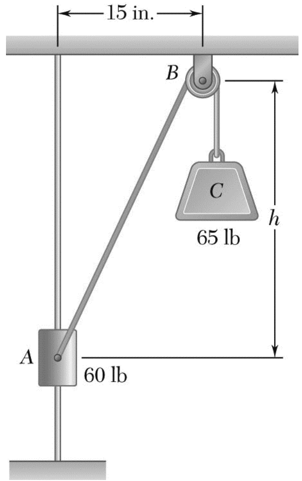
PROBLEM 2.F3

Two cables are tied together at A and loaded as shown. Draw the free-body diagram needed to determine the tension in each cable.

SOLUTION

Free-Body Diagram of Point *A*:



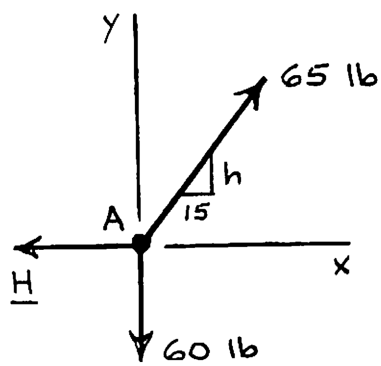


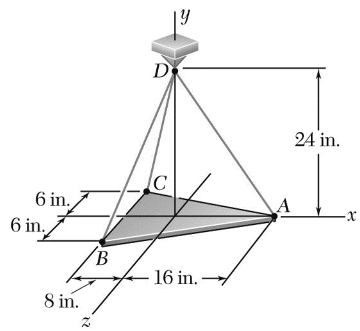
PROBLEM 2.F4

The 60-lb collar *A* can slide on a frictionless vertical rod and is connected as shown to a 65-lb counterweight *C*. Draw the free-body diagram needed to determine the value of *h* for which the system is in equilibrium.

SOLUTION

Free-Body Diagram of Point *A*:



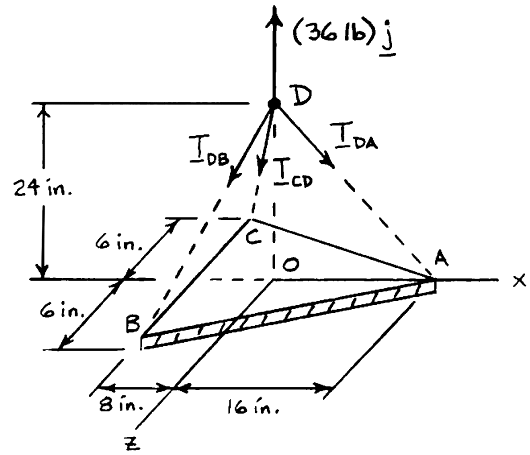


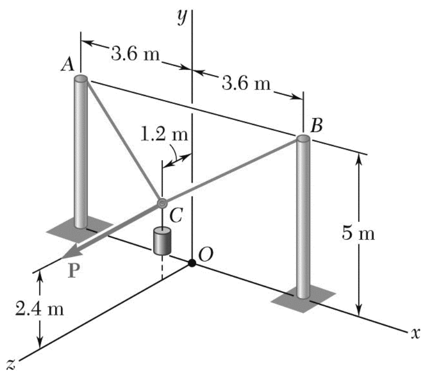
PROBLEM 2.F5

A 36-lb triangular plate is supported by three cables as shown. Draw the free-body diagram needed to determine the tension in each wire.

SOLUTION

Free-Body Diagram of Point *D*:



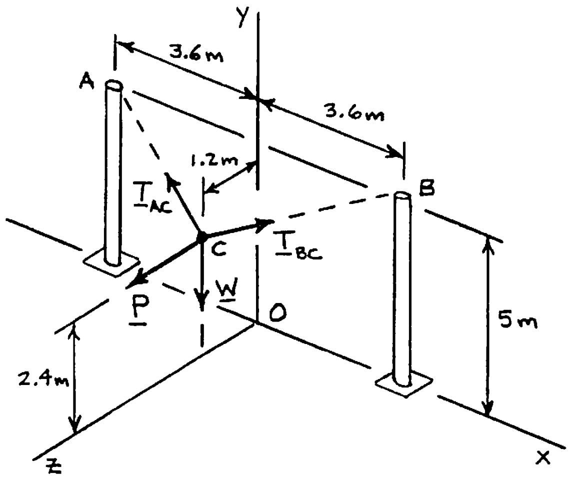


PROBLEM 2.F6

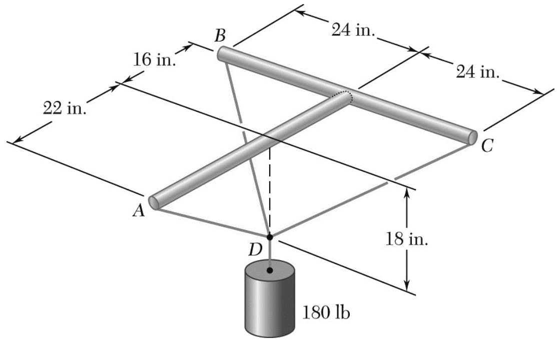
A 70-kg cylinder is supported by two cables *AC* and *BC*, which are attached to the top of vertical posts. A horizontal force **P**, perpendicular to the plane containing the posts, holds the cylinder in the position shown. Draw the free-body diagram needed to determine the magnitude of **P** and the force in each cable.

SOLUTION

Free-Body Diagram of Point *C*:



$$W = (70 \text{ kg})(9.81 \text{ m/s}^2)$$
$$= 686.7 \text{ N}$$
$$\mathbf{W} = -(686.7 \text{ N})\mathbf{j}$$

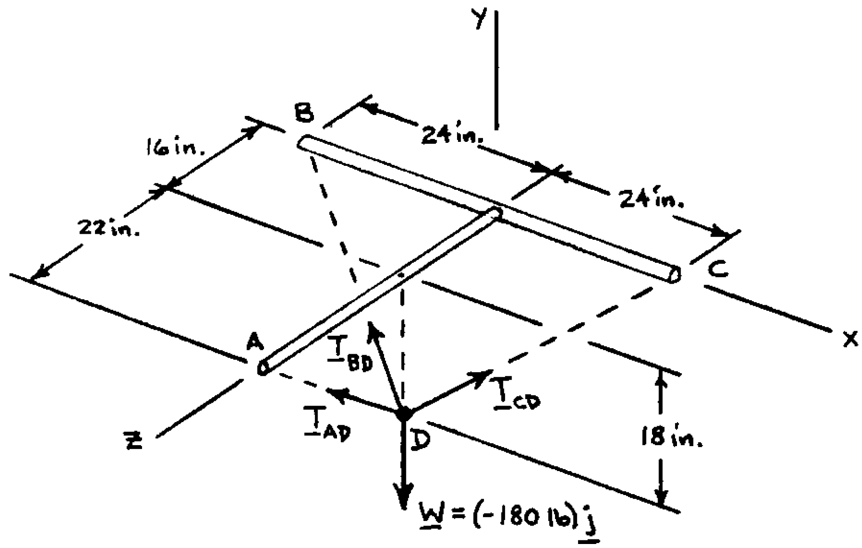


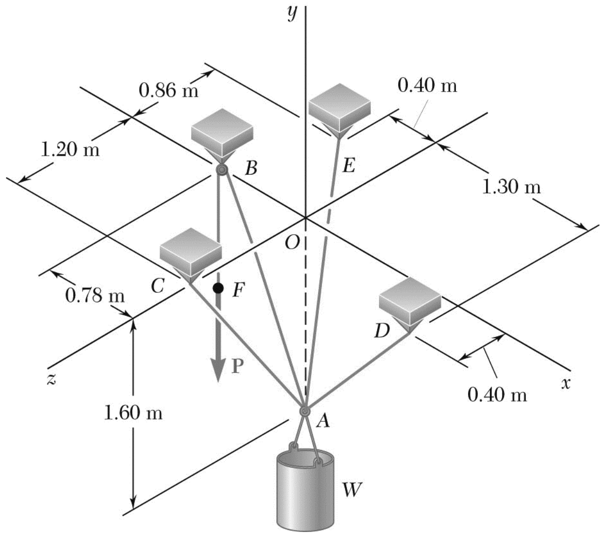
PROBLEM 2.F7

Three cables are connected at point D, which is located 18 in. below the T-shaped pipe support ABC. The cables support a 180-lb cylinder as shown. Draw the free-body diagram needed to determine the tension in each cable.

SOLUTION

Free-Body Diagram of Point *D*:



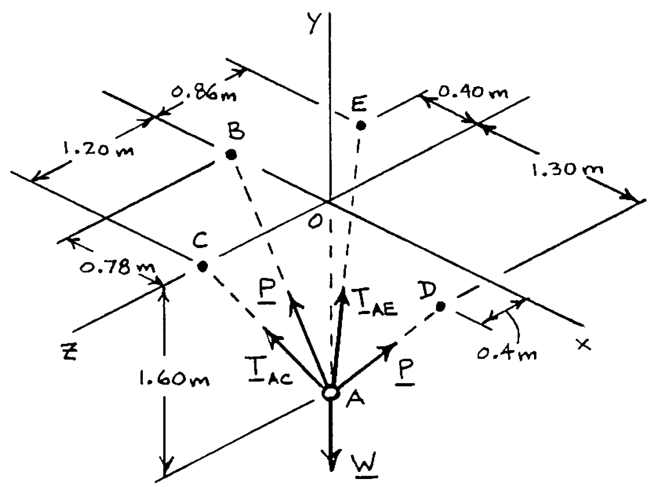


PROBLEM 2.F8

A 100-kg container is suspended from ring A, to which cables AC and AE are attached. A force P is applied to end F of a third cable that passes over a pulley at B and through ring A and then is attached to a support at D. Draw the free-body diagram needed to determine the magnitude of P. (Hint: The tension is the same in all portions of cable $FBAD$.)

SOLUTION

Free-Body Diagram of Ring *A*:



$$W = (100\text{ kg})(9.81\text{ m/s}^2)$$
$$= 981\text{ N}$$
$$\mathbf{W} = -(681\text{ N})\mathbf{j}$$