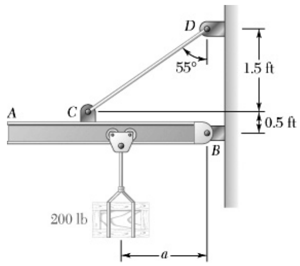
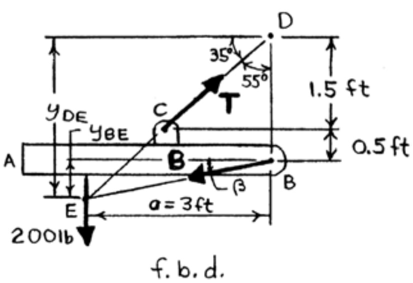
PROBLEM 4.74



Solve Problem 4.73 assuming that $a = 3$ ft.

P4.73 A 200-lb crate is attached to the trolley-beam system shown. Knowing that $a = 1.5$ ft, determine (*a*) the tension in cable *CD*, (*b*) the reaction
at *B*.

SOLUTION



From geometry of forces

$$\beta = \tan^{-1}\left(\frac{y_{BE}}{3 \text{ ft}}\right)$$

where

$$y_{BE} = y_{DE} - 2.0 \text{ ft}$$

$$= 3\tan 35° - 2.0$$

$$= 0.100623 \text{ ft}$$

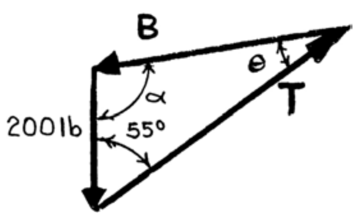
$$\therefore \beta = \tan^{-1}\left(\frac{0.100623}{3}\right) = 1.92103°$$

and

$$\alpha = 90° + \beta = 90° + 1.92103° = 91.921°$$

$$\theta = 35° - \beta = 35° - 1.92103° = 33.079°$$

Applying the law of sines to the force triangle,



$$\frac{200 \text{ lb}}{\sin\theta} = \frac{T}{\sin\alpha} = \frac{B}{\sin 55°}$$

or

$$\frac{200 \text{ lb}}{\sin 33.079°} = \frac{T}{\sin 91.921°} = \frac{\text{B}}{\sin 55°}$$

(*a*)

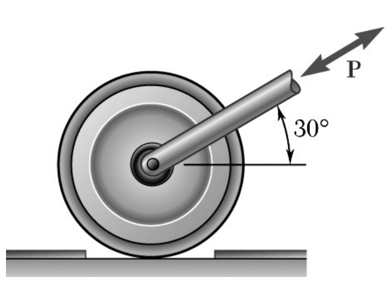
$$T = \frac{(200 \text{ lb})(\sin 91.921°)}{\sin 33.079°} = 366.23 \text{ lb}$$

or $T = 366$ lb ◀

(*b*)

$$B = \frac{(200 \text{ lb})(\sin 55°)}{\sin 33.079°} = 300.17 \text{ lb}$$

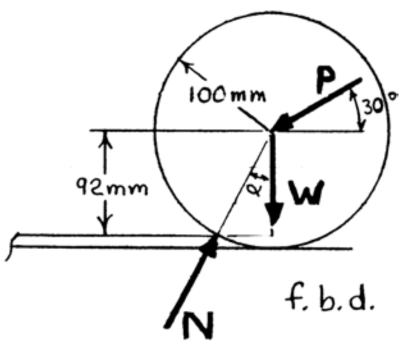
or **B** = 300 lb ↗ 1.921° ◀



PROBLEM 4.75

A 20-kg roller, of diameter 200 mm, which is to be used on a tile floor, is resting directly on the subflooring as shown. Knowing that the thickness of each tile is 8 mm, determine the force **P** required to move the roller onto the tiles if the roller is pushed to the left.

SOLUTION



Based on the roller having impending motion to the left, the only contact between the roller and floor will be at the edge of the tile.

First note $$W = mg = (20\text{ kg})(9.81\text{ m/s}^2) = 196.2\text{ N}$$

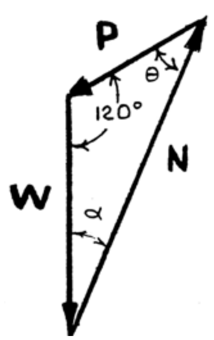
From the geometry of the three forces acting on the roller

$$\alpha = \cos^{-1}\left(\frac{92\text{ mm}}{100\text{ mm}}\right) = 23.074°$$

and $$\theta = 90° - 30° - \alpha$$

$$= 60° - 23.074$$

$$= 36.926°$$



Applying the law of sines to the force triangle,

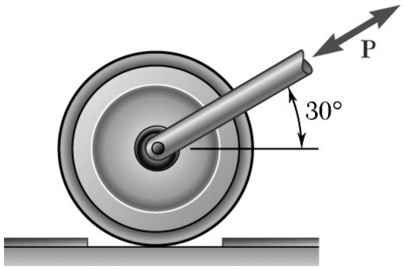
$$\frac{W}{\sin\theta} = \frac{P}{\sin\alpha}$$

or $$\frac{196.2\text{ N}}{\sin 36.926°} = \frac{P}{\sin 23.074°}$$

$$\therefore P = 127.991\text{ N}$$

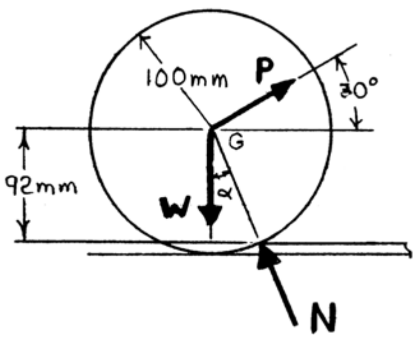
or $\mathbf{P} = 128.0\text{ N}$ ⦤ 30° ◀

PROBLEM 4.76



A 20-kg roller, of diameter 200 mm, which is to be used on a tile floor, is resting directly on the subflooring as shown. Knowing that the thickness of each tile is 8 mm, determine the force **P** required to move the roller onto the tiles if the roller is pulled to the right.

SOLUTION



Based on the roller having impending motion to the right, the only contact between the roller and floor will be at the edge of the tile.

First note $$W = mg = (20\text{ kg})(9.81\text{ m/s}^2)$$

$$= 196.2\text{ N}$$

From the geometry of the three forces acting on the roller

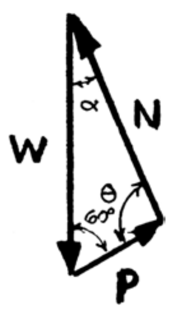
$$\alpha = \cos^{-1}\left(\frac{92\text{ mm}}{100\text{ mm}}\right) = 23.074°$$

and $$\theta = 90° + 30° - \alpha$$

$$= 120° - 23.074°$$

$$= 96.926°$$

Applying the law of sines to the force triangle,



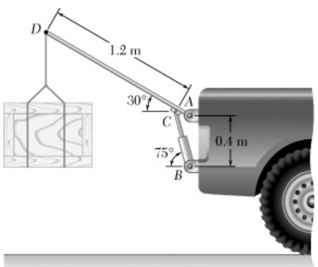
$$\frac{W}{\sin\theta} = \frac{P}{\sin\alpha}$$

or $$\frac{196.2\text{ N}}{\sin 96.926°} = \frac{P}{\sin 23.074}$$

$$\therefore\ P = 77.460\text{ N}$$

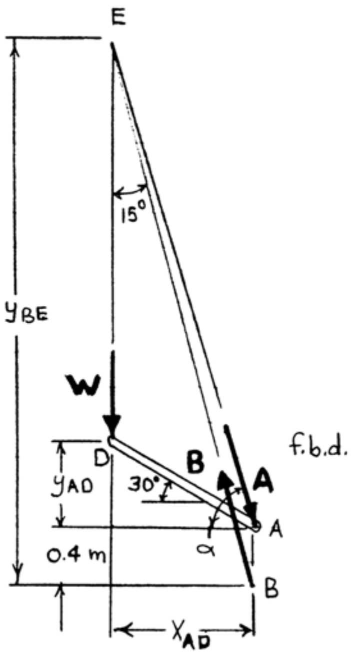
or $\mathbf{P} = 77.5\text{ N} \measuredangle\ 30°$ ◀

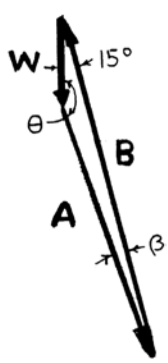
PROBLEM 4.77



A small hoist is mounted on the back of a pickup truck and is used to lift a 120-kg crate. Determine (*a*) the force exerted on the hoist by the hydraulic cylinder *BC*, (*b*) the reaction at *A*.

SOLUTION





First note $$W = mg = (120\text{ kg})(9.81\text{ m/s}^2) = 1177.2\text{ N}$$

From the geometry of the three forces acting on the small hoist

$$x_{AD} = (1.2\text{ m})\cos 30° = 1.03923\text{ m}$$

$$y_{AD} = (1.2\text{ m})\sin 30° = 0.6\text{ m}$$

and $$y_{BE} = x_{AD}\tan 75° = (1.03923\text{ m})\tan 75° = 3.8785\text{ m}$$

Then $$\alpha = \tan^{-1}\left(\frac{y_{BE} - 0.4\text{ m}}{x_{AD}}\right) = \tan^{-1}\left(\frac{3.4785}{1.03923}\right) = 73.366°$$

$$\beta = 75° - \alpha = 75° - 73.366° = 1.63412°$$

$$\theta = 180° - 15° - \beta = 165° - 1.63412° = 163.366°$$

Applying the law of sines to the force triangle,

$$\frac{W}{\sin\beta} = \frac{B}{\sin\theta} = \frac{A}{\sin 15°}$$

or $$\frac{1177.2\text{ N}}{\sin 1.63412°} = \frac{B}{\sin 163.366°} = \frac{A}{\sin 15°}$$

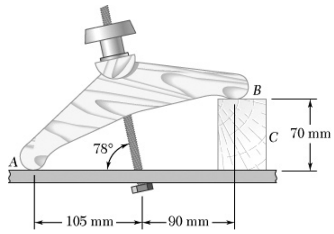
(*a*) $$B = 11\,816.9\text{ N}$$

or $\mathbf{B} = 11.82\text{ kN} \searrow 75.0°$ ◀

(*b*) $$A = 10\,684.2\text{ N}$$

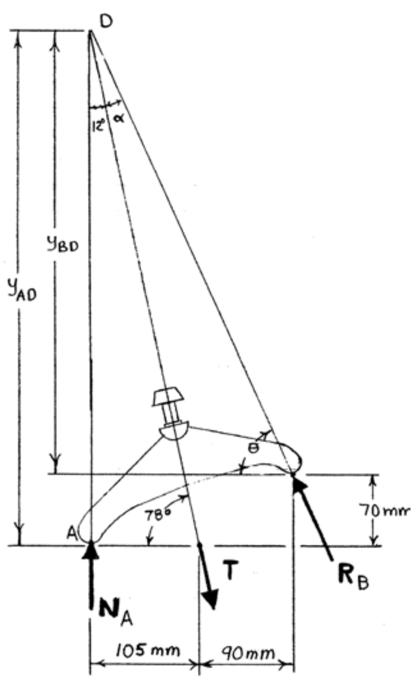
or $\mathbf{A} = 10.68\text{ kN} \nwarrow 73.4°$ ◀

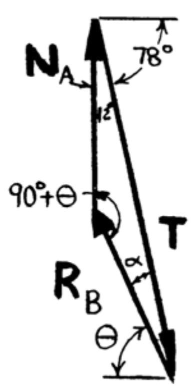
PROBLEM 4.78



The clamp shown is used to hold the rough workpiece *C*. Knowing that the maximum allowable compressive force on the workpiece is 200 N and neglecting the effect of friction at *A*, determine the corresponding (*a*) reaction at *B*, (*b*) reaction at *A*, (*c*) tension in the bolt.

SOLUTION





From the geometry of the three forces acting on the clamp

$$y_{AD} = (105 \text{ mm})\tan 78° = 493.99 \text{ mm}$$

$$y_{BD} = y_{AD} - 70 \text{ mm} = (493.99 - 70) \text{ mm} = 423.99 \text{ mm}$$

Then $$\theta = \tan^{-1}\left(\frac{y_{BD}}{195 \text{ mm}}\right) = \tan^{-1}\left(\frac{423.99}{195}\right) = 65.301°$$

$$\alpha = 90° - \theta - 12° = 78° - 65.301° = 12.6987°$$

(*a*) Based on the maximum allowable compressive force on the workpiece of 200 N,

$$(R_B)_y = 200 \text{ N}$$

or $$R_B \sin\theta = 200 \text{ N}$$

$$\therefore R_B = \frac{200 \text{ N}}{\sin 65.301°} = 220.14 \text{ N}$$

or $\mathbf{R}_B = 220 \text{ N} \searrow 65.3°$ ◀

Applying the law of sines to the force triangle,

$$\frac{R_B}{\sin 12°} = \frac{N_A}{\sin\alpha} = \frac{T}{\sin(90° + \theta)}$$

or $$\frac{220.14 \text{ N}}{\sin 12°} = \frac{N_A}{\sin 12.6987°} = \frac{T}{\sin 155.301°}$$

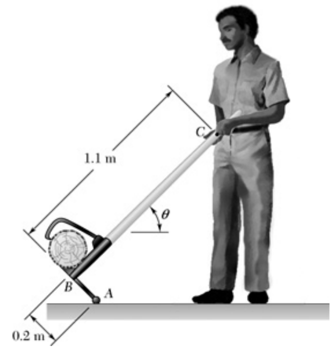
(*b*) $$N_A = 232.75 \text{ N}$$

or $\mathbf{N}_A = 233 \text{ N} \uparrow$ ◀

(*c*) $$T = 442.43 \text{ N}$$

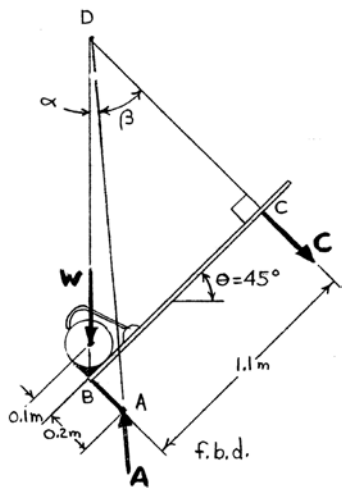
or $T = 442 \text{ N}$ ◀

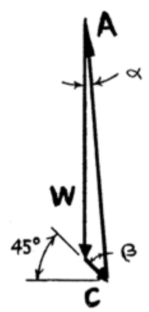
PROBLEM 4.79



A modified peavey is used to lift a 0.2-m-diameter log of mass 36 kg. Knowing that $\theta = 45°$ and that the force exerted at C by the worker is perpendicular to the handle of the peavey, determine (*a*) the force exerted at C, (*b*) the reaction at A.

SOLUTION





First note $\quad W = mg = (36\text{ kg})(9.81\text{ m/s}^2) = 353.16\text{ N}$

From the geometry of the three forces acting on the modified peavey

$$\beta = \tan^{-1}\left(\frac{1.1\text{ m}}{1.1\text{ m} + 0.2\text{ m}}\right) = 40.236°$$

$$\alpha = 45° - \beta = 45° - 40.236° = 4.7636°$$

Applying the law of sines to the force triangle,

$$\frac{W}{\sin\beta} = \frac{C}{\sin\alpha} = \frac{A}{\sin 135°}$$

or

$$\frac{353.16\text{ N}}{\sin 40.236°} = \frac{C}{\sin 4.7636} = \frac{A}{\sin 135°}$$

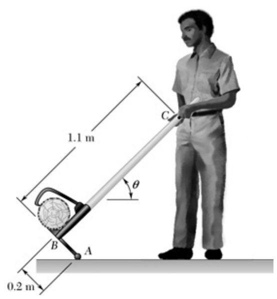
(*a*) $\quad C = 45.404\text{ N}$

or $\mathbf{C} = 45.4\text{ N}$ ⦨ $45.0°$ ◀

(*b*) $\quad A = 386.60\text{ N}$

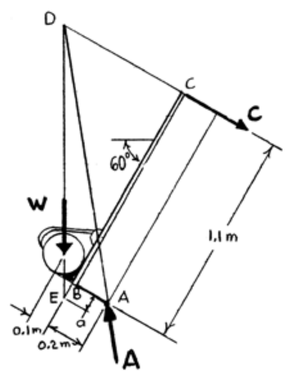
or $\mathbf{A} = 387\text{ N}$ ⦨ $85.2°$ ◀

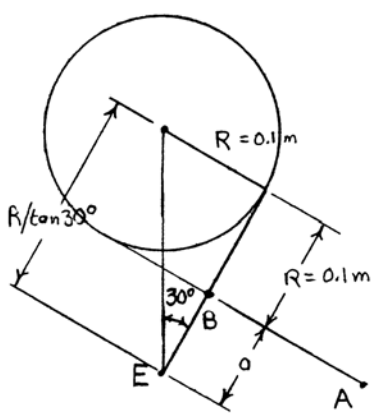
PROBLEM 4.80

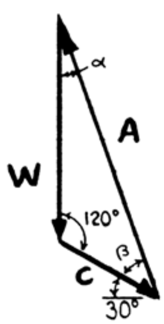


A modified peavey is used to lift a 0.2-m-diameter log of mass 36 kg. Knowing that $\theta = 60°$ and that the force exerted at C by the worker is perpendicular to the handle of the peavey, determine (a) the force exerted at C, (b) the reaction at A.

SOLUTION







First note $\quad W = mg = (36\text{ kg})(9.81\text{ m/s}^2) = 353.16\text{ N}$

From the geometry of the three forces acting on the modified peavey

$$\beta = \tan^{-1}\left(\frac{1.1\text{ m}}{DC + 0.2\text{ m}}\right)$$

where $\quad DC = (1.1\text{ m} + a)\tan 30°$

$$a = \left(\frac{R}{\tan 30°}\right) - R$$

$$= \left(\frac{0.1\text{ m}}{\tan 30°}\right) - 0.1\text{ m}$$

$$= 0.073205\text{ m}$$

$$\therefore\ DC = (1.173205)\tan 30°$$

$$= 0.67735\text{ m}$$

and $\quad \beta = \tan^{-1}\left(\frac{1.1}{0.87735}\right) = 51.424°$

$$\alpha = 60° - \beta = 60° - 51.424° = 8.5756°$$

Applying the law of sines to the force triangle,

$$\frac{W}{\sin\beta} = \frac{C}{\sin\alpha} = \frac{A}{\sin 120°}$$

or $\quad \dfrac{353.16\text{ N}}{\sin 51.424°} = \dfrac{C}{\sin 8.5756°} = \dfrac{A}{\sin 120°}$

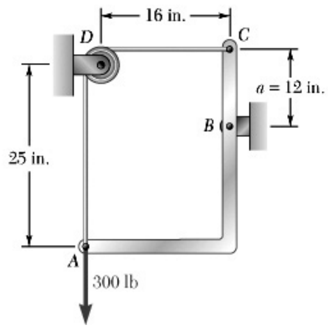
(a) $\quad C = 67.360\text{ N}$

or $\mathbf{C} = 67.4\text{ N}$ ⦬ $30°$ ◀

(b) $\quad A = 391.22\text{ N}$

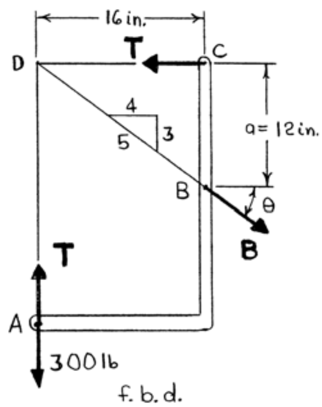
or $\mathbf{A} = 391\text{ N}$ ⦪ $81.4°$ ◀

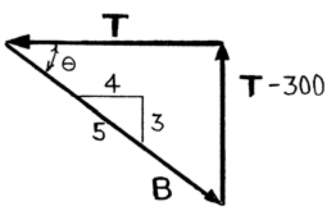
PROBLEM 4.81



Member *ABC* is supported by a pin and bracket at *B* and by an inextensible cord at *A* and *C* and passing over a frictionless pulley at *D*. The tension may be assumed to be the same in portion *AD* and *CD* of the cord. For the loading shown and neglecting the size of the pulley, determine the tension in the cord and the reaction at *B*.

SOLUTION





From the f.b.d. of member *ABC*, it is seen that the member can be treated as a three-force body.

From the force triangle

$$\frac{T - 300}{T} = \frac{3}{4}$$

$$3T = 4T - 1200$$

$$\therefore \quad T = 1200 \text{ lb} \blacktriangleleft$$

Also,

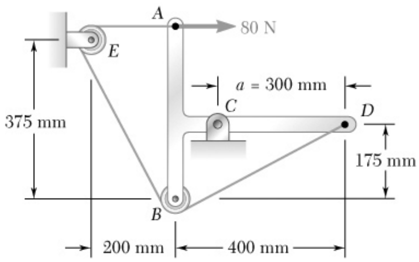
$$\frac{B}{T} = \frac{5}{4}$$

$$\therefore \quad B = \frac{5}{4}T = \frac{5}{4}(1200 \text{ lb}) = 1500 \text{ lb}$$

$$\theta = \tan^{-1}\left(\frac{3}{4}\right) = 36.870°$$

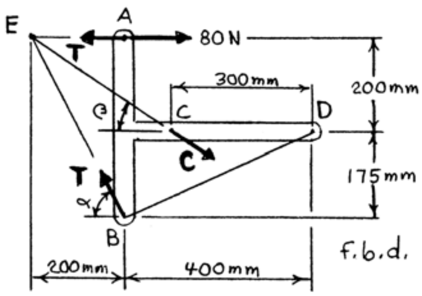
and $\mathbf{B} = 1500 \text{ lb} \searrow 36.9° \blacktriangleleft$

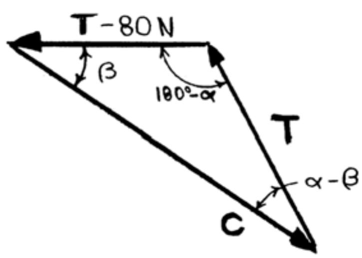
PROBLEM 4.82



Member *ABCD* is supported by a pin and bracket at *C* and by an inextensible cord attached at *A* and *D* and passing over frictionless pulleys at *B* and *E*. Neglecting the size of the pulleys, determine the tension in the cord and the reaction at *C*.

SOLUTION





From the geometry of the forces acting on member *ABCD*

$$\beta = \tan^{-1}\left(\frac{200}{300}\right) = 33.690°$$

$$\alpha = \tan^{-1}\left(\frac{375}{200}\right) = 61.928°$$

$$\alpha - \beta = 61.928° - 33.690° = 28.237°$$

$$180° - \alpha = 180° - 61.928° = 118.072°$$

Applying the law of sines to the force triangle,

$$\frac{T - 80\text{ N}}{\sin(\alpha - \beta)} = \frac{T}{\sin\beta} = \frac{C}{\sin(180° - \alpha)}$$

or

$$\frac{T - 80\text{ N}}{\sin 28.237°} = \frac{T}{\sin 33.690°} = \frac{C}{\sin 118.072°}$$

Then

$$(T - 80\text{ N})\sin 33.690° = T\sin 28.237°$$

$$\therefore\ T = 543.96\text{ N}$$

or $\text{T} = 544\text{ N}$ ◀

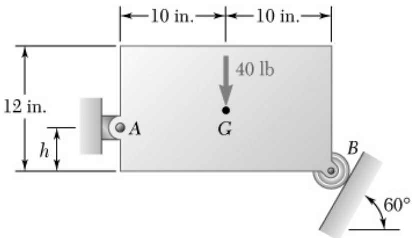
and

$$(543.96\text{ N})\sin 118.072 = C\sin 33.690°$$

$$\therefore\ C = 865.27\text{ N}$$

or $\mathbf{C} = 865\text{ N}$ ⦬ $33.7°$ ◀

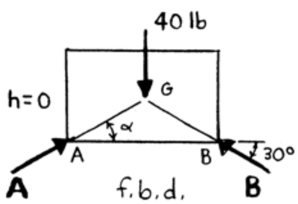
PROBLEM 4.83



Using the method of Section 4.7, solve Problem 4.18.

P4.18 Determine the reactions at *A* and *B* when (*a*) $h = 0$, (*b*) $h = 8$ in.

SOLUTION



(*a*) Based on symmetry

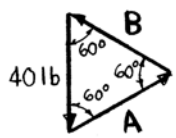
$$\alpha = 30°$$

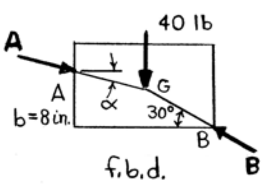
From force triangle

$$A = B = 40 \text{ lb}$$

or **A** = 40.0 lb ∠ 30° ◀

and **B** = 40.0 lb ∠ 30° ◀





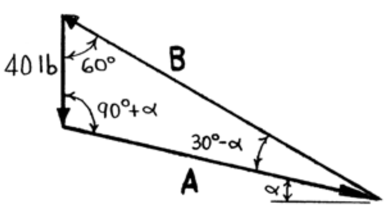
(*b*) From geometry of forces

$$\alpha = \tan^{-1}\left(\frac{8 \text{ in.} - (10 \text{ in.})\tan 30°}{10 \text{ in.}}\right) = 12.5521°$$

Also,

$$30° - \alpha = 30° - 12.5521° = 17.4479°$$

$$90° + \alpha = 90° + 12.5521° = 102.5521°$$



Applying law of sines to the force triangle,

$$\frac{40 \text{ lb}}{\sin(30° - \alpha)} = \frac{A}{\sin 60°} = \frac{B}{\sin(90° + \alpha)}$$

or

$$\frac{40 \text{ lb}}{\sin 17.4479°} = \frac{A}{\sin 60°} = \frac{B}{\sin 102.5521}$$

$$A = 115.533 \text{ lb}$$

or **A** = 115.5 lb ∠ 12.55° ◀

$$B = 130.217 \text{ lb}$$

or **B** = 130.2 lb ∠ 30.0° ◀