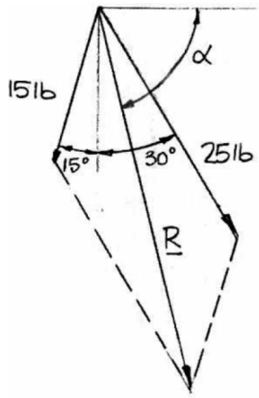
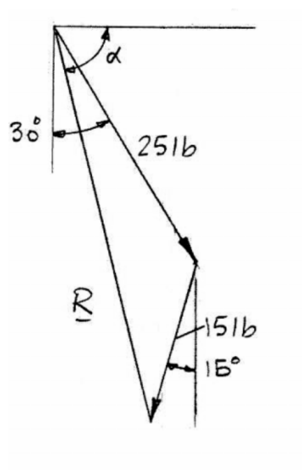
Chapter 2, Solution 1.

(*a*)



(*b*)

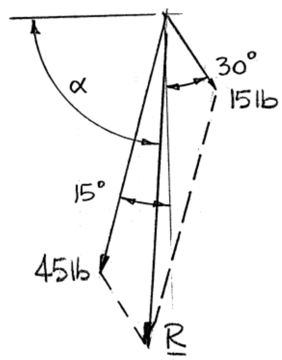


We measure: $R = 37$ lb, $\alpha = 76°$

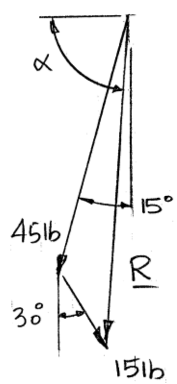
R = 37 lb ↘ 76° ◀

Chapter 2, Solution 2.

(*a*)



(*b*)

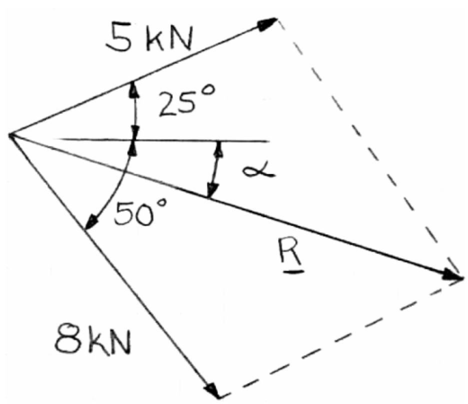


We measure: $R = 57$ lb, $\alpha = 86°$

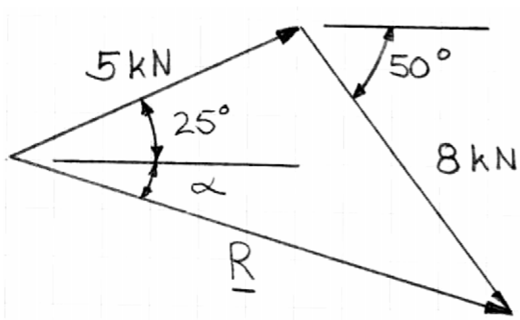
R = 57 lb ↙ 86° ◀

Chapter 2, Solution 3.

(*a*) Parallelogram law:



(*b*) Triangle rule:



We measure:

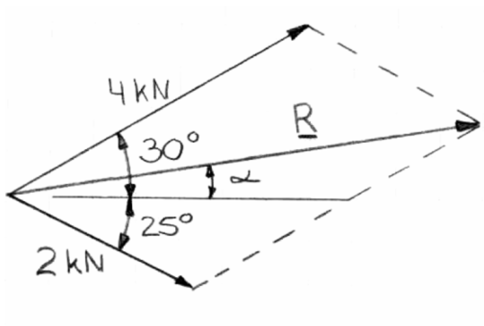
$R = 10.5$ kN

$\alpha = 22.5°$

R = 10.5 kN ⦪ 22.5° ◀

Chapter 2, Solution 4.

(*a*) Parallelogram law:

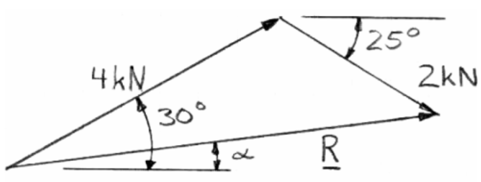


We measure:

$R = 5.4$ kN $\alpha = 12°$

R = 5.4 kN ∡ 12° ◀

(*b*) Triangle rule:

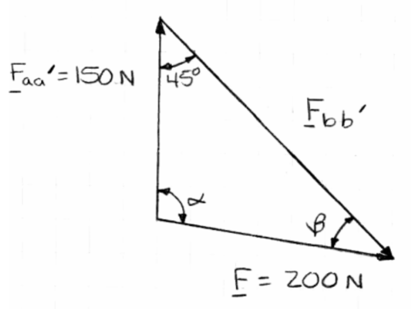


We measure:

$R = 5.4$ kN $\alpha = 12°$

R = 5.4 kN ∡ 12° ◀

Chapter 2, Solution 5.



Using the triangle rule and the Law of Sines

(*a*) $$\frac{\sin\beta}{150\text{ N}} = \frac{\sin 45^\circ}{200\text{ N}}$$

$$\sin\beta = 0.53033$$

$$\beta = 32.028^\circ$$

$$\alpha + \beta + 45^\circ = 180^\circ$$

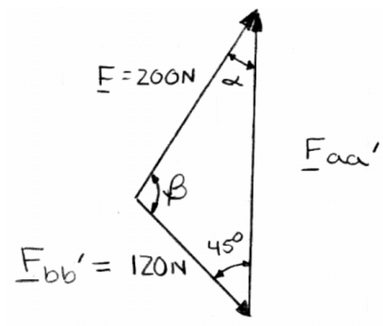
$\alpha = 103.0^\circ$ ◀

(*b*) Using the Law of Sines

$$\frac{F_{bb'}}{\sin\alpha} = \frac{200\text{ N}}{\sin 45^\circ}$$

$F_{bb'} = 276\text{ N}$ ◀

Chapter 2, Solution 6.



Using the triangle rule and the Law of Sines

(*a*)

$$\frac{\sin\alpha}{120\text{ N}} = \frac{\sin 45^\circ}{200\text{ N}}$$

$$\sin\alpha = 0.42426$$

$$\alpha = 25.104^\circ$$

or $\alpha = 25.1^\circ$ ◀

(*b*)

$$\beta + 45^\circ + 25.104^\circ = 180^\circ$$

$$\beta = 109.896^\circ$$

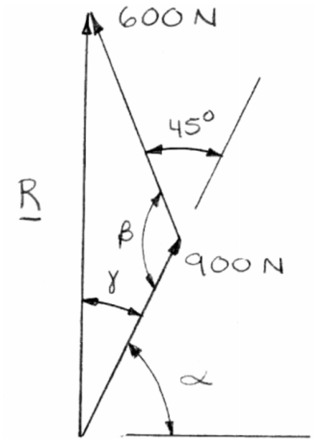
Using the Law of Sines

$$\frac{F_{aa'}}{\sin\beta} = \frac{200\text{ N}}{\sin 45^\circ}$$

$$\frac{F_{aa'}}{\sin 109.896^\circ} = \frac{200\text{ N}}{\sin 45^\circ}$$

or $F_{aa'} = 266\text{ N}$ ◀

Chapter 2, Solution 7.



Using the triangle rule and the Law of Cosines,

Have: $\beta = 180° - 45°$

$\beta = 135°$

Then:

$$R^2 = (900)^2 + (600)^2 - 2(900)(600)\cos 135°$$

or $R = 1390.57$ N

Using the Law of Sines,

$$\frac{600}{\sin\gamma} = \frac{1390.57}{\sin 135°}$$

or $\gamma = 17.7642°$

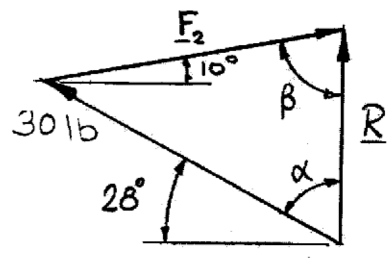
and $\alpha = 90° - 17.7642°$

$\alpha = 72.236°$

(*a*) $\alpha = 72.2°$ ◀

(*b*) $R = 1.391$ kN ◀

Chapter 2, Solution 8.



By trigonometry: Law of Sines

$$\frac{F_2}{\sin\alpha} = \frac{R}{\sin 38°} = \frac{30}{\sin\beta}$$

$$\alpha = 90° - 28° = 62°, \beta = 180° - 62° - 38° = 80°$$

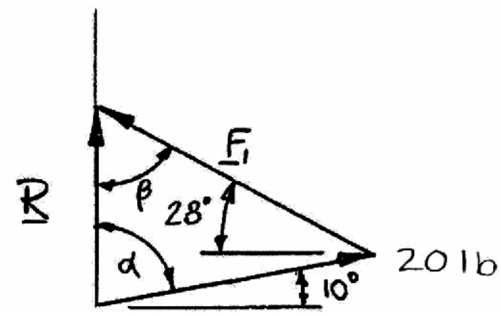
Then:

$$\frac{F_2}{\sin 62°} = \frac{R}{\sin 38°} = \frac{30 \text{ lb}}{\sin 80°}$$

or (*a*) $F_2 = 26.9$ lb ◀

(*b*) $R = 18.75$ lb ◀

Chapter 2, Solution 9.



Using the Law of Sines

$$\frac{F_1}{\sin\alpha} = \frac{R}{\sin 38°} = \frac{20\text{ lb}}{\sin\beta}$$

$$\alpha = 90° - 10° = 80°, \beta = 180° - 80° - 38° = 62°$$

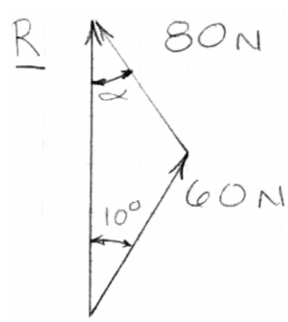
Then:

$$\frac{F_1}{\sin 80°} = \frac{R}{\sin 38°} = \frac{20\text{ lb}}{\sin 62°}$$

or (*a*) $F_1 = 22.3$ lb ◀

(*b*) $R = 13.95$ lb ◀

Chapter 2, Solution 10.



Using the Law of Sines: $\dfrac{60\text{ N}}{\sin\alpha} = \dfrac{80\text{ N}}{\sin 10°}$

or $\alpha = 7.4832°$

$\beta = 180° - (10° + 7.4832°)$

$= 162.517°$

Then:

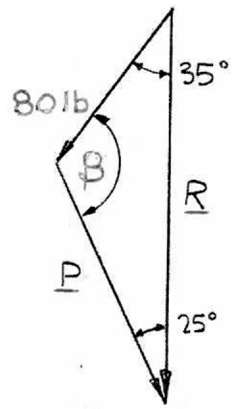
$$\frac{R}{\sin 162.517°} = \frac{80\text{ N}}{\sin 10°}$$

or $R = 138.405$ N

(*a*) $\alpha = 7.48°$ ◀

(*b*) $R = 138.4$ N ◀

Chapter 2, Solution 11.



Using the triangle rule and the Law of Sines

Have: $\beta = 180° - (35° + 25°)$

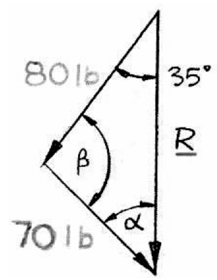
$= 120°$

Then: $\dfrac{P}{\sin 35°} = \dfrac{R}{\sin 120°} = \dfrac{80\text{ lb}}{\sin 25°}$

or (*a*) $P = 108.6$ lb ◀

(*b*) $R = 163.9$ lb ◀

Chapter 2, Solution 12.



Using the triangle rule and the Law of Sines

(*a*) Have:

$$\frac{80\text{ lb}}{\sin\alpha} = \frac{70\text{ lb}}{\sin 35°}$$

$$\sin\alpha = 0.65552$$

$$\alpha = 40.959°$$

or $\alpha = 41.0°$ ◀

(*b*)

$$\beta = 180 - \left(35° + 40.959°\right)$$

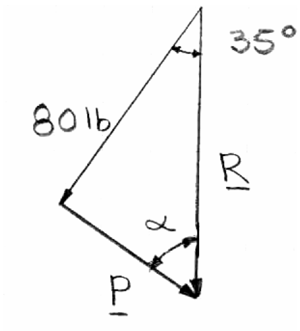
$$= 104.041°$$

Then:

$$\frac{R}{\sin 104.041°} = \frac{70\text{ lb}}{\sin 35°}$$

or $R = 118.4$ lb ◀

Chapter 2, Solution 13.



We observe that force **P** is minimum when $\alpha = 90°$.

Then:

(a) $P = (80 \text{ lb})\sin 35°$

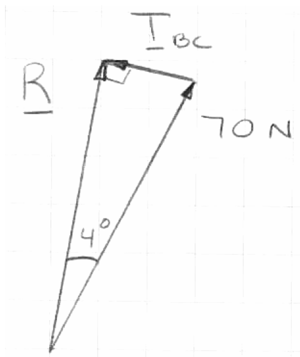
or **P** = 45.9 lb $\longrightarrow$ ◀

And:

(b) $R = (80 \text{ lb})\cos 35°$

or **R** = 65.5 lb ◀

Chapter 2, Solution 14.



For T_{BC} to be a minimum,

R and T_{BC} must be perpendicular.

Thus $T_{BC} = (70 \text{ N})\sin 4°$

$= 4.8829 \text{ N}$

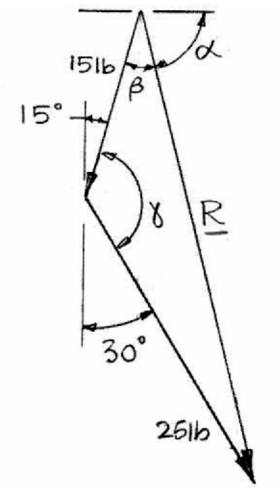
And $R = (70 \text{ N})\cos 4°$

$= 69.829 \text{ N}$

(*a*) $T_{BC} = 4.88 \text{ N}$ ⦬ $6.00°$ ◀

(*b*) $R = 69.8 \text{ N}$ ◀

Chapter 2, Solution 15.



Using the force triangle and the Laws of Cosines and Sines

We have:

$$\gamma = 180^\circ - (15^\circ + 30^\circ)$$

$$= 135^\circ$$

Then: $$R^2 = (15\text{ lb})^2 + (25\text{ lb})^2 - 2(15\text{ lb})(25\text{ lb})\cos 135^\circ$$

$$= 1380.33\text{ lb}^2$$

or $$R = 37.153\text{ lb}$$

and

$$\frac{25\text{ lb}}{\sin\beta} = \frac{37.153\text{ lb}}{\sin 135^\circ}$$

$$\sin\beta = \left(\frac{25\text{ lb}}{37.153\text{ lb}}\right)\sin 135^\circ$$

$$= 0.47581$$

$$\beta = 28.412^\circ$$

Then: $$\alpha + \beta + 75^\circ = 180^\circ$$

$$\alpha = 76.588^\circ$$

$\mathbf{R} = 37.2\text{ lb}$ ⦪ 76.6° ◀

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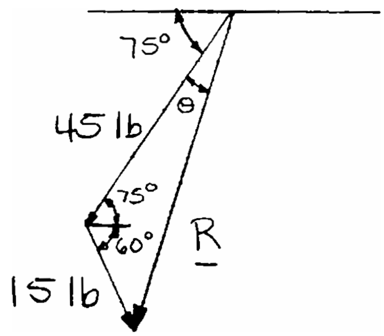
Chapter 2, Solution 16.



Using the Law of Cosines and the Law of Sines,

$$R^2 = (45 \text{ lb})^2 + (15 \text{ lb})^2 - 2(45 \text{ lb})(15 \text{ lb})\cos 135°$$

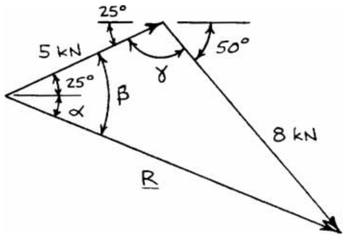
or $R = 56.609$ lb

$$\frac{56.609 \text{ lb}}{\sin 135°} = \frac{15 \text{ lb}}{\sin\theta}$$

or $\theta = 10.7991°$

R = 56.6 lb ⦣ 85.8° ◀

Chapter 2, Solution 17.



$\gamma = 180° - 25° - 50°$

$\gamma = 105°$

Using the Law of Cosines:

$$R^2 = (5 \text{ kN})^2 + (8 \text{ kN})^2 - 2(5 \text{ kN})(8 \text{ kN})\cos 105°$$

or $R = 10.4740$ kN

Using the Law of Sines:

$$\frac{10.4740 \text{ kN}}{\sin 105°} = \frac{8 \text{ kN}}{\sin \beta}$$

or $\beta = 47.542°$

and $\alpha = 47.542° - 25°$

$\alpha = 22.542°$

$\mathbf{R} = 10.47$ kN ⦪ 22.5° ◀

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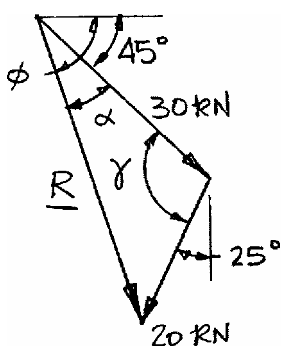
Chapter 2, Solution 19.



Using the force triangle and the Laws of Cosines and Sines

We have: $\gamma = 180° - (45° + 25°) = 110°$

Then: $R^2 = (30\text{ kN})^2 + (20\text{ kN})^2 - 2(30\text{ kN})(20\text{ kN})\cos 110°$

$= 1710.42\text{ kN}^2$

$R = 41.357\text{ kN}$

and

$$\frac{20\text{ kN}}{\sin\alpha} = \frac{41.357\text{ kN}}{\sin 110°}$$

$$\sin\alpha = \left(\frac{20\text{ kN}}{41.357\text{ kN}}\right)\sin 110°$$

$$= 0.45443$$

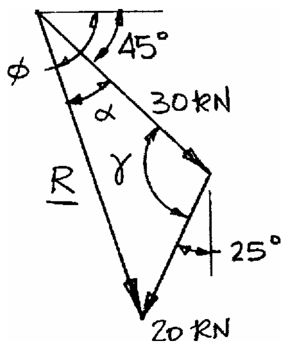
$$\alpha = 27.028°$$

Hence: $\phi = \alpha + 45° = 72.028°$

R $= 41.4\text{ kN}$ ⦣ $72.0°$ ◀

Vector Mechanics for Engineers: Statics and Dynamics, 8/e, Ferdinand P. Beer, E. Russell Johnston, Jr., Elliot R. Eisenberg, William E. Clausen, David Mazurek, Phillip J. Cornwell

Chapter 2, Solution 19.



Using the force triangle and the Laws of Cosines and Sines

We have: $\gamma = 180° - (45° + 25°) = 110°$

Then: $R^2 = (30 \text{ kN})^2 + (20 \text{ kN})^2 - 2(30 \text{ kN})(20 \text{ kN})\cos 110°$

$= 1710.42 \text{ kN}^2$

$R = 41.357 \text{ kN}$

and

$$\frac{20 \text{ kN}}{\sin\alpha} = \frac{41.357 \text{ kN}}{\sin 110°}$$

$$\sin\alpha = \left(\frac{20 \text{ kN}}{41.357 \text{ kN}}\right)\sin 110°$$

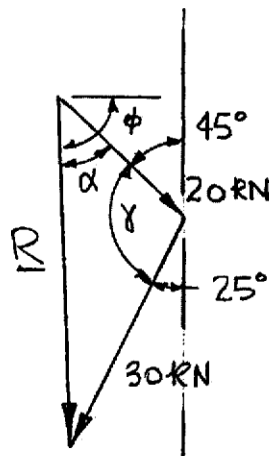
$$= 0.45443$$

$$\alpha = 27.028°$$

Hence: $\phi = \alpha + 45° = 72.028°$

$\mathbf{R} = 41.4 \text{ kN}$ ⦪ $72.0°$ ◀

Chapter 2, Solution 20.



Using the force triangle and the Laws of Cosines and Sines

We have: $\gamma = 180° - (45° + 25°) = 110°$

Then: $R^2 = (30\text{ kN})^2 + (20\text{ kN})^2 - 2(30\text{ kN})(20\text{ kN})\cos 110°$

$= 1710.42\text{ kN}^2$

$R = 41.357\text{ kN}$

and

$$\frac{30\text{ kN}}{\sin\alpha} = \frac{41.357\text{ kN}}{\sin 110°}$$

$$\sin\alpha = \left(\frac{30\text{ kN}}{41.357\text{ kN}}\right)\sin 110°$$

$$= 0.68164$$

$$\alpha = 42.972°$$

Finally: $\phi = \alpha + 45° = 87.972°$

$\mathbf{R} = 41.4\text{ kN} \nwarrow 88.0°$ ◀

Chapter 2, Solution 21.

2.4 kN Force: $F_x = (2.4 \text{ kN})\cos 50°$

$F_x = 1.543 \text{ kN}$ ◀

$F_y = (2.4 \text{ kN})\sin 50°$

$F_y = 1.839 \text{ kN}$ ◀

1.85 kN Force: $F_x = (1.85 \text{ kN})\cos 20°$

$F_x = 1.738 \text{ kN}$ ◀

$F_y = (1.85 \text{ kN})\sin 20°$

$F_y = 0.633 \text{ kN}$ ◀

1.40 kN Force: $F_x = (1.40 \text{ kN})\cos 35°$

$F_x = 1.147 \text{ kN}$ ◀

$F_y = -(1.40 \text{ kN})\sin 35°$

$F_y = -0.803 \text{ kN}$ ◀

Chapter 2, Solution 22.

5 kips: $F_x = (5 \text{ kips})\cos 40^\circ$

or $F_x = 3.83 \text{ kips}$ ◀

$F_y = (5 \text{ kips})\sin 40^\circ$

or $F_y = 3.21 \text{ kips}$ ◀

7 kips: $F_x = -(7 \text{ kips})\cos 70^\circ$

or $F_x = -2.39 \text{ kips}$ ◀

$F_y = (7 \text{ kips})\sin 70^\circ$

or $F_y = 6.58 \text{ kips}$ ◀

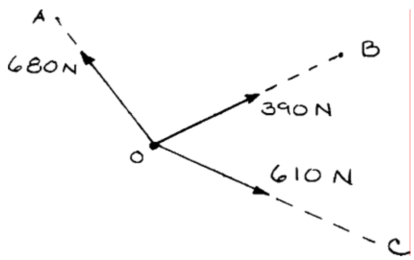
9 kips: $F_x = -(9 \text{ kips})\cos 20^\circ$

or $F_x = -8.46 \text{ kips}$ ◀

$F_y = (9 \text{ kips})\sin 20^\circ$

or $F_y = 3.08 \text{ kips}$ ◀

Chapter 2, Solution 23.



Determine the following distances:

$$d_{OA} = \sqrt{(-160 \text{ mm})^2 + (300 \text{ mm})^2} = 340 \text{ mm}$$

$$d_{OB} = \sqrt{(600 \text{ mm})^2 + (250 \text{ mm})^2} = 650 \text{ mm}$$

$$d_{OC} = \sqrt{(600 \text{ mm})^2 + (-110 \text{ mm})^2} = 610 \text{ mm}$$

680 N Force:

$$F_x = 680 \text{ N}\frac{(-160 \text{ mm})}{340 \text{ mm}}$$

$F_x = -320 \text{ N}$ ◀

$$F_y = 680 \text{ N}\frac{(300 \text{ mm})}{340 \text{ mm}}$$

$F_y = 600 \text{ N}$ ◀

390 N Force:

$$F_x = 390 \text{ N}\frac{(600 \text{ mm})}{650 \text{ mm}}$$

$F_x = 360 \text{ N}$ ◀

$$F_y = 390 \text{ N}\frac{(250 \text{ mm})}{650 \text{ mm}}$$

$F_y = 150 \text{ N}$ ◀

610 N Force:

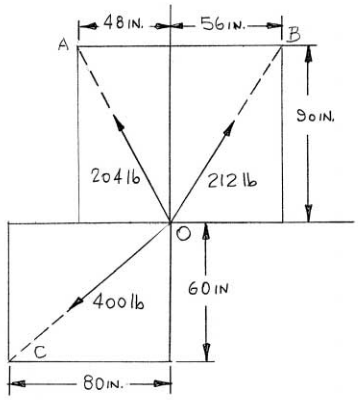
$$F_x = 610 \text{ N}\frac{(600 \text{ mm})}{610 \text{ mm}}$$

$F_x = 600 \text{ N}$ ◀

$$F_y = 610 \text{ N}\frac{(-110 \text{ mm})}{610 \text{ mm}}$$

$F_y = -110 \text{ N}$ ◀

Chapter 2, Solution 24.



We compute the following distances:

$$OA = \sqrt{(48)^2 + (90)^2} = 102 \text{ in.}$$

$$OB = \sqrt{(56)^2 + (90)^2} = 106 \text{ in.}$$

$$OC = \sqrt{(80)^2 + (60)^2} = 100 \text{ in.}$$

Then:

204 lb Force:

$$F_x = -(204 \text{ lb})\frac{48}{102}, \qquad F_x = -96.0 \text{ lb} \blacktriangleleft$$

$$F_y = +(204 \text{ lb})\frac{90}{102}, \qquad F_y = 180.0 \text{ lb} \blacktriangleleft$$

212 lb Force:

$$F_x = +(212 \text{ lb})\frac{56}{106}, \qquad F_x = 112.0 \text{ lb} \blacktriangleleft$$

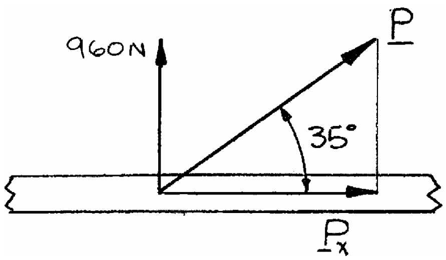
$$F_y = +(212 \text{ lb})\frac{90}{106}, \qquad F_y = 180.0 \text{ lb} \blacktriangleleft$$

400 lb Force:

$$F_x = -(400 \text{ lb})\frac{80}{100}, \qquad F_x = -320 \text{ lb} \blacktriangleleft$$

$$F_y = -(400 \text{ lb})\frac{60}{100}, \qquad F_y = -240 \text{ lb} \blacktriangleleft$$

Chapter 2, Solution 25.



(*a*)

$$P = \frac{P_y}{\sin 35°}$$

$$= \frac{960 \text{ N}}{\sin 35°}$$

or $P = 1674 \text{ N}$ ◀

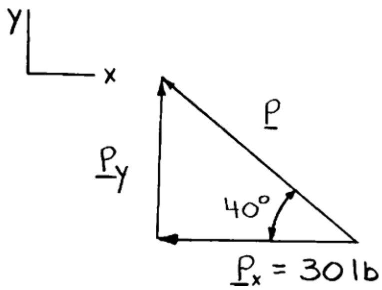
(*b*)

$$P_x = \frac{P_y}{\tan 35°}$$

$$= \frac{960 \text{ N}}{\tan 35°}$$

or $P_x = 1371 \text{ N}$ ◀

Chapter 2, Solution 26.



(*a*) $P = \dfrac{P_x}{\cos 40°}$

$P = \dfrac{30 \text{ lb}}{\cos 40°}$

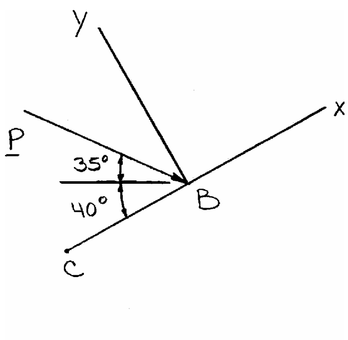
or $P = 39.2$ lb ◀

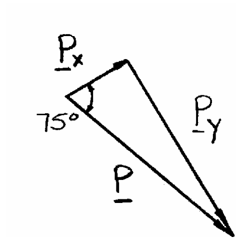
(*b*) $P_y = P_x \tan 40°$

$P_y = (30 \text{ lb}) \tan 40°$

or $P_y = 25.2$ lb ◀

Chapter 2, Solution 27.





(*a*) $P_y = 100 \text{ N}$

$$P = \frac{P_y}{\sin 75°}$$

$$P = \frac{100 \text{ N}}{\sin 75°}$$

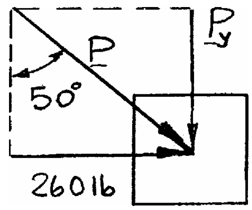
or $P = 103.5 \text{ N}$ ◀

(*b*) $$P_x = \frac{P_y}{\tan 75°}$$

$$P_x = \frac{100 \text{ N}}{\tan 75°}$$

or $P_x = 26.8 \text{ N}$ ◀

Chapter 2, Solution 28.



We note:

CB exerts force **P** on *B* along *CB*, and the horizontal component of **P** is $P_x = 260 \text{ lb}$.

Then:

(*a*) $$P_x = P\sin 50°$$

$$P = \frac{P_x}{\sin 50°}$$

$$= \frac{260 \text{ lb}}{\sin 50°}$$

$$= 339.40 \text{ lb}$$

$P = 339 \text{ lb}$ ◀

(*b*) $$P_x = P_y \tan 50°$$

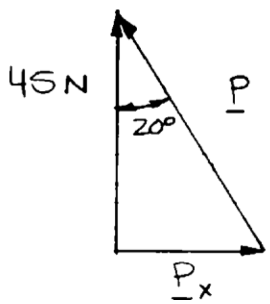
$$P_y = \frac{P_x}{\tan 50°}$$

$$= \frac{260 \text{ lb}}{\tan 50°}$$

$$= 218.16 \text{ lb}$$

$\mathbf{P}_y = 218 \text{ lb} \downarrow$ ◀

Chapter 2, Solution 29.



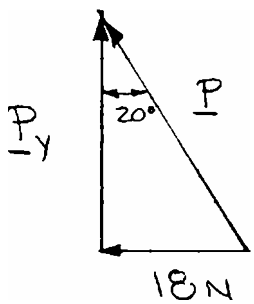
(*a*) $P = \dfrac{45\text{ N}}{\cos 20°}$

or $P = 47.9\text{ N}$ ◀

(*b*) $P_x = (47.9\text{ N})\sin 20°$

or $P_x = 16.38\text{ N}$ ◀

Chapter 2, Solution 30.



(*a*) $P = \dfrac{18 \text{ N}}{\sin 20°}$

or $P = 52.6$ N ◀

(*b*) $P_y = \dfrac{18 \text{ N}}{\tan 20°}$

or $P_y = 49.5$ N ◀

Chapter 2, Solution 31.

From the solution to Problem 2.21:

$$\mathbf{F}_{2.4} = (1.543\text{ kN})\mathbf{i} + (1.839\text{ kN})\mathbf{j}$$

$$\mathbf{F}_{1.85} = (1.738\text{ kN})\mathbf{i} + (0.633\text{ kN})\mathbf{j}$$

$$\mathbf{F}_{1.40} = (1.147\text{ kN})\mathbf{i} - (0.803\text{ kN})\mathbf{j}$$

$$\mathbf{R} = \Sigma\mathbf{F} = (4.428\text{ kN})\mathbf{i} + (1.669\text{ kN})\mathbf{j}$$

$$R = \sqrt{(4.428\text{ kN})^2 + (1.669\text{ kN})^2}$$

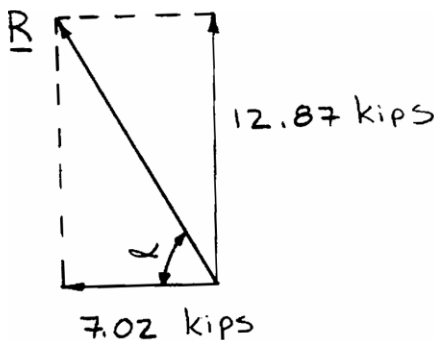
$$= 4.7321\text{ kN}$$

$$\tan\alpha = \frac{1.669\text{ kN}}{4.428\text{ kN}}$$

$$\alpha = 20.652°$$

$$\mathbf{R} = 4.73\text{ kN} \measuredangle\ 20.6° \blacktriangleleft$$

Chapter 2, Solution 32.



From the solution to Problem 2.22:

$$\mathbf{F}_5 = (3.83 \text{ kips})\mathbf{i} + (3.21 \text{ kips})\mathbf{j}$$

$$\mathbf{F}_7 = -(2.39 \text{ kips})\mathbf{i} + (6.58 \text{ kips})\mathbf{j}$$

$$\mathbf{F}_9 = -(8.46 \text{ kips})\mathbf{i} + (3.08 \text{ kips})\mathbf{j}$$

$$\mathbf{R} = \Sigma\mathbf{F} = -(7.02 \text{ kips})\mathbf{i} + (12.87)\mathbf{j}$$

$$R = \sqrt{(-7.02 \text{ kips})^2 + (12.87 \text{ kips})^2} = 14.66 \text{ kips}$$

$$\alpha = \tan^{-1}\left(\frac{12.87}{-7.02}\right) = 61.4°$$

$\mathbf{R} = 14.66$ kips ⦪ 61.4° ◀

Chapter 2, Solution 33.

From the solution to Problem 2.24:

$$\mathbf{F}_{OA} = -(48.0\text{ lb})\mathbf{i} + (90.0\text{ lb})\mathbf{j}$$

$$\mathbf{F}_{OB} = (112.0\text{ lb})\mathbf{i} + (180.0\text{ lb})\mathbf{j}$$

$$\mathbf{F}_{OC} = -(320\text{ lb})\mathbf{i} - (240\text{ lb})\mathbf{j}$$

$$\mathbf{R} = \Sigma\mathbf{F} = -(256\text{ lb})\mathbf{i} + (30\text{ lb})\mathbf{j}$$

$$R = \sqrt{(-256\text{ lb})^2 + (30\text{ lb})^2}$$

$$= 257.75\text{ lb}$$

$$\tan\alpha = \frac{30\text{ lb}}{-256\text{ lb}}$$

$$\alpha = -6.6839°$$

$\mathbf{R} = 258\text{ lb}$ ⦣ $6.68°$ ◀

Chapter 2, Solution 34.

From Problem 2.23:

$$\mathbf{F}_{OA} = -(320\text{ N})\mathbf{i} + (600\text{ N})\mathbf{j}$$

$$\mathbf{F}_{OB} = (360\text{ N})\mathbf{i} + (150\text{ N})\mathbf{j}$$

$$\mathbf{F}_{OC} = (600\text{ N})\mathbf{i} - (110\text{ N})\mathbf{j}$$

$$\mathbf{R} = \Sigma\mathbf{F} = (640\text{ N})\mathbf{i} + (640\text{ N})\mathbf{j}$$

$$R = \sqrt{(640\text{ N})^2 + (640\text{ N})^2}$$

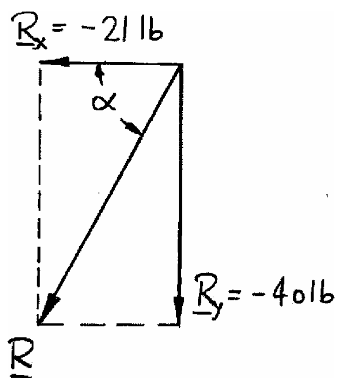
$$= 905.097\text{ N}$$

$$\tan\alpha = \frac{640\text{ N}}{640\text{ N}}$$

$$\alpha = 45.0°$$

$\mathbf{R} = 905\text{ N} \measuredangle 45.0°$ ◀

Chapter 2, Solution 35.



Cable BC Force:

$$F_x = -(145\text{ lb})\frac{84}{116} = -105\text{ lb}$$

$$F_y = (145\text{ lb})\frac{80}{116} = 100\text{ lb}$$

100-lb Force:

$$F_x = -(100\text{ lb})\frac{3}{5} = -60\text{ lb}$$

$$F_y = -(100\text{ lb})\frac{4}{5} = -80\text{ lb}$$

156-lb Force:

$$F_x = (156\text{ lb})\frac{12}{13} = 144\text{ lb}$$

$$F_y = -(156\text{ lb})\frac{5}{13} = -60\text{ lb}$$

and

$$R_x = \Sigma F_x = -21\text{ lb}, \qquad R_y = \Sigma F_y = -40\text{ lb}$$

$$R = \sqrt{(-21\text{ lb})^2 + (-40\text{ lb})^2} = 45.177\text{ lb}$$

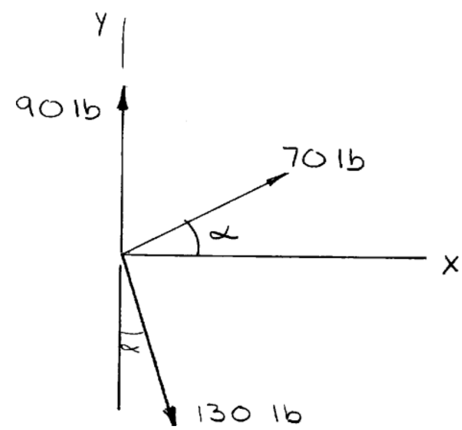
Further:

$$\tan\alpha = \frac{40}{21}$$

$$\alpha = \tan^{-1}\frac{40}{21} = 62.3°$$

Thus: **R** = 45.2 lb ⦩ 62.3° ◀

Chapter 2, Solution 36.



(*a*) Since **R** is to be horizontal, $R_y = 0$

Then, $R_y = \Sigma F_y = 0$

$$90 \text{ lb} + (70 \text{ lb})\sin\alpha - (130 \text{ lb})\cos\alpha = 0$$

$$(13)\cos\alpha = (7)\sin\alpha + 9$$

$$13\sqrt{1-\sin^2\alpha} = (7)\sin\alpha + 9$$

Squaring both sides: $169\left(1-\sin^2\alpha\right) = (49)\sin^2\alpha + (126)\sin\alpha + 81$

$$(218)\sin^2\alpha + (126)\sin\alpha - 88 = 0$$

Solving by quadratic formula: $\sin\alpha = 0.40899$

or $\alpha = 24.1°$ ◀

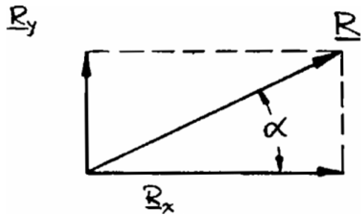
(*b*) Since R is horizontal, $\mathbf{R} = R_x$

Then, $\mathbf{R} = R_x = \Sigma F_x$

$$\Sigma F_x = (70)\cos 24.142° + (130)\sin 24.142°$$

or $R = 117.0 \text{ lb}$ ◀

Chapter 2, Solution 37.



300-N Force:

$$F_x = (300 \text{ N})\cos 20° = 281.91 \text{ N}$$

$$F_y = (300 \text{ N})\sin 20° = 102.61 \text{ N}$$

400-N Force:

$$F_x = (400 \text{ N})\cos 85° = 34.862 \text{ N}$$

$$F_y = (400 \text{ N})\sin 85° = 398.48 \text{ N}$$

600-N Force:

$$F_x = (600 \text{ N})\cos 5° = 597.72 \text{ N}$$

$$F_y = -(600 \text{ N})\sin 5° = -52.293 \text{ N}$$

and

$$R_x = \Sigma F_x = 914.49 \text{ N}$$

$$R_y = \Sigma F_y = 448.80 \text{ N}$$

$$R = \sqrt{(914.49 \text{ N})^2 + (448.80 \text{ N})^2} = 1018.68 \text{ N}$$

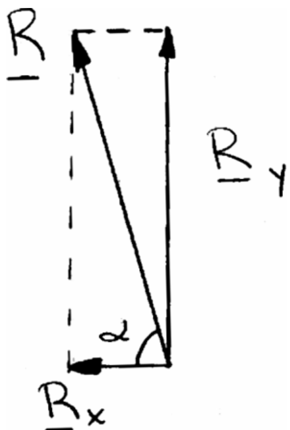
Further:

$$\tan\alpha = \frac{448.80}{914.49}$$

$$\alpha = \tan^{-1}\frac{448.80}{914.49} = 26.1°$$

$\mathbf{R} = 1019 \text{ N} \measuredangle 26.1°$ ◀

Chapter 2, Solution 38.



$\Sigma F_x :$

$R_x = \Sigma F_x$

$R_x = (600\text{ N})\cos 50° + (300\text{ N})\cos 85° - (700\text{ N})\cos 50°$

$R_x = -38.132\text{ N}$

$\Sigma F_y :$

$R_y = \Sigma F_y$

$R_y = (600\text{ N})\sin 50° + (300\text{ N})\sin 85° + (700\text{ N})\sin 50°$

$R_y = 1294.72\text{ N}$

$\mathbf{R} = \sqrt{(-38.132\text{ N})^2 + (1294.72\text{ N})^2}$

$\mathbf{R} = 1295\text{ N}$

$\tan\alpha = \dfrac{1294.72\text{ N}}{38.132\text{ N}}$

$\alpha = 88.3°$

$\mathbf{R} = 1.295\text{ kN} \measuredangle 88.3°$ ◀

Chapter 2, Solution 39.

We have:

$$R_x = \Sigma F_x = -\frac{84}{116}T_{BC} + \frac{12}{13}(156 \text{ lb}) - \frac{3}{5}(100 \text{ lb})$$

or

$$R_x = -0.72414T_{BC} + 84 \text{ lb}$$

and

$$R_y = \Sigma F_y = \frac{80}{116}T_{BC} - \frac{5}{13}(156 \text{ lb}) - \frac{4}{5}(100 \text{ lb})$$

$$R_y = 0.68966T_{BC} - 140 \text{ lb}$$

(*a*) So, for *R* to be vertical,

$$R_x = -0.72414T_{BC} + 84 \text{ lb} = 0$$

$$T_{BC} = 116.0 \text{ lb} \blacktriangleleft$$

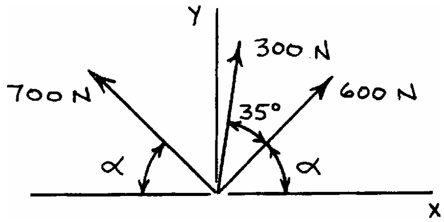
(*b*) Using

$$T_{BC} = 116.0 \text{ lb}$$

$$R = R_y = 0.68966(116.0 \text{ lb}) - 140 \text{ lb} = -60 \text{ lb}$$

$$R = |R| = 60.0 \text{ lb} \blacktriangleleft$$

Chapter 2, Solution 40.



(*a*) Since *R* is to be vertical, $R_x = 0$

Then, $R_x = \Sigma F_x = 0$

$$(600\text{ N})\cos\alpha + (300\text{ N})\cos(\alpha + 35°) - (700\text{ N})\cos\alpha = 0$$

Expanding: $3(\cos\alpha\cos 35° - \sin\alpha\sin 35°) - \cos\alpha = 0$

Then: $$\tan\alpha = \frac{\cos 35° - \left(\frac{1}{3}\right)}{\sin 35°}$$

$$\alpha = 40.265°$$

$\alpha = 40.3°$ ◀

(*b*) Since *R* is vertical, $R = R_y$

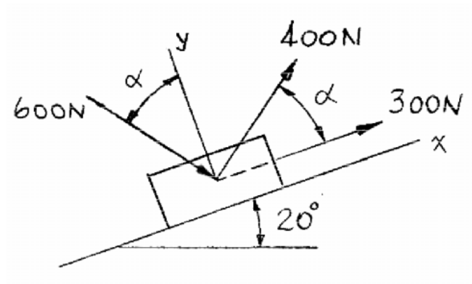
Then: $R = R_y = \Sigma F_y$

$$R = (600\text{ N})\sin 40.265° + (300\text{ N})\sin 75.265° + (700\text{ N})\sin 40.265°$$

$$R = 1130\text{ N}$$

$R = 1.130$ kN ◀

Chapter 2, Solution 41.



Selecting the x axis along aa', we write

$$R_x = \Sigma F_x = 300 \text{ N} + (400 \text{ N})\cos\alpha + (600 \text{ N})\sin\alpha \qquad (1)$$

$$R_y = \Sigma F_y = (400 \text{ N})\sin\alpha - (600 \text{ N})\cos\alpha \qquad (2)$$

(a) Setting $R_y = 0$ in Equation (2):

Thus $$\tan\alpha = \frac{600}{400} = 1.5$$

$\alpha = 56.3°$ ◀

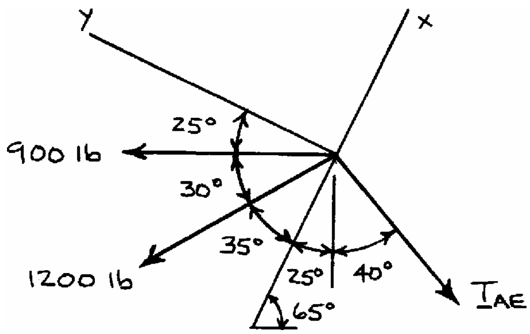
(b) Substituting for α in Equation (1):

$$R_x = 300 \text{ N} + (400 \text{ N})\cos 56.3° + (600 \text{ N})\sin 56.3°$$

$$R_x = 1021.11 \text{ N}$$

$R = R_x = 1021 \text{ N}$ ◀

Chapter 2, Solution 42.



(*a*) Require $R_y = \Sigma F_y = 0$:

$$(900\text{ lb})\cos 25° + (1200\text{ lb})\sin 35° - T_{AE}\sin 65° = 0$$

or $T_{AE} = 1659.45\text{ lb}$

$T_{AE} = 1659\text{ lb}$ ◀

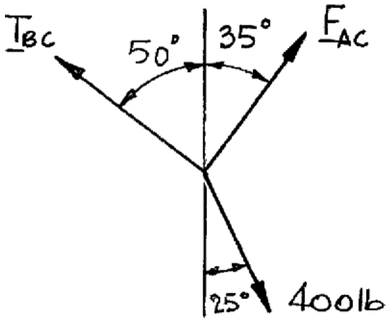
(*b*) $R = \Sigma F_x$

$$R = -(900\text{ lb})\sin 25° - (1200\text{ lb})\cos 35° - (1659.45\text{ lb})\cos 65°$$

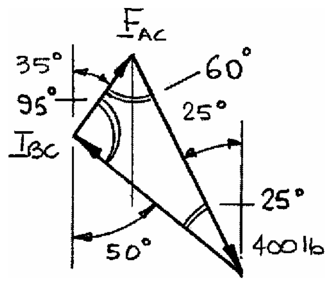
$R = 2060\text{ lb}$ ◀

Chapter 2, Solution 43.

Free-Body Diagram



Force Triangle



Law of Sines:

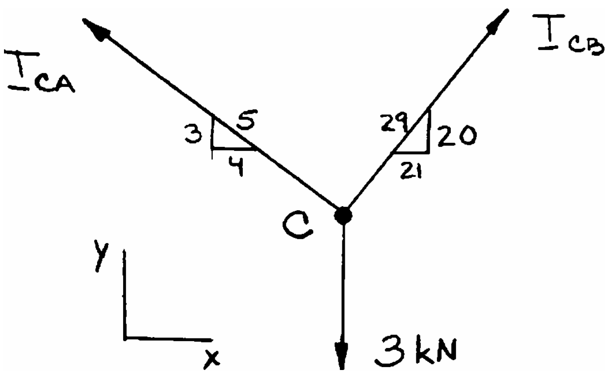
$$\frac{F_{AC}}{\sin 25°} = \frac{T_{BC}}{\sin 60°} = \frac{400 \text{ lb}}{\sin 95°}$$

(*a*) $$F_{AC} = \frac{400 \text{ lb}}{\sin 95°}\sin 25° = 169.691 \text{ lb} \qquad F_{AC} = 169.7 \text{ lb} ◀$$

(*b*) $$T_{BC} = \frac{400}{\sin 95°}\sin 60° = 347.73 \text{ lb} \qquad T_{BC} = 348 \text{ lb} ◀$$

Chapter 2, Solution 44.

Free-Body Diagram:



$\xrightarrow{+} \Sigma F_x = 0: \quad -\frac{4}{5}T_{CA} + \frac{21}{29}T_{CB} = 0$

or $\quad T_{CB} = \left(\frac{29}{21}\right)\left(\frac{4}{5}\right)T_{CA}$

$+\uparrow \Sigma F_y = 0: \quad \frac{3}{5}T_{CA} + \frac{20}{29}T_{CB} - (3\text{ kN}) = 0$

Then $\quad \frac{3}{5}T_{CA} + \frac{20}{29}\left(\frac{29}{21} \times \frac{4}{5}T_{CA}\right) - (3\text{ kN}) = 0$

or $\quad T_{CA} = 2.2028\text{ kN}$

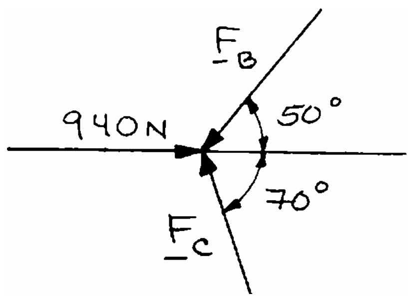
(*a*) $T_{CA} = 2.20\text{ kN}$ ◀

(*b*) $T_{CB} = 2.43\text{ kN}$ ◀

Vector Mechanics for Engineers: Statics and Dynamics, 8/e, Ferdinand P. Beer, E. Russell Johnston, Jr.,
Elliot R. Eisenberg, William E. Clausen, David Mazurek, Phillip J. Cornwell

Chapter 2, Solution 45.

Free-Body Diagram:



$\Sigma F_y = 0$: $\quad -F_B \sin 50° + F_C \sin 70° = 0$

$$F_C = \frac{\sin 50°}{\sin 70°}(F_B)$$

$\Sigma F_x = 0$: $\quad -F_B \cos 50° - F_C \cos 70° + 940 \text{ N} = 0$

$$F_B\left[\cos 50° + \cos 70°\left(\frac{\sin 50°}{\sin 70°}\right)\right] = 940$$

$$F_B = 1019.96 \text{ N}$$

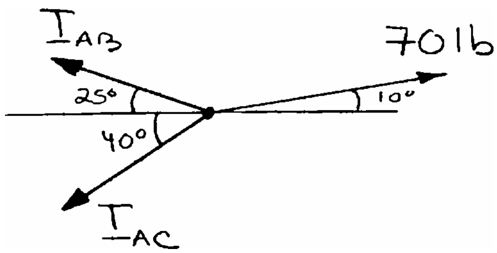
$$F_C = \frac{\sin 50°}{\sin 70°}(1019.96 \text{ N})$$

or $\quad F_C = 831 \text{ N}$ ◀

$F_B = 1020 \text{ N}$ ◀

Chapter 2, Solution 46.

Free-Body Diagram:



$\Sigma F_x = 0$: $\quad -T_{AB}\cos 25° - T_{AC}\cos 40° + (70\text{ lb})\cos 10° = 0 \quad (1)$

$\Sigma F_y = 0$: $\quad T_{AB}\sin 25° - T_{AC}\sin 40° + (70\text{ lb})\sin 10° = 0 \quad (2)$

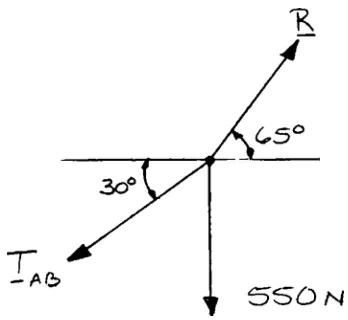
Solving Equations (1) and (2) simultaneously:

(*a*) $T_{AB} = 38.6$ lb ◀

(*b*) $T_{AC} = 44.3$ lb ◀

Chapter 2, Solution 47.

Free-Body Diagram:



(*a*) $\Sigma F_x = 0$: $-T_{AB}\cos 30° + R\cos 65° = 0$

$$R = \frac{\cos 30°}{\cos 65°}T_{AB}$$

$\Sigma F_y = 0$: $-T_{AB}\sin 30° + R\sin 65° - (550\text{ N}) = 0$

$$T_{AB}\left(-\sin 30° + \frac{\cos 30°}{\cos 65°}\sin 65°\right) - 550 = 0$$

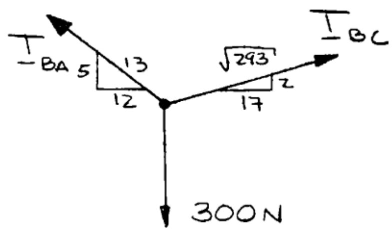
or $T_{AB} = 405\text{ N}$ ◀

(*b*) $R = \dfrac{\cos 30°}{\cos 65°}(450\text{ N})$

or $R = 830\text{ N}$ ◀

Chapter 2, Solution 48.

Free-Body Diagram At B:



$$\Sigma F_x = 0: \quad -\frac{12}{13}T_{BA} + \frac{17}{\sqrt{293}}T_{BC} = 0$$

or $T_{BA} = 1.07591\, T_{BC}$

$$\Sigma F_y = 0: \quad \frac{5}{13}T_{BA} + \frac{2}{\sqrt{293}}T_{BC} - 300 \text{ N} = 0$$

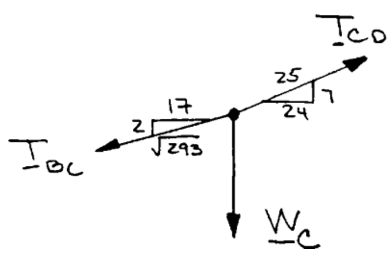
$$T_{BC} = \left(300 - \frac{5}{13}T_{BA}\right)\frac{\sqrt{293}}{2}$$

$$T_{BC} = 2567.6 - 3.2918 T_{BA}$$

$$T_{BC} = 2567.6 - 3.2918\left(1.07591 T_{BC}\right)$$

or $T_{BC} = 565.34$ N

Free-Body Diagram At C:



$$\Sigma F_x = 0: \quad -\frac{17}{\sqrt{293}}T_{BC} + \frac{24}{25}T_{CD} = 0$$

$$T_{CD} = \frac{17}{\sqrt{293}}(565.34 \text{ N})\left(\frac{25}{24}\right)$$

$$T_{CD} = 584.86 \text{ N}$$

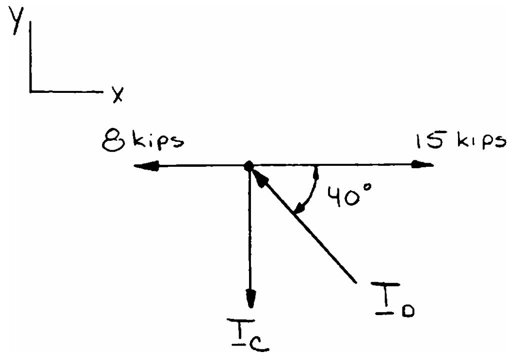
$$\Sigma F_y = 0: \quad -\frac{2}{\sqrt{293}}T_{BC} + \frac{7}{25}T_{CD} - W_C = 0$$

$$W_C = -\frac{2}{\sqrt{293}}(565.34 \text{ N}) + \frac{7}{25}(584.86 \text{ N})$$

or $W_C = 97.7$ N ◀

Chapter 2, Solution 49.

Free-Body Diagram:



$\xrightarrow{+}$ $\Sigma F_x = 0$:

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

$$T_D = 9.1378 \text{ kips}$$

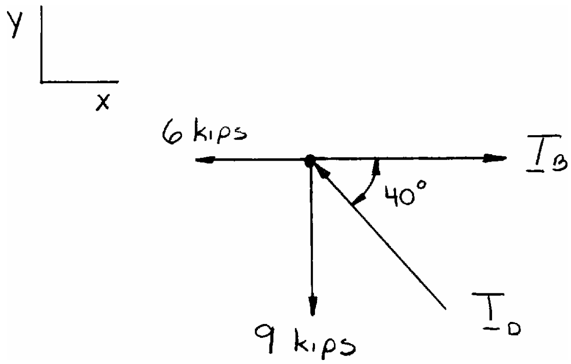
$T_D = 9.14$ kips ◀

$+\uparrow$ $\Sigma F_y = 0$: $(9.1378 \text{ kips})\sin 40° - T_C = 0$

$T_C = 5.87$ kips ◀

Chapter 2, Solution 50.

Free-Body Diagram:



$+\uparrow \Sigma F_y = 0:$

$-9 \text{ kips} + T_D \sin 40° = 0$

$T_D = 14.0015 \text{ kips}$

$T_D = 14.00 \text{ kips}$ ◀

$\xrightarrow{+} \Sigma F_x = 0:$

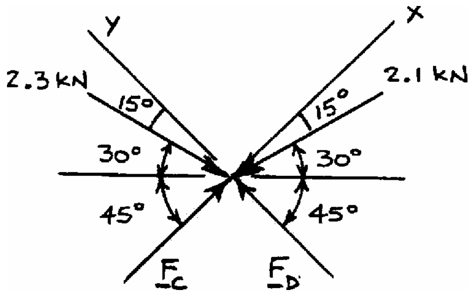
$-6 \text{ kips} + T_B - (14.0015 \text{ kips})\cos 40° = 0$

$T_B = 16.73 \text{ kips}$

$T_B = 16.73 \text{ kips}$ ◀

Chapter 2, Solution 51.

Free-Body Diagram:



$\Sigma F_x = 0$: $\quad F_C + (2.3 \text{ kN})\sin 15° - (2.1 \text{ kN})\cos 15° = 0$

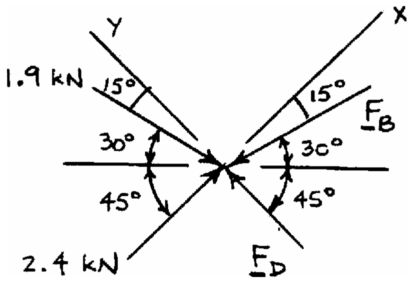
or $\quad F_C = 1.433 \text{ kN}$ ◀

$\Sigma F_y = 0$: $\quad F_D - (2.3 \text{ kN})\cos 15° + (2.1 \text{ kN})\sin 15° = 0$

or $\quad F_D = 1.678 \text{ kN}$ ◀

Chapter 2, Solution 52.

Free-Body Diagram:



$\Sigma F_x = 0$: $-F_B \cos 15° + 2.4 \text{ kN} + (1.9 \text{kN})\sin 15° = 0$

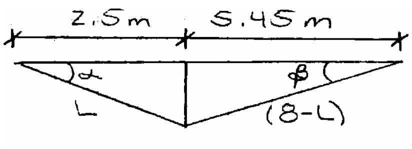
or $F_B = 2.9938 \text{ kN}$

$F_B = 2.99 \text{ kN}$ ◀

$\Sigma F_y = 0$: $F_D - (1.9 \text{ kN})\cos 15° + (2.9938 \text{ kN})\sin 15° = 0$

$F_D = 1.060 \text{ kN}$ ◀

Chapter 2, Solution 53.



From Similar Triangles we have:

$$L^2 - (2.5\text{ m})^2 = (8 - L)^2 - (5.45\text{ m})^2$$

$$-6.25 = 64 - 16\,L - 29.7025$$

or $L = 2.5342$ m

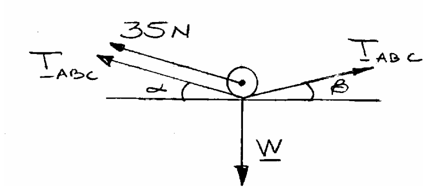
And $\cos\beta = \dfrac{5.45\text{ m}}{8\text{ m} - 2.5342\text{ m}}$

or $\beta = 4.3576°$

Then $\cos\alpha = \dfrac{2.5\text{ m}}{2.5342\text{ m}}$

or $\alpha = 9.4237°$

Free-Body Diagram At B:



$\Sigma F_x = 0$:

$$-T_{ABC}\cos\alpha - (35\text{ N})\cos\alpha + T_{ABC}\cos\beta = 0$$

or $T_{ABC} = \dfrac{(35)\cos 9.4237°}{\cos 4.3576° - \cos 9.4237°}$

$T_{ABC} = 3255.9$ N

$\Sigma F_y = 0$:

$$T_{ABC}\sin\alpha + (35\text{ N})\sin\alpha + T_{ABC}\sin\beta - W = 0$$

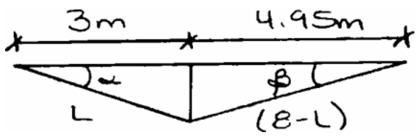
$$\sin 9.4237°(3255.9\text{ N} + 35\text{ N}) + (3255.9\text{ N})\sin 4.3576° - W = 0$$

or $W = 786.22$ N

(*a*) $W = 786$ N ◀

(*b*) $T_{ABC} = 3.26$ kN ◀

Chapter 2, Solution 54.



From Similar Triangles we have:

$$L^2 - (3\text{ m})^2 = (8 - L)^2 - (4.95\text{ m})^2$$

$$-9 = 64 - 16L - 24.5025$$

or $L = 3.0311\text{ m}$

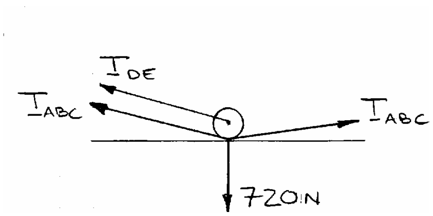
Then $\cos\beta = \dfrac{4.95\text{ m}}{8\text{ m} - 3.0311\text{ m}}$

or $\beta = 4.9989°$

And $\cos\alpha = \dfrac{3\text{ m}}{3.0311\text{ m}}$

or $\alpha = 8.2147°$

Free-Body Diagram At B:



(*a*) $\Sigma F_x = 0$:

$$-T_{ABC}\cos\alpha - T_{DE}\cos\alpha + T_{ABC}\cos\beta = 0$$

or $T_{DE} = \dfrac{\cos\beta - \cos\alpha}{\cos\alpha}T_{ABC}$

$\Sigma F_y = 0$:

$$T_{ABC}\sin\alpha + T_{DE}\sin\alpha + T_{ABC}\sin\beta - (720\text{ N}) = 0$$

$$T_{ABC}\left[\sin\alpha + \sin\alpha\left(\frac{\cos\beta - \cos\alpha}{\cos\alpha}\right) + \sin\beta\right] = 720$$

$$T_{ABC} = \frac{(720)\cos\alpha}{\sin(\alpha + \beta)}$$

Substituting for α and β gives

$$T_{ABC} = \frac{(720)\cos 8.2147°}{\sin(8.2147° + 4.9989°)}$$

$$T_{ABC} = 3117.5\text{ N}$$

or $T_{ABC} = 3.12\text{ kN}$ ◀

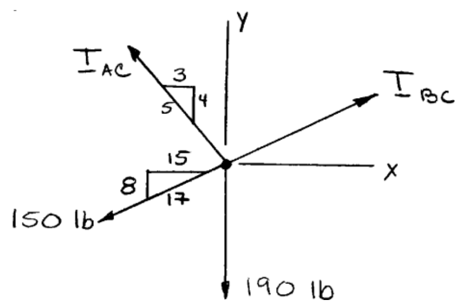
(*b*) $T_{DE} = \dfrac{\cos 4.9989° - \cos 8.2147°}{\cos 8.2147°}(3117.5\text{ N})$

$$T_{DE} = 20.338\text{ N}$$

or $T_{DE} = 20.3\text{ N}$ ◀

Chapter 2, Solution 55.

Free-Body Diagram At C:



$\xrightarrow{+}$ $\Sigma F_x = 0$: $-\frac{3}{5}T_{AC} + \frac{15}{17}T_{BC} - \frac{15}{17}(150 \text{ lb}) = 0$

or $$-\frac{17}{5}T_{AC} + 5T_{BC} = 750 \quad (1)$$

$+\uparrow$ $\Sigma F_y = 0$: $\frac{4}{5}T_{AC} + \frac{8}{17}T_{BC} - \frac{8}{17}(150 \text{ lb}) - 190 \text{ lb} = 0$

or $$\frac{17}{5}T_{AC} + 2T_{BC} = 1107.5 \quad (2)$$

Then adding Equations (1) and (2)

$$7T_{BC} = 1857.5$$

or $$T_{BC} = 265.36 \text{ lb}$$

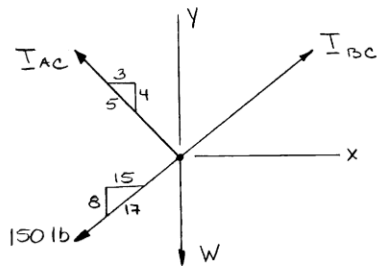
Therefore

(*a*) $T_{AC} = 169.6 \text{ lb}$ ◀

(*b*) $T_{BC} = 265 \text{ lb}$ ◀

Chapter 2, Solution 56.

Free-Body Diagram At C:



$$\xrightarrow{+} \Sigma F_x = 0: \; -\frac{3}{5}T_{AC} + \frac{15}{17}T_{BC} - \frac{15}{17}(150 \text{ lb}) = 0$$

or $$-\frac{17}{5}T_{AC} + 5T_{BC} = 750 \qquad (1)$$

$$+\uparrow \Sigma F_y = 0: \; \frac{4}{5}T_{AC} + \frac{8}{17}T_{BC} - \frac{8}{17}(150 \text{ lb}) - W = 0$$

or $$\frac{17}{5}T_{AC} + 2T_{BC} = 300 + \frac{17}{4}W \qquad (2)$$

Adding Equations (1) and (2) gives $$7T_{BC} = 1050 + \frac{17}{4}W$$

or $$T_{BC} = 150 + \frac{17}{28}W$$

Using Equation (1) $$-\frac{17}{5}T_{AC} + 5\left(150 + \frac{17}{28}W\right) = 750$$

or $$T_{AC} = \frac{25}{28}W$$

Now for $T \le 240$ lb $\Rightarrow$ $$T_{AC}: 240 = \frac{25}{28}W$$

or $$W = 269 \text{ lb}$$

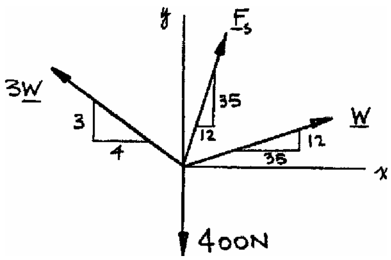
$$T_{BC}: 240 = 150 + \frac{17}{28}W$$

or $$W = 148.2 \text{ lb}$$

Therefore $0 \le W \le 148.2$ lb ◀

Chapter 2, Solution 57.

Free-Body Diagram At A:



First note from geometry:

The sides of the triangle with hypotenuse *AD* are in the ratio 12:35:37.

The sides of the triangle with hypotenuse *AC* are in the ratio 3:4:5.

The sides of the triangle with hypotenuse *AB* are also in the ratio 12:35:37.

Then:

$$\xrightarrow{+} \Sigma F_x = 0: \quad -\frac{4}{5}(3W) + \frac{35}{37}(W) + \frac{12}{37}F_s = 0$$

or

$$F_s = 4.4833W$$

and

$$+\uparrow \Sigma F_y = 0: \quad \frac{3}{5}(3W) + \frac{12}{37}(W) + \frac{35}{37}F_s - 400\text{ N} = 0$$

Then:

$$\frac{3}{5}(3W) + \frac{12}{37}(W) + \frac{35}{37}(4.4833W) - 400\text{ N} = 0$$

or

$$W = 62.841\text{ N}$$

and

$$F_s = 281.74\text{ N}$$

or

(*a*) $W = 62.8\text{ N}$ ◀

(*b*) Have spring force

$$F_s = k\left(L_{AB} - L_O\right)$$

Where

$$F_{AB} = k_{AB}\left(L_{AB} - L_O\right)$$

and

$$L_{AB} = \sqrt{(0.360\text{ m})^2 + (1.050\text{ m})^2} = 1.110\text{ m}$$

So:

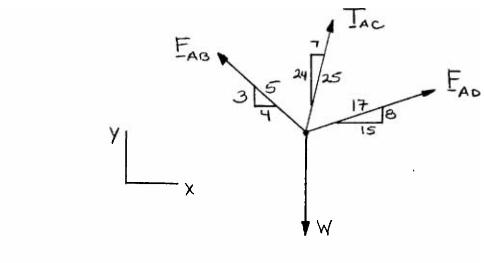
$$281.74\text{ N} = 800\text{ N/m}\left(1.110 - L_O\right)\text{m}$$

or

$L_O = 758\text{ mm}$ ◀

Chapter 2, Solution 58.

Free-Body Diagram At A:



First Note ...

With $L_{AB} = \sqrt{(22 \text{ in.})^2 + (16.5 \text{ in.})^2}$

$$L_{AB} = 27.5 \text{ in.}$$

$$L_{AD} = \sqrt{(30 \text{ in.})^2 + (16 \text{ in.})^2}$$

$$L_{AD} = 34 \text{ in.}$$

Then $F_{AB} = k_{AB}(L_{AB} - L_O)$

$$= (9 \text{ lb/in.})(27.5 \text{ in.} - 22.5 \text{ in.})$$

$$= 45 \text{ lb}$$

$$F_{AD} = k_{AD}(L_{AD} - L_O)$$

$$= (3 \text{ lb/in.})(34 \text{ in.} - 22.5 \text{ in.})$$

$$= 34.5 \text{ lb}$$

(*a*) $\xrightarrow{+} \Sigma F_x = 0$: $\quad -\frac{4}{5}(45 \text{ lb}) + \frac{7}{25}T_{AC} + \frac{15}{17}(34.5 \text{ lb}) = 0$

or $T_{AC} = 19.8529 \text{ lb}$

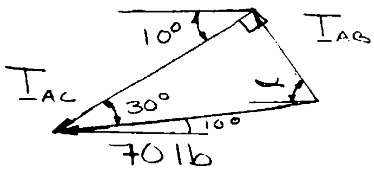
$T_{AC} = 19.85 \text{ lb}$ ◀

(*b*) $+\uparrow \Sigma F_y = 0$: $\quad \frac{3}{5}(45 \text{ lb}) + \frac{24}{25}(19.8529 \text{ lb}) + \frac{8}{17}(34.5 \text{ lb}) - W = 0$

$W = 62.3 \text{ lb}$ ◀

Chapter 2, Solution 59.

(*a*)



For T_{AB} to be a minimum

T_{AB} must be perpendicular to T_{AC}

$\therefore \alpha + 10° = 60°$

or $\alpha = 50.0°$ ◀

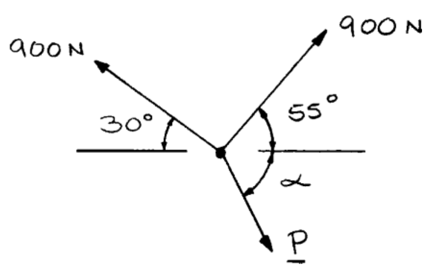
(*b*) Then $T_{AB} = (70 \text{ lb})\sin 30°$

or $T_{AB} = 35.0$ lb ◀

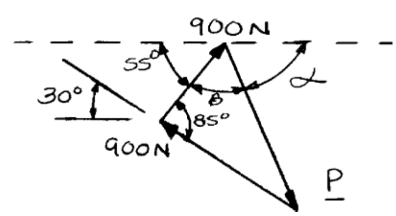
Chapter 2, Solution 60.

Note: In problems of this type, **P** may be directed along one of the cables, with $T = T_{max}$ in that cable and $T = 0$ in the other, or **P** may be directed in such a way that T is maximum in both cables. The second possibility is investigated first.

Free-Body Diagram At C:



Force Triangle



Force triangle is isoceles with $2\beta = 180° - 85°$

$$\beta = 47.5°$$

$$P = 2(900 \text{ N})\cos 47.5° = 1216 \text{ N}$$

Since $P > 0$, solution is correct

(*a*) $P = 1216$ N ◀

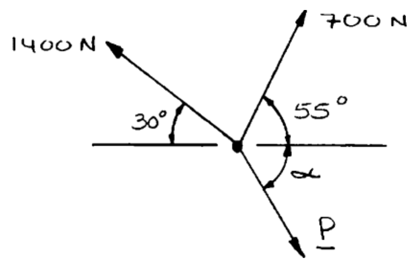
$$\alpha = 180° - 55° - 47.5° = 77.5°$$

(*b*) $\alpha = 77.5°$ ◀

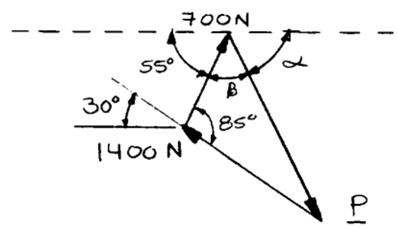
Chapter 2, Solution 61.

Note: Refer to Note in Problem 2.60

Free-Body Diagram At C:



Force Triangle



(*a*) Law of Cosines

$$P^2 = (1400\text{ N})^2 + (700\text{ N})^2 - 2(1400\text{ N})(700\text{ N})\cos 85°$$

or $P = 1510\text{ N}$ ◀

(*b*) Law of Sines

$$\frac{\sin\beta}{1400\text{ N}} = \frac{\sin 85°}{1510\text{ N}}$$

$$\sin\beta = 0.92362$$

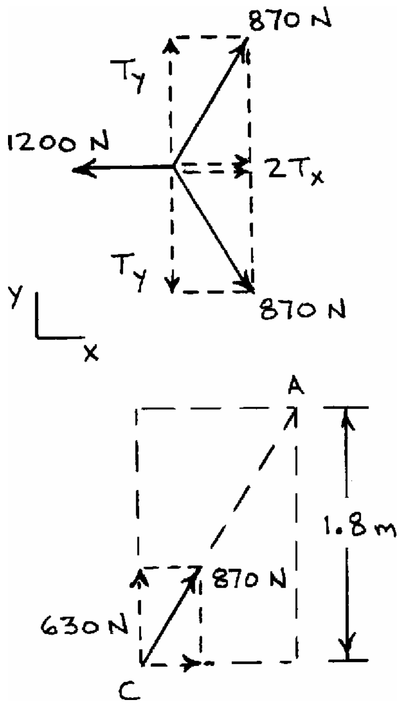
$$\beta = 67.461°$$

$$\alpha = 180° - 55° - 67.461°$$

or $\alpha = 57.5°$ ◀

Chapter 2, Solution 62.

Free-Body Diagram At C:



$\xrightarrow{+} \Sigma F_x = 0:$

$$2T_x - 1200\text{ N} = 0$$

$$T_x = 600\text{ N}$$

$$(T_x)^2 + (T_y)^2 = T^2$$

$$(600\text{ N})^2 + (T_y)^2 = (870\text{ N})^2$$

$$T_y = 630\text{ N}$$

By similar triangles:

$$\frac{AC}{870\text{ N}} = \frac{1.8\text{ m}}{630\text{ N}}$$

$$AC = 2.4857\text{ m}$$

$$L = 2(AC)$$

$$L = 2(2.4857\text{ m})$$

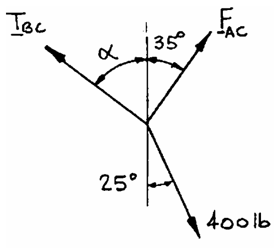
$$L = 4.97\text{ m}$$

$L = 4.97\text{ m}$ ◀

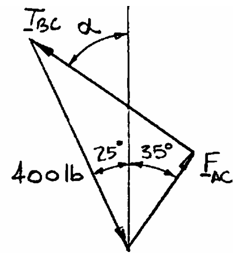
Chapter 2, Solution 63.

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

Free-Body Diagram: C



Force Triangle is a Right Triangle



(*a*) We observe: $\alpha = 55°$

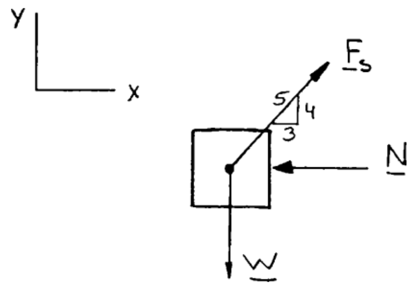
$\alpha = 55°$ ◀

(*b*) $T_{BC} = (400 \text{ lb})\sin 60°$

or $T_{BC} = 346.41 \text{ lb}$ $T_{BC} = 346 \text{ lb}$ ◀

Chapter 2, Solution 64.

At Collar *A* ...



Have $$F_s = k\left(L'_{AB} - L_{AB}\right)$$

For stretched length

$$L'_{AB} = \sqrt{(12 \text{ in.})^2 + (16 \text{ in.})^2}$$

$$L'_{AB} = 20 \text{ in.}$$

For unstretched length

$$L_{AB} = 12\sqrt{2} \text{ in.}$$

Then $$F_s = 4 \text{ lb/in.}\left(20 - 12\sqrt{2}\right) \text{ in.}$$

$$F_s = 12.1177 \text{ lb}$$

For the collar ...

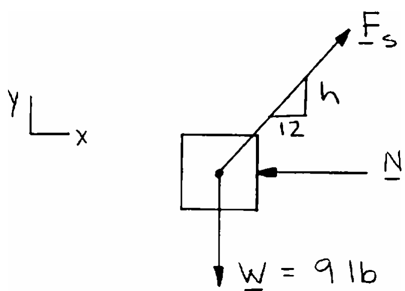
$$+\uparrow \Sigma F_y = 0$$

$$-W + \frac{4}{5}(12.1177 \text{ lb}) = 0$$

$W = 9.69$ lb ◀

Chapter 2, Solution 65.

At Collar *A* ...



$+\uparrow \Sigma F_y = 0$:

$$-9 \text{ lb} + \frac{h}{\sqrt{12^2 + h^2}} F_s = 0$$

or $$hF_s = 9\sqrt{144 + h^2}$$

Now $$F_s = k\left(L'_{AB} - L_{AB}\right)$$

Where the stretched length

$$L'_{AB} = \sqrt{(12 \text{ in.})^2 + h^2}$$

$$L_{AB} = 12\sqrt{2} \text{ in.}$$

Then $$hF_s = 9\sqrt{144 + h^2}$$

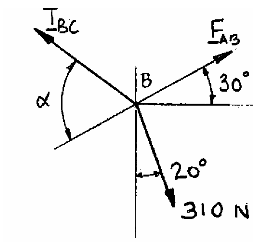
Becomes $$h\left[3 \text{ lb/in.}\left(\sqrt{144 + h^2} - 12\sqrt{2}\right)\right] = 9\sqrt{144 + h^2}$$

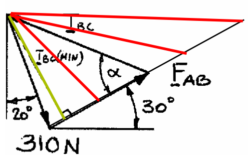
or $$(h - 3)\sqrt{144 + h^2} = 12\sqrt{2}\, h$$

Solving Numerically ... $h = 16.81$ in. ◀

Chapter 2, Solution 66.

Free-Body Diagram: B





(*a*) Have: $\mathbf{T}_{BD} + \mathbf{F}_{AB} + \mathbf{T}_{BC} = 0$

where magnitude and direction of $\mathbf{T}_{BD}$ are known, and the direction of $\mathbf{F}_{AB}$ is known.

Then, in a force triangle:

By observation, T_{BC} is minimum when $\alpha = 90.0°$ ◀

(*b*) Have $T_{BC} = (310\text{ N})\sin(180° - 70° - 30°)$

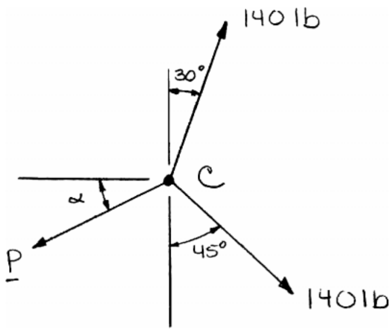
$= 305.29\text{ N}$

$T_{BC} = 305\text{ N}$ ◀

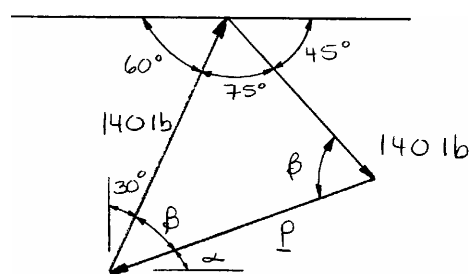
Vector Mechanics for Engineers: Statics and Dynamics, 8/e, Ferdinand P. Beer, E. Russell Johnston, Jr., Elliot R. Eisenberg, William E. Clausen, David Mazurek, Phillip J. Cornwell

Chapter 2, Solution 67.

Free-Body Diagram At C:



Since $T_{AB} = T_{BC} = 140$ lb, Force triangle is isosceles:



With $2\beta + 75° = 180°$

$\beta = 52.5°$

Then $\alpha = 90° - 52.5° - 30°$

$\alpha = 7.50°$

$\frac{P}{2} = (140 \text{ lb})\cos 52.5°$

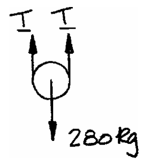
$P = 170.453$ lb

P = 170.5 lb ⦫ 7.50° ◀

Chapter 2, Solution 68.

Free-Body Diagram of Pulley

(*a*)

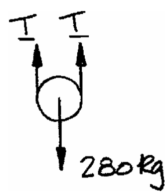


$$+\uparrow \Sigma F_y = 0: \quad 2T - (280\text{ kg})(9.81\text{ m/s}^2) = 0$$

$$T = \frac{1}{2}(2746.8\text{ N})$$

$$T = 1373\text{ N} \blacktriangleleft$$

(*b*)

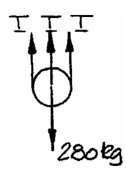


$$+\uparrow \Sigma F_y = 0: \quad 2T - (280\text{ kg})(9.81\text{ m/s}^2) = 0$$

$$T = \frac{1}{2}(2746.8\text{ N})$$

$$T = 1373\text{ N} \blacktriangleleft$$

(*c*)

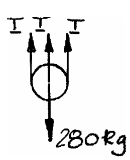


$$+\uparrow \Sigma F_y = 0: \quad 3T - (280\text{ kg})(9.81\text{ m/s}^2) = 0$$

$$T = \frac{1}{3}(2746.8\text{ N})$$

$$T = 916\text{ N} \blacktriangleleft$$

(*d*)

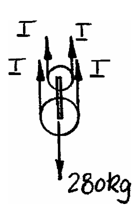


$$+\uparrow \Sigma F_y = 0: \quad 3T - (280\text{ kg})(9.81\text{ m/s}^2) = 0$$

$$T = \frac{1}{3}(2746.8\text{ N})$$

$$T = 916\text{ N} \blacktriangleleft$$

(*e*)



$$+\uparrow \Sigma F_y = 0: \quad 4T - (280\text{ kg})(9.81\text{ m/s}^2) = 0$$

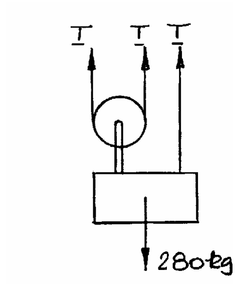
$$T = \frac{1}{4}(2746.8\text{ N})$$

$$T = 687\text{ N} \blacktriangleleft$$

Chapter 2, Solution 69.

Free-Body Diagram of Pulley and Crate

(*b*)

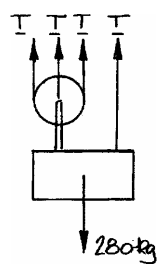


$$+\uparrow \Sigma F_y = 0: \quad 3T - (280 \text{ kg})(9.81 \text{ m/s}^2) = 0$$

$$T = \frac{1}{3}(2746.8 \text{ N})$$

$$T = 916 \text{ N} \blacktriangleleft$$

(*d*)



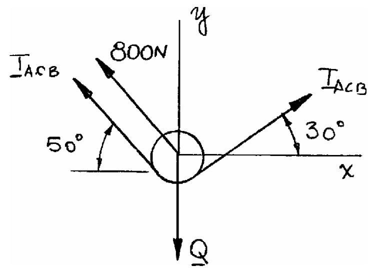
$$+\uparrow \Sigma F_y = 0: \quad 4T - (280 \text{ kg})(9.81 \text{ m/s}^2) = 0$$

$$T = \frac{1}{4}(2746.8 \text{ N})$$

$$T = 687 \text{ N} \blacktriangleleft$$

Chapter 2, Solution 70.

Free-Body Diagram: Pulley C



(*a*) $\overset{+}{\rightarrow} \Sigma F_x = 0$: $T_{ACB}(\cos 30° - \cos 50°) - (800 \text{ N})\cos 50° = 0$

Hence $T_{ACB} = 2303.5 \text{ N}$

$T_{ACB} = 2.30 \text{ kN}$ ◀

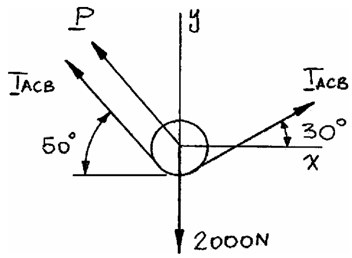
(*b*) $+\uparrow \Sigma F_y = 0$: $T_{ACB}(\sin 30° + \sin 50°) + (800 \text{ N})\sin 50° - Q = 0$

$$(2303.5 \text{ N})(\sin 30° + \sin 50°) + (800 \text{ N})\sin 50° - Q = 0$$

or $Q = 3529.2 \text{ N}$ $Q = 3.53 \text{ kN}$ ◀

Chapter 2, Solution 71.

Free-Body Diagram: Pulley C



$$\xrightarrow{+} \Sigma F_x = 0: \quad T_{ACB}\left(\cos 30° - \cos 50°\right) - P\cos 50° = 0$$

or $$P = 0.34730 T_{ACB} \qquad (1)$$

$$+\uparrow \Sigma F_y = 0: \quad T_{ACB}\left(\sin 30° + \sin 50°\right) + P\sin 50° - 2000\text{ N} = 0$$

or $$1.26604 T_{ACB} + 0.76604 P = 2000\text{ N} \qquad (2)$$

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

$$1.26604 T_{ACB} + 0.76604\left(0.34730 T_{ACB}\right) = 2000\text{ N}$$

Hence: $$T_{ACB} = 1305.41\text{ N}$$

$T_{ACB} = 1305\text{ N}$ ◀

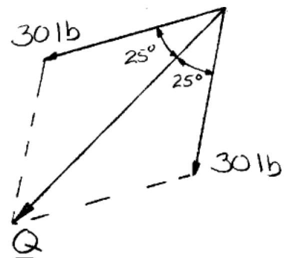
(*b*) Using (1)

$$P = 0.34730\left(1305.41\text{ N}\right) = 453.37\text{ N}$$

$P = 453\text{ N}$ ◀

Chapter 2, Solution 72.

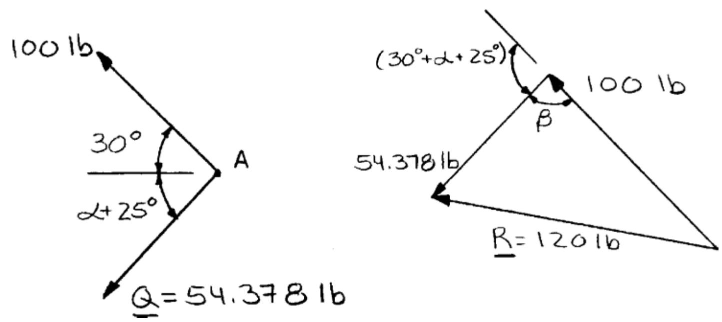
First replace 30 lb forces by their resultant **Q**:



$$Q = 2(30 \text{ lb})\cos 25°$$

$$Q = 54.378 \text{ lb}$$

Equivalent loading at *A*:



Law of Cosines:

$$(120 \text{ lb})^2 = (100 \text{ lb})^2 + (54.378 \text{ lb})^2 - 2(100 \text{ lb})(54.378 \text{ lb})\cos(125° - \alpha)\cos(125° - \alpha) = -0.132685$$

This gives two values: $125° - \alpha = 97.625°$

$$\alpha = 27.4°$$

$$125° - \alpha = -97.625°$$

$$\alpha = 223°$$

Thus for $R < 120$ lb:

$$27.4° < \alpha < 223° \blacktriangleleft$$

Chapter 2, Solution 73.

(*a*)

$$F_x = (950 \text{ lb})\sin 50° \cos 40°$$

$$= 557.48 \text{ lb}$$

$$F_x = 557 \text{ lb} ◀$$

$$F_y = -(950 \text{ lb})\cos 50°$$

$$= -610.65 \text{ lb}$$

$$F_y = -611 \text{ lb} ◀$$

$$F_z = (950 \text{ lb})\sin 50° \sin 40°$$

$$= 467.78 \text{ lb}$$

$$F_z = 468 \text{ lb} ◀$$

(*b*)

$$\cos\theta_x = \frac{557.48 \text{ lb}}{950 \text{ lb}}$$

$$\text{or } \theta_x = 54.1° ◀$$

$$\cos\theta_y = \frac{-610.65 \text{ lb}}{950 \text{ lb}}$$

$$\text{or } \theta_y = 130.0° ◀$$

$$\cos\theta_z = \frac{467.78 \text{ lb}}{950 \text{ lb}}$$

$$\text{or } \theta_z = 60.5° ◀$$

Chapter 2, Solution 74.

(*a*) $F_x = -(810 \text{ lb})\cos 45° \sin 25°$

$= -242.06 \text{ lb}$

$F_x = -242 \text{ lb}$ ◀

$F_y = -(810 \text{ lb})\sin 45°$

$= -572.76 \text{ lb}$

$F_y = -573 \text{ lb}$ ◀

$F_z = (810 \text{ lb})\cos 45° \cos 25°$

$= 519.09 \text{ lb}$

$F_z = 519 \text{ lb}$ ◀

(*b*) $\cos\theta_x = \dfrac{-242.06 \text{ lb}}{810 \text{ lb}}$

or $\theta_x = 107.4°$ ◀

$\cos\theta_y = \dfrac{-572.76 \text{ lb}}{810 \text{ lb}}$

or $\theta_y = 135.0°$ ◀

$\cos\theta_z = \dfrac{519.09 \text{ lb}}{810 \text{ lb}}$

or $\theta_z = 50.1°$ ◀

Chapter 2, Solution 75.

(*a*)

$$F_x = (900\text{ N})\cos 30°\cos 25°$$
$$= 706.40\text{ N}$$

$F_x = 706\text{ N}$ ◀

$$F_y = (900\text{ N})\sin 30°$$
$$= 450.00\text{ N}$$

$F_y = 450\text{ N}$ ◀

$$F_z = -(900\text{ N})\cos 30°\sin 25°$$
$$= -329.04\text{ N}$$

$F_z = -329\text{ N}$ ◀

(*b*)

$$\cos\theta_x = \frac{706.40\text{ N}}{900\text{ N}}$$

or $\theta_x = 38.3°$ ◀

$$\cos\theta_y = \frac{450.00\text{ N}}{900\text{ N}}$$

or $\theta_y = 60.0°$ ◀

$$\cos\theta_z = \frac{-329.40\text{ N}}{900\text{ N}}$$

or $\theta_z = 111.5°$ ◀

Chapter 2, Solution 76.

(*a*) $F_x = -(1900\text{ N})\sin 20°\sin 70°$

$= -610.65\text{ N}$

$F_x = -611\text{ N}$ ◀

$F_y = (1900\text{ N})\cos 20°$

$= 1785.42\text{ N}$

$F_y = 1785\text{ N}$ ◀

$F_z = (1900\text{ N})\sin 20°\cos 70°$

$= 222.26\text{ N}$

$F_z = 222\text{ N}$ ◀

(*b*) $\cos\theta_x = \dfrac{-610.65\text{ N}}{1900\text{ N}}$

or $\theta_x = 108.7°$ ◀

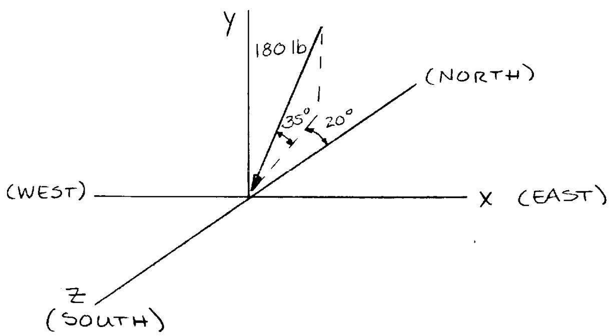
$\cos\theta_y = \dfrac{1785.42\text{ N}}{1900\text{ N}}$

or $\theta_y = 20.0°$ ◀

$\cos\theta_z = \dfrac{222.26\text{ N}}{1900\text{ N}}$

or $\theta_z = 83.3°$ ◀

Chapter 2, Solution 77.



(*a*)

$$F_x = (180 \text{ lb})\cos 35° \sin 20°$$
$$= 50.430 \text{ lb}$$

$F_x = 50.4 \text{ lb}$ ◀

$$F_y = -(180 \text{ lb})\sin 35°$$
$$= -103.244 \text{ lb}$$

$F_y = -103.2 \text{ lb}$ ◀

$$F_z = (180 \text{ lb})\cos 35° \cos 20°$$
$$= 138.555 \text{ lb}$$

$F_z = 138.6 \text{ lb}$ ◀

(*b*)

$$\cos\theta_x = \frac{50.430 \text{ lb}}{180 \text{ lb}}$$

or $\theta_x = 73.7°$ ◀

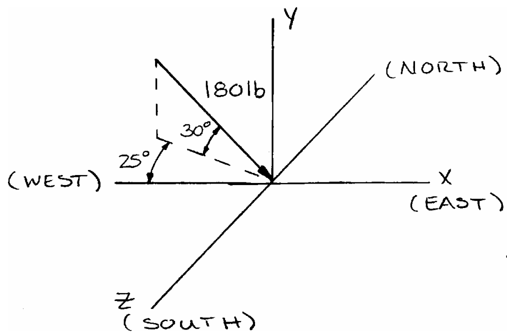
$$\cos\theta_y = \frac{-103.244 \text{ lb}}{180 \text{ lb}}$$

or $\theta_y = 125.0°$ ◀

$$\cos\theta_z = \frac{138.555 \text{ lb}}{180 \text{ lb}}$$

or $\theta_z = 39.7°$ ◀

Chapter 2, Solution 78.



(*a*)

$$F_x = (180 \text{ lb})\cos 30°\cos 25°$$
$$= 141.279 \text{ lb}$$

$F_x = 141.3 \text{ lb}$ ◀

$$F_y = -(180 \text{ lb})\sin 30°$$
$$= -90.000 \text{ lb}$$

$F_y = -90.0 \text{ lb}$ ◀

$$F_z = (180 \text{ lb})\cos 30°\sin 25°$$
$$= 65.880 \text{ lb}$$

$F_z = 65.9 \text{ lb}$ ◀

(*b*)

$$\cos\theta_x = \frac{141.279 \text{ lb}}{180 \text{ lb}}$$

or $\theta_x = 38.3°$ ◀

$$\cos\theta_y = \frac{-90.000 \text{ lb}}{180 \text{ lb}}$$

or $\theta_y = 120.0°$ ◀

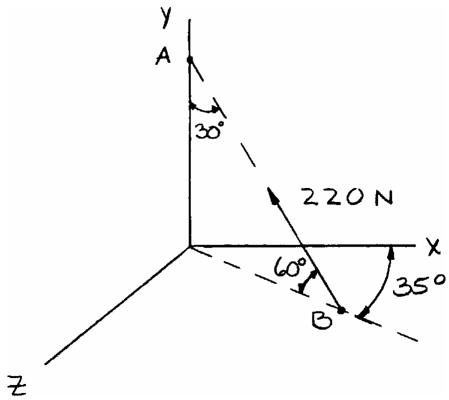
$$\cos\theta_z = \frac{65.880 \text{ lb}}{180 \text{ lb}}$$

or $\theta_z = 68.5°$ ◀

Chapter 2, Solution 79.

(*a*)

$$F_x = -(220\text{ N})\cos 60°\cos 35°$$
$$= -90.107\text{ N}$$



$F_x = -90.1\text{ N}$ ◀

$$F_y = (220\text{ N})\sin 60°$$
$$= 190.526\text{ N}$$

$F_y = 190.5\text{ N}$ ◀

$$F_z = -(220\text{ N})\cos 60°\sin 35°$$
$$= -63.093\text{ N}$$

$F_z = -63.1\text{ N}$ ◀

(*b*)

$$\cos\theta_x = \frac{-90.107\text{ N}}{220\text{ N}}$$

$\theta_x = 114.2°$ ◀

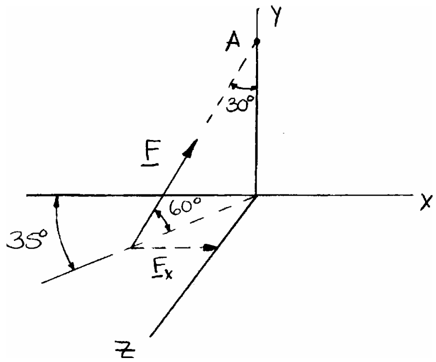
$$\cos\theta_y = \frac{190.526\text{ N}}{220\text{ N}}$$

$\theta_y = 30.0°$ ◀

$$\cos\theta_z = \frac{-63.093\text{ N}}{220\text{ N}}$$

$\theta_z = 106.7°$ ◀

Chapter 2, Solution 80.



(*a*) $F_x = 180 \text{ N}$

With $F_x = F\cos 60°\cos 35°$

$180 \text{ N} = F\cos 60°\cos 35°$

or $F = 439.38 \text{ N}$

$F = 439 \text{ N}$ ◀

(*b*) $\cos\theta_x = \dfrac{180 \text{ N}}{439.48 \text{ N}}$

$\theta_x = 65.8°$ ◀

$F_y = (439.48 \text{ N})\sin 60°$

$F_y = 380.60 \text{ N}$

$\cos\theta_y = \dfrac{380.60 \text{ N}}{439.48 \text{ N}}$

$\theta_y = 30.0°$ ◀

$F_z = -(439.48 \text{ N})\cos 60°\sin 35°$

$F_z = -126.038 \text{ N}$

$\cos\theta_z = \dfrac{-126.038 \text{ N}}{439.48 \text{ N}}$

$\theta_z = 106.7°$ ◀

Chapter 2, Solution 81.

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

$$F = \sqrt{(65\text{ N})^2 + (-80\text{ N})^2 + (-200\text{ N})^2}$$

$$F = 225\text{ N} ◀$$

$$\cos\theta_x = \frac{F_x}{F} = \frac{65\text{ N}}{225\text{ N}}$$

$$\theta_x = 73.2° ◀$$

$$\cos\theta_y = \frac{F_y}{F} = \frac{-80\text{ N}}{225\text{ N}}$$

$$\theta_y = 110.8° ◀$$

$$\cos\theta_z = \frac{F_z}{F} = \frac{-200\text{ N}}{225\text{ N}}$$

$$\theta_z = 152.7° ◀$$

Chapter 2, Solution 82.

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

$$F = \sqrt{(450\text{ N})^2 + (600\text{ N})^2 + (-1800\text{ N})^2}$$

$F = 1950\text{ N}$ ◀

$$\cos\theta_x = \frac{F_x}{F} = \frac{450\text{ N}}{1950\text{ N}}$$

$\theta_x = 76.7°$ ◀

$$\cos\theta_y = \frac{F_y}{F} = \frac{600\text{ N}}{1950\text{ N}}$$

$\theta_y = 72.1°$ ◀

$$\cos\theta_z = \frac{F_z}{F} = \frac{-1800\text{ N}}{1950\text{ N}}$$

$\theta_z = 157.4°$ ◀

Chapter 2, Solution 83.

(*a*) We have $(\cos\theta_x)^2 + (\cos\theta_y)^2 + (\cos\theta_z)^2 = 1$

$$(\cos\theta_y)^2 = 1 - (\cos\theta_x)^2 - (\cos\theta_z)^2$$

Since $F_y < 0$ we must have $\cos\theta_y < 0$

Thus $\cos\theta_y = -\sqrt{1 - (\cos 43.2°)^2 - \cos(83.8°)^2}$

$$\cos\theta_y = -0.67597$$

$$\theta_y = 132.5° \blacktriangleleft$$

(*b*) Then: $F = \dfrac{F_y}{\cos\theta_y}$

$$F = \frac{-50 \text{ lb}}{-0.67597}$$

$$F = 73.968 \text{ lb}$$

And $F_x = F\cos\theta_x$

$$F_x = (73.968 \text{ lb})\cos 43.2°$$

$$F_x = 53.9 \text{ lb} \blacktriangleleft$$

$$F_z = F\cos\theta_z$$

$$F_z = (73.968 \text{ lb})\cos 83.8°$$

$$F_z = 7.99 \text{ lb} \blacktriangleleft$$

$$F = 74.0 \text{ lb} \blacktriangleleft$$

Chapter 2, Solution 84.

(*a*) We have $(\cos\theta_x)^2 + (\cos\theta_y)^2 + (\cos\theta_z)^2 = 1$

or $(\cos\theta_z)^2 = 1 - (\cos\theta_x)^2 - (\cos\theta_y)^2$

Since $F_z < 0$ we must have $\cos\theta_z < 0$

Thus $\cos\theta_z = -\sqrt{1 - (\cos 113.2°)^2 - \cos(78.4°)^2}$

$\cos\theta_z = -0.89687$

$\theta_z = 153.7°$ ◀

(*b*) Then: $F = \dfrac{F_z}{\cos\theta_z} = \dfrac{-35 \text{ lb}}{-0.89687}$

$F = 39.025 \text{ lb}$

And $F_x = F\cos\theta_x$

$F_x = (39.025 \text{ lb})\cos 113.2°$

$F_x = -15.37 \text{ lb}$ ◀

$F_y = F\cos\theta_y$

$F_y = (39.025 \text{ lb})\cos 78.4°$

$F_y = 7.85 \text{ lb}$ ◀

$F = 39.0 \text{ lb}$ ◀

Chapter 2, Solution 85.

(*a*) We have $F_y = F\cos\theta_y$

$$F_y = (250\text{ N})\cos 72.4°$$

$$F_y = 75.592\text{ N}$$

$$F_y = 75.6\text{ N} \blacktriangleleft$$

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

$$(250\text{ N})^2 = (80\text{ N})^2 + (75.592\text{ N})^2 + F_z^2$$

$$F_z = 224.47\text{ N}$$

$$F_z = 224\text{ N} \blacktriangleleft$$

(*b*) $\cos\theta_x = \dfrac{F_x}{F}$

$$\cos\theta_x = \frac{80\text{ N}}{250\text{ N}}$$

$$\theta_x = 71.3° \blacktriangleleft$$

$$\cos\theta_z = \frac{F_z}{F}$$

$$\cos\theta_z = \frac{224.47\text{ N}}{250\text{ N}}$$

$$\theta_z = 26.1° \blacktriangleleft$$

Chapter 2, Solution 86.

(*a*) Have $F_x = F\cos\theta_x$

$$F_x = (320\text{ N})\cos 104.5°$$

$$F_x = -80.122\text{ N}$$

$$F_x = -80.1\text{ N} ◀$$

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

$$(320\text{ N})^2 = (-80.122\text{ N})^2 + F_y^2 + (-120\text{ N})^2$$

$$F_y = 285.62\text{ N}$$

$$F_y = 286\text{ N} ◀$$

(*b*) $\cos\theta_y = \dfrac{F_y}{F}$

$$\cos\theta_y = \frac{285.62\text{ N}}{320\text{ N}}$$

$$\theta_y = 26.8° ◀$$

$$\cos\theta_z = \frac{F_z}{F}$$

$$\cos\theta_z = \frac{-120\text{ N}}{320\text{ N}}$$

$$\theta_z = 112.0° ◀$$

Chapter 2, Solution 87.

$$\overrightarrow{DB} = (36 \text{ in.})\mathbf{i} - (42 \text{ in.})\mathbf{j} - (36 \text{ in.})\mathbf{k}$$

$$DB = \sqrt{(36 \text{ in.})^2 + (-42 \text{ in.})^2 + (-36 \text{ in.})^2} = 66 \text{ in.}$$

$$\mathbf{T}_{DB} = T_{DB}\lambda_{DB} = T_{DB}\frac{\overrightarrow{DB}}{DB}$$

$$\mathbf{T}_{DB} = \frac{55 \text{ lb}}{66 \text{ in.}}\left[(36 \text{ in.})\mathbf{i} - (42 \text{ in.})\mathbf{j} - (36 \text{ in.})\mathbf{k}\right]$$

$$= (30 \text{ lb})\mathbf{i} - (35 \text{ lb})\mathbf{j} - (30 \text{ lb})\mathbf{k}$$

$$\therefore\ (T_{DB})_x = 30.0 \text{ lb} \blacktriangleleft$$

$$(T_{DB})_y = -35.0 \text{ lb} \blacktriangleleft$$

$$(T_{DB})_z = -30.0 \text{ lb} \blacktriangleleft$$

Chapter 2, Solution 88.

$$\overrightarrow{EB} = (36\text{ in.})\mathbf{i} - (45\text{ in.})\mathbf{j} + (48\text{ in.})\mathbf{k}$$

$$EB = \sqrt{(36\text{ in.})^2 + (-45\text{ in.})^2 + (48\text{ in.})^2} = 75\text{ in.}$$

$$\mathbf{T}_{EB} = T_{EB}\lambda_{EB} = T_{EB}\frac{\overrightarrow{EB}}{EB}$$

$$\mathbf{T}_{EB} = \frac{60\text{ lb}}{75\text{ in.}}\left[(36\text{ in.})\mathbf{i} - (45\text{ in.})\mathbf{j} + (48\text{ in.})\mathbf{k}\right]$$

$$= (28.8\text{ lb})\mathbf{i} - (36\text{ lb})\mathbf{j} + (38.4\text{ lb})\mathbf{k}$$

$$\therefore\ (T_{EB})_x = 28.8\text{ lb} \blacktriangleleft$$

$$(T_{EB})_y = -36.0\text{ lb} \blacktriangleleft$$

$$(T_{EB})_z = 38.4\text{ lb} \blacktriangleleft$$

Chapter 2, Solution 89.

$$\overrightarrow{BA} = (4\text{ m})\mathbf{i} + (20\text{ m})\mathbf{j} - (5\text{ m})\mathbf{k}$$

$$BA = \sqrt{(4\text{ m})^2 + (20\text{ m})^2 + (-5\text{ m})^2} = 21\text{ m}$$

$$\mathbf{F} = F\boldsymbol{\lambda}_{BA} = F\frac{\overrightarrow{BA}}{BA} = \frac{2100\text{ N}}{21\text{ m}}\left[(4\text{ m})\mathbf{i} + (20\text{ m})\mathbf{j} - (5\text{ m})\mathbf{k}\right]$$

$$\mathbf{F} = (400\text{ N})\mathbf{i} + (2000\text{ N})\mathbf{j} - (500\text{ N})\mathbf{k}$$

$F_x = +400\text{ N},\ F_y = +2000\text{ N},\ F_z = -500\text{ N}$ ◀

Chapter 2, Solution 90.

$$\overrightarrow{DA} = (4 \text{ m})\mathbf{i} + (20 \text{ m})\mathbf{j} + (14.8 \text{ m})\mathbf{k}$$

$$DA = \sqrt{(4 \text{ m})^2 + (20 \text{ m})^2 + (14.8 \text{ m})^2} = 25.2 \text{ m}$$

$$\mathbf{F} = F\boldsymbol{\lambda}_{DA} = F\frac{\overrightarrow{DA}}{DA} = \frac{1260 \text{ N}}{25.2 \text{ m}}\left[(4 \text{ m})\mathbf{i} + (20 \text{ m})\mathbf{j} + (14.8 \text{ m})\mathbf{k}\right]$$

$$\mathbf{F} = (200 \text{ N})\mathbf{i} + (1000 \text{ N})\mathbf{j} + (740 \text{ N})\mathbf{k}$$

$F_x = +200 \text{ N}, \; F_y = +1000 \text{ N}, \; F_z = +740 \text{ N}$ ◀

Chapter 2, Solution 91.

$$\overrightarrow{BG} = -(1 \text{ m})\mathbf{i} + (1.85 \text{ m})\mathbf{j} - (0.8 \text{ m})\mathbf{k}$$

$$BG = \sqrt{(-1 \text{ m})^2 + (1.85 \text{ m})^2 + (-0.8 \text{ m})^2}$$

$$BG = 2.25 \text{ m}$$

$$\mathbf{T}_{BG} = T_{BG}\,\lambda_{BG} = T_{BG}\frac{\overrightarrow{BG}}{BG}$$

$$\mathbf{T}_{BG} = \frac{450 \text{ N}}{2.25 \text{ m}}\left[-(1 \text{ m})\mathbf{i} + (1.85 \text{ m})\mathbf{j} - (0.8 \text{ m})\mathbf{k}\right]$$

$$= -(200 \text{ N})\mathbf{i} + (370 \text{ N})\mathbf{j} - (160 \text{ N})\mathbf{k}$$

$$\therefore\ (T_{BG})_x = -200 \text{ N} \blacktriangleleft$$

$$(T_{BG})_y = 370 \text{ N} \blacktriangleleft$$

$$(T_{BG})_z = -160.0 \text{ N} \blacktriangleleft$$

Chapter 2, Solution 92.

$$\overline{BH} = (0.75\text{ m})\mathbf{i} + (1.5\text{ m})\mathbf{j} - (1.5\text{ m})\mathbf{k}$$

$$BH = \sqrt{(0.75\text{ m})^2 + (1.5\text{ m})^2 + (-1.5\text{ m})^2}$$

$$= 2.25\text{ m}$$

$$\mathbf{T}_{BH} = T_{BH}\lambda_{BH} = T_{BH}\frac{\overline{BH}}{BH}$$

$$\mathbf{T}_{BH} = \frac{600\text{ N}}{2.25\text{ m}}\left[(0.75\text{ m})\mathbf{i} + (1.5\text{ m})\mathbf{j} - (1.5\text{ m})\mathbf{k}\right]$$

$$= (200\text{ N})\mathbf{i} + (400\text{ N})\mathbf{j} - (400\text{ N})\mathbf{k}$$

$$\therefore (T_{BH})_x = 200\text{ N} \blacktriangleleft$$

$$(T_{BH})_y = 400\text{ N} \blacktriangleleft$$

$$(T_{BH})_z = -400\text{ N} \blacktriangleleft$$

Chapter 2, Solution 93.

$$\mathbf{P} = (4 \text{ kips})[\cos 30° \sin 20° \mathbf{i} - \sin 30° \mathbf{j} + \cos 30° \cos 20° \mathbf{k}]$$

$$= (1.18479 \text{ kips})\mathbf{i} - (2 \text{ kips})\mathbf{j} + (3.2552 \text{ kips})\mathbf{k}$$

$$\mathbf{Q} = (8 \text{ kips})[-\cos 45° \sin 15° \mathbf{i} + \sin 45° \mathbf{j} - \cos 45° \cos 15° \mathbf{k}]$$

$$= -(1.46410 \text{ kips})\mathbf{i} + (5.6569 \text{ kips})\mathbf{j} - (5.4641 \text{ kips})\mathbf{k}$$

$$\mathbf{R} = \mathbf{P} + \mathbf{Q} = -(0.27931 \text{ kip})\mathbf{i} + (3.6569 \text{ kips})\mathbf{j} - (2.2089 \text{ kips})\mathbf{k}$$

$$R = \sqrt{(-0.27931 \text{ kip})^2 + (3.6569 \text{ kips})^2 + (-2.2089 \text{ kips})^2}$$

$R = 4.2814$ kips or $R = 4.28$ kips ◀

$$\cos\theta_x = \frac{R_x}{R} = \frac{-0.27931 \text{ kip}}{4.2814 \text{ kips}} = -0.065238$$

$$\cos\theta_y = \frac{R_y}{R} = \frac{3.6569 \text{ kips}}{4.2814 \text{ kips}} = 0.85414$$

$$\cos\theta_z = \frac{R_z}{R} = \frac{-2.2089 \text{ kips}}{4.2814 \text{ kips}} = -0.51593$$

or $\theta_x = 93.7°$ ◀

$\theta_y = 31.3°$ ◀

$\theta_z = 121.1°$ ◀

Chapter 2, Solution 94.

$$\mathbf{P} = (6\text{ kips})[\cos 30°\sin 20°\mathbf{i} - \sin 30°\mathbf{j} + \cos 30°\cos 20°\mathbf{k}]$$

$$= (1.77719\text{ kips})\mathbf{i} - (3\text{ kips})\mathbf{j} + (4.8828\text{ kips})\mathbf{k}$$

$$\mathbf{Q} = (7\text{ kips})[-\cos 45°\sin 15°\mathbf{i} + \sin 45°\mathbf{j} - \cos 45°\cos 15°\mathbf{k}]$$

$$= -(1.28109\text{ kips})\mathbf{i} + (4.94975\text{ kips})\mathbf{j} - (4.7811\text{ kips})\mathbf{k}$$

$$\mathbf{R} = \mathbf{P} + \mathbf{Q} = (0.49610\text{ kip})\mathbf{i} + (1.94975\text{ kips})\mathbf{j} + (0.101700\text{ kip})\mathbf{k}$$

$$R = \sqrt{(0.49610\text{ kip})^2 + (1.94975\text{ kips})^2 + (0.101700\text{ kip})^2}$$

$$R = 2.0144\text{ kips}$$

or $R = 2.01\text{ kips}$ ◀

$$\cos\theta_x = \frac{R_x}{R} = \frac{0.49610\text{ kip}}{2.0144\text{ kips}} = 0.24628$$

$$\cos\theta_y = \frac{R_y}{R} = \frac{1.94975\text{ kips}}{2.0144\text{ kips}} = 0.967906$$

$$\cos\theta_z = \frac{R_z}{R} = \frac{0.101700\text{ kip}}{2.0144\text{ kips}} = 0.050486$$

or $\theta_x = 75.7°$ ◀

$\theta_y = 14.56°$ ◀

$\theta_z = 87.1°$ ◀

Chapter 2, Solution 95.

$$\overrightarrow{AB} = -(600 \text{ mm})\mathbf{i} + (360 \text{ mm})\mathbf{j} + (270 \text{ mm})\mathbf{k}$$

$$AB = \sqrt{(-600 \text{ mm})^2 + (360 \text{ mm})^2 + (270 \text{ mm})^2}$$

$$AB = 750 \text{ mm}$$

$$\overrightarrow{AC} = -(600 \text{ mm})\mathbf{i} + (320 \text{ mm})\mathbf{j} - (510 \text{ mm})\mathbf{k}$$

$$AC = \sqrt{(-600 \text{ mm})^2 + (320 \text{ mm})^2 + (-510 \text{ mm})^2}$$

$$AC = 850 \text{ mm}$$

$$\mathbf{T}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = \frac{510 \text{ N}}{750 \text{ mm}}\left[-(600 \text{ mm})\mathbf{i} + (360 \text{ mm})\mathbf{j} + (270 \text{ mm})\mathbf{k}\right]$$

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

$$\mathbf{T}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = \frac{765 \text{ N}}{850 \text{ mm}}\left[-(600 \text{ mm})\mathbf{i} + (320 \text{ mm})\mathbf{j} - (510 \text{ mm})\mathbf{k}\right]$$

$$\mathbf{T}_{AC} = -(540 \text{ N})\mathbf{i} + (288 \text{ N})\mathbf{j} - (459 \text{ N})\mathbf{k}$$

$$\mathbf{R} = \mathbf{T}_{AB} + \mathbf{T}_{AC} = -(948 \text{ N})\mathbf{i} + (532.8 \text{ N})\mathbf{j} - (275.4 \text{ N})\mathbf{k}$$

Then $R = 1121.80 \text{ N}$ $\qquad R = 1122 \text{ N}$ ◀

and $\cos\theta_x = \dfrac{-948 \text{ N}}{1121.80 \text{ N}}$ $\qquad \theta_x = 147.7°$ ◀

$\cos\theta_y = \dfrac{532.8 \text{ N}}{1121.80 \text{ N}}$ $\qquad \theta_y = 61.6°$ ◀

$\cos\theta_z = \dfrac{-275.4 \text{ N}}{1121.80 \text{ N}}$ $\qquad \theta_z = 104.2°$ ◀

Chapter 2, Solution 96.

$$\overrightarrow{AB} = -(600 \text{ mm})\mathbf{i} + (360 \text{ mm})\mathbf{j} + (270 \text{ mm})\mathbf{k}$$

$$AB = \sqrt{(-600 \text{ mm})^2 + (360 \text{ mm})^2 + (270 \text{ mm})^2} = 750 \text{ mm}$$

$$AB = 750 \text{ mm}$$

$$\overrightarrow{AC} = -(600 \text{ mm})\mathbf{i} + (320 \text{ mm})\mathbf{j} - (510 \text{ mm})\mathbf{k}$$

$$AC = \sqrt{(-600 \text{ mm})^2 + (320 \text{ mm})^2 + (-510 \text{ mm})^2} = 850 \text{ mm}$$

$$AC = 850 \text{ mm}$$

$$\mathbf{T}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = \frac{765 \text{ N}}{750 \text{ mm}}\left[-(600 \text{ mm})\mathbf{i} + (360 \text{ mm})\mathbf{j} + (270 \text{ mm})\mathbf{k}\right]$$

$$\mathbf{T}_{AB} = -(612 \text{ N})\mathbf{i} + (367.2 \text{ N})\mathbf{j} + (275.4 \text{ N})\mathbf{k}$$

$$\mathbf{T}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = \frac{510 \text{ N}}{850 \text{ mm}}\left[-(600 \text{ mm})\mathbf{i} + (320 \text{ mm})\mathbf{j} - (510 \text{ mm})\mathbf{k}\right]$$

$$\mathbf{T}_{AC} = -(360 \text{ N})\mathbf{i} + (192 \text{ N})\mathbf{j} - (306 \text{ N})\mathbf{k}$$

$$\mathbf{R} = \mathbf{T}_{AB} + \mathbf{T}_{AC} = -(972 \text{ N})\mathbf{i} + (559.2 \text{ N})\mathbf{j} - (30.6 \text{ N})\mathbf{k}$$

Then

$$\mathbf{R} = 1121.80 \text{ N} \quad R = 1122 \text{ N} \blacktriangleleft$$

$$\cos\theta_x = \frac{-972 \text{ N}}{1121.80 \text{ N}} \quad \theta_x = 150.1° \blacktriangleleft$$

$$\cos\theta_y = \frac{559.2 \text{ N}}{1121.80 \text{ N}} \quad \theta_y = 60.1° \blacktriangleleft$$

$$\cos\theta_z = \frac{-30.6 \text{ N}}{1121.80 \text{ N}} \quad \theta_z = 91.6° \blacktriangleleft$$

Chapter 2, Solution 97.

Have $\mathbf{T}_{AB} = (760\text{ lb})(\sin 50°\cos 40°\mathbf{i} - \cos 50°\mathbf{j} + \sin 50°\sin 40°\mathbf{k})$

$$\mathbf{T}_{AC} = T_{AC}(-\cos 45°\sin 25°\mathbf{i} - \sin 45°\mathbf{j} + \cos 45°\cos 25°\mathbf{k})$$

(*a*) $\mathbf{R}_A = \mathbf{T}_{AB} + \mathbf{T}_{AC}$ $\quad (R_A)_x = 0$

$$\therefore (R_A)_x = \Sigma F_x = 0:$$

$$(760\text{ lb})\sin 50°\cos 40° - T_{AC}\cos 45°\sin 25° = 0$$

or $\quad T_{AC} = 1492.41\text{ lb}$

$$\therefore T_{AC} = 1492\text{ lb} \blacktriangleleft$$

(*b*) $(R_A)_y = \Sigma F_y = (-760\text{ lb})\cos 50° - (1492.41\text{ lb})\sin 45°$

$$(R_A)_y = -1543.81\text{ lb}$$

$(R_A)_z = \Sigma F_z = (760\text{ lb})\sin 50°\sin 40° + (1492.41\text{ lb})\cos 45°\cos 25°$

$$(R_A)_z = 1330.65\text{ lb}$$

$$\therefore \mathbf{R}_A = -(1543.81\text{ lb})\mathbf{j} + (1330.65\text{ lb})\mathbf{k}$$

Then $\quad R_A = 2038.1\text{ lb}$ $\qquad R_A = 2040\text{ lb} \blacktriangleleft$

$$\cos\theta_x = \frac{0}{2038.1\text{ lb}} \qquad \theta_x = 90.0° \blacktriangleleft$$

$$\cos\theta_y = \frac{-1543.81\text{ lb}}{2038.1\text{ lb}} \qquad \theta_y = 139.2° \blacktriangleleft$$

$$\cos\theta_z = \frac{1330.65\text{ lb}}{2038.1\text{ lb}} \qquad \theta_z = 49.2° \blacktriangleleft$$

Chapter 2, Solution 98.

Have $\mathbf{T}_{AB} = T_{AB}\left(\sin 50^\circ \cos 40^\circ \mathbf{i} - \cos 50^\circ \mathbf{j} + \sin 50^\circ \sin 40^\circ \mathbf{k}\right)$

$$\mathbf{T}_{AC} = (980\text{ lb})\left(-\cos 45^\circ \sin 25^\circ \mathbf{i} - \sin 45^\circ \mathbf{j} + \cos 45^\circ \cos 25^\circ \mathbf{k}\right)$$

(*a*) $\mathbf{R}_A = \mathbf{T}_{AB} + \mathbf{T}_{AC}$ $\qquad (R_A)_x = 0$

$$\therefore (R_A)_x = \Sigma F_x = 0:$$

$$T_{AB} \sin 50^\circ \cos 40^\circ - (980\text{ lb})\cos 45^\circ \sin 25^\circ = 0$$

or $T_{AB} = 499.06\text{ lb}$

$$\therefore T_{AB} = 499\text{ lb} \blacktriangleleft$$

(*b*) $(R_A)_y = \Sigma F_y = -(499.06\text{ lb})\cos 50^\circ - (980\text{ lb})\sin 45^\circ$

$$(R_A)_y = -1013.75\text{ lb}$$

$(R_A)_z = \Sigma F_z = (499.06\text{ lb})\sin 50^\circ \sin 40^\circ + (980\text{ lb})\cos 45^\circ \cos 25^\circ$

$$(R_A)_z = 873.78\text{ lb}$$

$\therefore \mathbf{R}_A = -(1013.75\text{ lb})\mathbf{j} + (873.78\text{ lb})\mathbf{k}$

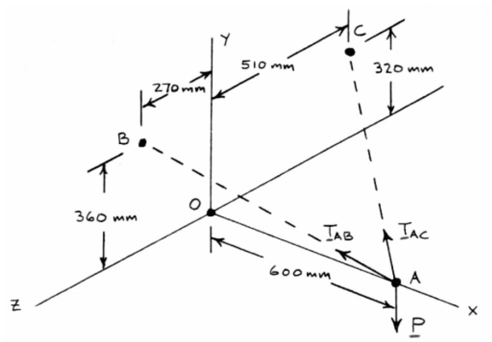
Then $R_A = 1338.35\text{ lb}$ $\qquad R_A = 1338\text{ lb} \blacktriangleleft$

and $\cos\theta_x = \dfrac{0}{1338.35\text{ lb}}$ $\qquad \theta_x = 90.0^\circ \blacktriangleleft$

$$\cos\theta_y = \frac{-1013.75\text{ lb}}{1338.35\text{ lb}} \qquad \theta_y = 139.2^\circ \blacktriangleleft$$

$$\cos\theta_z = \frac{873.78\text{ lb}}{1338.35\text{ lb}} \qquad \theta_z = 49.2^\circ \blacktriangleleft$$

Chapter 2, Solution 99.



Cable AB:

$$\overrightarrow{AB} = -(600\text{ mm})\mathbf{i} + (360\text{ mm})\mathbf{j} + (270\text{ mm})\mathbf{k}$$

$$AB = \sqrt{(-600\text{ mm})^2 + (360\text{ mm})^2 + (270\text{ mm})^2} = 750\text{ mm}$$

$$\mathbf{T}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = \frac{600\text{ N}}{750\text{ mm}}\left[-(600\text{ mm})\mathbf{i} + (360\text{ mm})\mathbf{j} + (270\text{ mm})\mathbf{k}\right]$$

$$\mathbf{T}_{AB} = -(480\text{ N})\mathbf{i} + (288\text{ N})\mathbf{j} + (216\text{ N})\mathbf{k}$$

Cable AC:

$$\overrightarrow{AC} = -(600\text{ mm})\mathbf{i} + (320\text{ mm})\mathbf{j} - (510\text{ mm})\mathbf{k}$$

$$AC = \sqrt{(-600\text{ mm})^2 + (320\text{ mm})^2 + (-510\text{ mm})^2} = 850\text{ mm}$$

$$\mathbf{T}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = \frac{T_{AC}}{850\text{ mm}}\left[-(600\text{ mm})\mathbf{i} + (320\text{ mm})\mathbf{j} - (510\text{ mm})\mathbf{k}\right]$$

$$\mathbf{T}_{AC} = -\frac{60}{85}T_{AC}\mathbf{i} + \frac{32}{85}T_{AC}\mathbf{j} - \frac{51}{85}T_{AC}\mathbf{k}$$

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

(a) $(R_A)_z = \Sigma F_z = 0$: $(216\text{ N}) - \frac{51}{85}T_{AC} = 0$ or $T_{AC} = 360\text{ N}$ ◀

(b) $(R_A)_y = \Sigma F_y = 0$: $(288\text{ N}) + \frac{32}{85}T_{AC} - P = 0$ or $P = 424\text{ N}$ ◀

Chapter 2, Solution 100.

Cable *AB*:

$$\overrightarrow{AB} = -(4\text{ m})\mathbf{i} - (20\text{ m})\mathbf{j} + (5\text{ m})\mathbf{k}$$

$$AB = \sqrt{(-4\text{ m})^2 + (-20\text{ m})^2 + (5\text{ m})^2} = 21\text{ m}$$

$$\mathbf{T}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = \frac{T_{AB}}{21\text{ m}}\left[-(4\text{ m})\mathbf{i} - (20\text{ m})\mathbf{j} + (5\text{ m})\mathbf{k}\right]$$

Cable *AC*:

$$\overrightarrow{AC} = (12\text{ m})\mathbf{i} - (20\text{ m})\mathbf{j} + (3.6\text{ m})\mathbf{k}$$

$$AC = \sqrt{(12\text{ m})^2 + (-20\text{ m})^2 + (3.6\text{ m})^2} = 23.6\text{ m}$$

$$\mathbf{T}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = \frac{1770\text{ N}}{23.6\text{ m}}\left[(12\text{ m})\mathbf{i} - (20\text{ m})\mathbf{j} + (3.6\text{ m})\mathbf{k}\right]$$

$$= (900\text{ N})\mathbf{i} - (1500\text{ N})\mathbf{j} + (270\text{ N})\mathbf{k}$$

Cable *AD*:

$$\overrightarrow{AD} = -(4\text{ m})\mathbf{i} - (20\text{ m})\mathbf{j} + (14.8\text{ m})\mathbf{k}$$

$$AD = \sqrt{(-4\text{ m})^2 + (-20\text{ m})^2 + (14.8\text{ m})^2} = 25.2\text{ m}$$

$$\mathbf{T}_{AD} = T_{AD}\frac{\overrightarrow{AD}}{AD} = \frac{T_{AD}}{25.2\text{ m}}\left[-(4\text{ m})\mathbf{i} - (20\text{ m})\mathbf{j} + (14.8\text{ m})\mathbf{k}\right]$$

$$= \frac{T_{AD}}{63\text{ m}}\left[-(10\text{ m})\mathbf{i} - (50\text{ m})\mathbf{j} - (37\text{ m})\mathbf{k}\right]$$

Now...

$$\mathbf{R} = \mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{T}_{AD} \text{ and } \mathbf{R} = R_{\mathbf{j}}; \quad R_x = R_z = 0$$

$$\Sigma F_x = 0: \quad -\frac{4}{21}T_{AB} + 900 - \frac{10}{63}T_{AD} = 0 \qquad (1)$$

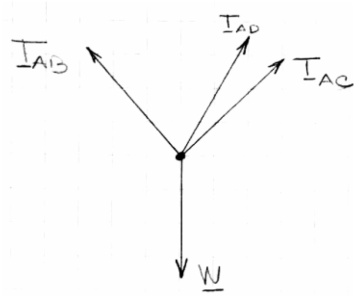
$$\Sigma F_y = 0: \quad \frac{5}{21}T_{AB} + 270 - \frac{37}{63}T_{AD} = 0 \qquad (2)$$

Solving equations (1) and (2) simultaneously yields:

$T_{AD} = 1.775\text{ kN}$ ◀

$T_{AB} = 3.25\text{ kN}$ ◀

Chapter 2, Solution 101.



$$d_{AB} = \sqrt{(-450\text{ mm})^2 + (600\text{ mm})^2} = 750\text{ mm}$$

$$d_{AC} = \sqrt{(600\text{ mm})^2 + (-320\text{ mm})^2} = 680\text{ mm}$$

$$d_{AD} = \sqrt{(500\text{ mm})^2 + (600\text{ mm})^2 + (360\text{ mm})^2} = 860\text{ mm}$$

$$\mathbf{T}_{AB} = \frac{T_{AB}}{750\text{ mm}}\left[-(450\text{ mm})\mathbf{i} + (600\text{ mm})\mathbf{j}\right]$$

$$\mathbf{T}_{AB} = (-0.6\mathbf{i} + 0.8\mathbf{j})T_{AB}$$

$$\mathbf{T}_{AC} = \frac{T_{AC}}{680\text{ mm}}\left[(600\text{ mm})\mathbf{j} - (320\text{ mm})\mathbf{k}\right]$$

$$\mathbf{T}_{AC} = \left(\frac{15}{17}\mathbf{j} - \frac{8}{17}\mathbf{k}\right)T_{AC}$$

$$\mathbf{T}_{AD} = \frac{T_{AD}}{860\text{ mm}}\left[(500\text{ mm})\mathbf{i} + (600\text{ mm})\mathbf{j} + (360\text{ mm})\mathbf{k}\right]$$

$$\mathbf{T}_{AD} = \left(\frac{25}{43}\mathbf{i} + \frac{30}{43}\mathbf{j} + \frac{18}{43}\mathbf{k}\right)T_{AD}$$

$$\mathbf{W} = -W\mathbf{j}$$

At point A: $\Sigma F = 0$: $\mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{T}_{AD} + \mathbf{W} = 0$

i component: $-0.6T_{AB} + \frac{25}{43}T_{AD} = 0$

or $$T_{AB} = \left(\frac{5}{3}\right)\left(\frac{25}{43}\right)T_{AD} \quad (1)$$

k component: $-\frac{18}{17}T_{AC} + \frac{18}{43}T_{AD} = 0$

or $$T_{AC} = \left(\frac{17}{8}\right)\left(\frac{18}{43}\right)T_{AD} \quad (2)$$

j component:

$$0.8T_{AB} + \frac{15}{17}T_{AC} + \frac{30}{43}T_{AD} - W = 0$$

$$0.8T_{AB} + \frac{15}{17}\left(\frac{17}{8}\cdot\frac{18}{43}T_{AD}\right) + \frac{30}{43}T_{AD} - W = 0$$

$$0.8T_{AB} + \frac{255}{172}T_{AD} - W = 0 \quad (3)$$

From Equation (1):

$$6\text{ kN} = \left(\frac{5}{3}\right)\left(\frac{25}{43}\right)T_{AD}$$

or $T_{AD} = 6.1920\text{ kN}$

From Equation (3):

$$0.8(6\text{ kN}) + \frac{255}{172}(6.1920\text{ kN}) - W = 0$$

$\therefore W = 13.98\text{ kN}$ ◀

Chapter 2, Solution 102.

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

$$T_{AB} = \left(\frac{5}{3}\right)\left(\frac{25}{43}\right)T_{AD} \tag{1}$$

$$T_{AC} = \left(\frac{17}{8}\right)\left(\frac{18}{43}\right)T_{AD} \tag{2}$$

$$0.8T_{AB} + \frac{255}{172}T_{AD} - W = 0 \tag{3}$$

From Equation (1)

$$T_{AB} = \left(\frac{5}{3}\right)\left(\frac{25}{43}\right)(4.3 \text{ kN})$$

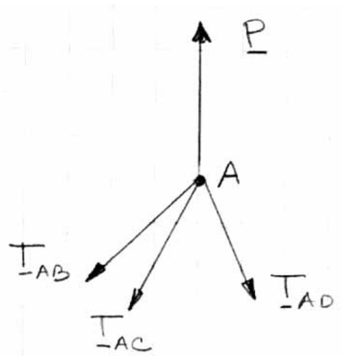
$$\text{or} \qquad T_{AB} = 4.1667 \text{ kN}$$

From Equation (3)

$$0.8(4.1667 \text{ kN}) + \frac{255}{172}(4.3 \text{ kN}) - W = 0$$

$$\therefore\ W = 9.71 \text{ kN} \blacktriangleleft$$

Chapter 2, Solution 103.



$$\overrightarrow{AB} = -(4.20\text{ m})\mathbf{i} - (5.60\text{ m})\mathbf{j}$$

$$AB = \sqrt{(-4.20\text{ m})^2 + (-5.60\text{ m})^2} = 7.00\text{ m}$$

$$\overrightarrow{AC} = (2.40\text{ m})\mathbf{i} - (5.60\text{ m})\mathbf{j} + (4.20\text{ m})\mathbf{k}$$

$$AC = \sqrt{(2.40\text{ m})^2 + (-5.60\text{ m})^2 + (4.20\text{ m})^2} = 7.40\text{ m}$$

$$\overrightarrow{AD} = -(5.60\text{ m})\mathbf{j} - (3.30\text{ m})\mathbf{k}$$

$$AD = \sqrt{(-5.60\text{ m})^2 + (-3.30\text{ m})^2} = 6.50\text{ m}$$

$$\mathbf{T}_{AB} = T_{AB}\lambda_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = \frac{T_{AB}}{7.00\text{ m}}(-4.20\mathbf{i} - 5.60\mathbf{j})$$

$$\mathbf{T}_{AB} = \left(-\frac{3}{5}\mathbf{i} - \frac{4}{5}\mathbf{j}\right)T_{AB}$$

$$\mathbf{T}_{AC} = T_{AC}\lambda_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = \frac{T_{AC}}{7.40\text{ m}}(2.40\mathbf{i} - 5.60\mathbf{j} + 4.20\mathbf{k})$$

$$\mathbf{T}_{AC} = \left(\frac{12}{37}\mathbf{i} - \frac{28}{37}\mathbf{j} + \frac{21}{37}\mathbf{k}\right)T_{AC}$$

$$\mathbf{T}_{AD} = T_{AD}\lambda_{AD} = T_{AD}\frac{\overrightarrow{AD}}{AD} = \frac{T_{AD}}{6.50\text{ m}}(-5.60\mathbf{j} - 3.30\mathbf{k})$$

$$\mathbf{T}_{AD} = \left(-\frac{56}{65}\mathbf{j} - \frac{33}{65}\mathbf{k}\right)T_{AD}$$

$$\mathbf{P} = P\,\mathbf{j}$$

For equilibrium at point A: $\Sigma\mathbf{F} = 0$

$$\mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{T}_{AD} + \mathbf{P} = 0$$

$\mathbf{i}$ component: $-\frac{3}{5}T_{AB} + \frac{12}{37}T_{AC} = 0$

or $$T_{AB} = \frac{20}{37}T_{AC} \qquad (1)$$

j component: $$-\frac{4}{5}T_{AB} - \frac{28}{37}T_{AC} - \frac{56}{65}T_{AD} + P = 0$$

$$-\frac{4}{5}T_{AB} - \frac{28}{37}T_{AC} - \frac{56}{65}\left(\frac{65}{11}\cdot\frac{7}{37}T_{AC}\right) + P = 0$$

$$-\frac{4}{5}T_{AB} - \frac{700}{407}T_{AC} + P = 0 \qquad (2)$$

k component: $$\frac{21}{37}T_{AC} - \frac{33}{65}T_{AD} = 0$$

or $$T_{AD} = \left(\frac{65}{11}\right)\left(\frac{7}{37}\right)T_{AC} \qquad (3)$$

From Equation (1):

$$259\text{ N} = \left(\frac{20}{37}\right)T_{AC}$$

or $$T_{AC} = 479.15\text{ N}$$

From Equation (2): $$-\frac{4}{5}(259\text{ N}) - \frac{700}{407}(479.15\text{ N}) + P = 0$$

$\therefore \mathbf{P} = 1031\text{ N}$ ↑ ◀

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Chapter 2, Solution 104.

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

$$T_{AB} = \frac{20}{37} T_{AC} \qquad (1)$$

$$-\frac{4}{5} T_{AB} - \frac{700}{407} T_{AC} + P = 0 \quad (2)$$

$$T_{AD} = \left(\frac{65}{11}\right)\left(\frac{7}{37}\right) T_{AC} \qquad (3)$$

Substituting for $T_{AC} = 444\text{ N}$ into Equation (1)

Gives $$T_{AB} = \frac{20}{37}\left(444\text{ N}\right)$$

or $$T_{AB} = 240\text{ N}$$

And from Equation (3)

$$-\frac{4}{5}\left(240\text{ N}\right) - \frac{700}{407}\left(444\text{ N}\right) + P = 0$$

$\therefore \mathbf{P} = 956\text{ N} \uparrow$ ◀

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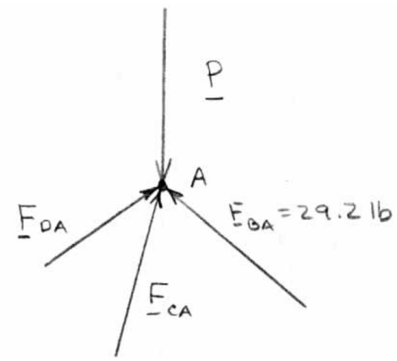
Chapter 2, Solution 105.



$$d_{BA} = \sqrt{(-11 \text{ in.})^2 + (9.6 \text{ in.})^2} = 14.6 \text{ in.}$$

$$d_{CA} = \sqrt{(9.6 \text{ in.})^2 + (-7.2 \text{ in.})^2} = 12.0 \text{ in.}$$

$$d_{DA} = \sqrt{(9.6 \text{ in.})^2 + (9.6 \text{ in.})^2 + (4.8 \text{ in.})^2} = 14.4 \text{ in.}$$

$$\mathbf{F}_{BA} = F_{BA}\lambda_{BA} = \frac{F_{BA}}{14.6 \text{ in.}}\left[(-11 \text{ in.})\mathbf{i} + (9.6 \text{ in.})\mathbf{j}\right]$$

$$= F_{BA}\left[-\left(\frac{11}{14.6}\right)\mathbf{i} + \left(\frac{9.6}{14.6}\right)\mathbf{j}\right]$$

$$\mathbf{F}_{CA} = F_{CA}\lambda_{CA} = \frac{F_{CA}}{12.0 \text{ in.}}\left[(9.6 \text{ in.})\mathbf{j} - (7.2 \text{ in.})\mathbf{k}\right]$$

$$= F_{CA}\left[\left(\frac{4}{5}\right)\mathbf{j} - \left(\frac{3}{5}\right)\mathbf{k}\right]$$

$$\mathbf{F}_{DA} = F_{DA}\lambda_{DA} = \frac{F_{DA}}{14.4 \text{ in.}}\left[(9.6 \text{ in.})\mathbf{i} + (9.6 \text{ in.})\mathbf{j} + (4.8 \text{ in.})\mathbf{k}\right]$$

$$= F_{DA}\left[\left(\frac{2}{3}\right)\mathbf{i} + \left(\frac{2}{3}\right)\mathbf{j} + \left(\frac{1}{3}\right)\mathbf{k}\right]$$

$$\mathbf{P} = -P\,\mathbf{j}$$

At point A: $\Sigma\mathbf{F} = 0$: $\mathbf{F}_{BA} + \mathbf{F}_{CA} + \mathbf{F}_{DA} + \mathbf{P} = 0$

i component: $-\left(\frac{11}{14.6}\right)F_{BA} + \left(\frac{2}{3}\right)F_{DA} = 0$ (1)

j component: $\left(\frac{9.6}{14.6}\right)F_{BA} + \left(\frac{4}{5}\right)F_{CA} + \left(\frac{2}{3}\right)F_{DA} - P = 0$ (2)

k component: $-\left(\frac{3}{5}\right)F_{CA} + \left(\frac{1}{3}\right)F_{DA} = 0$ (3)

continued

From Equation (1) $$F_{BA} = \left(\frac{14.6}{11}\right)\left(\frac{2}{3}\right)F_{DA}$$

$$29.2\text{ lb} = \left(\frac{14.6}{11}\right)\left(\frac{2}{3}\right)F_{DA}$$

or $$F_{DA} = 33\text{ lb}$$

Solving Eqn. (3) for F_{CA} gives: $$F_{CA} = \left(\frac{5}{9}\right)F_{DA}$$

$$F_{CA} = \left(\frac{5}{9}\right)(33\text{ lb})$$

Substituting into Eqn. (2) for $F_{BA}, F_{DA,}$ and F_{CA} in terms of F_{DA} gives:

$$\left(\frac{9.6}{14.6}\right)(29.2\text{ lb}) + \left(\frac{4}{5}\right)\left(\frac{5}{9}\right)(33\text{ lb}) + \left(\frac{2}{3}\right)(33\text{ lb}) - P = 0$$

$\therefore$

$P = 55.9\text{ lb}$ ◀

Chapter 2, Solution 106.

See Problem 2.105 for the figure and the analysis leading to the linear algebraic Equations (1), (2), and (3) below.

$$-\left(\frac{11}{14.6}\right)F_{BA} + \left(\frac{2}{3}\right)F_{DA} = 0 \qquad (1)$$

$$\left(\frac{9.6}{14.6}\right)F_{BA} + \left(\frac{4}{5}\right)F_{CA} + \left(\frac{2}{3}\right)F_{DA} - P = 0 \qquad (2)$$

$$-\left(\frac{3}{5}\right)F_{CA} + \left(\frac{1}{3}\right)F_{DA} = 0 \quad (3)$$

From Equation (1): $F_{BA} = \left(\frac{14.6}{11}\right)\left(\frac{2}{3}\right)F_{DA}$

From Equation (3): $F_{CA} = \left(\frac{5}{9}\right)F_{DA}$

Substituting into Equation (2) for F_{BA} and F_{CA} gives:

$$\left(\frac{9.6}{14.6}\right)\left(\frac{14.6}{11}\right)\left(\frac{2}{3}\right)F_{DA} + \left(\frac{4}{5}\right)\left(\frac{5}{9}\right)F_{DA} + \left(\frac{2}{3}\right)F_{DA} - P = 0$$

$$\text{or } \left(\frac{838}{495}\right)F_{DA} = P$$

Since $P = 45$ lb $\qquad \left(\frac{838}{495}\right)F_{DA} = 45 \text{ lb}$

$$\text{or } F_{DA} = 26.581 \text{ lb}$$

$$\text{and } F_{BA} = \left(\frac{14.6}{11}\right)\left(\frac{2}{3}\right)(26.581 \text{ lb})$$

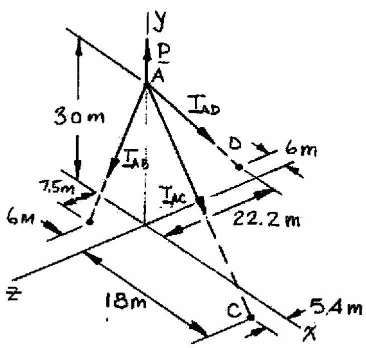
or $F_{BA} = 23.5$ lb ◀

$$\text{and } F_{CA} = \left(\frac{5}{9}\right)(26.581 \text{ lb})$$

or $F_{CA} = 14.77$ lb ◀

and $F_{DA} = 26.6$ lb ◀

Chapter 2, Solution 107.



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

$$\overrightarrow{AC} = (18\text{ m})\mathbf{i} - (30\text{ m})\mathbf{j} + (5.4\text{ m})\mathbf{k}$$

$$AC = \sqrt{(18\text{ m})^2 + (-30\text{ m})^2 + (5.4\text{ m})^2} = 35.4\text{ m}$$

$$\mathbf{T}_{AC} = T\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = \frac{T_{AC}}{35.4\text{ m}}\left[(18\text{ m})\mathbf{i} - (30\text{ m})\mathbf{j} + (5.4\text{ m})\mathbf{k}\right]$$

$$\mathbf{T}_{AC} = T_{AC}(0.50847\mathbf{i} - 0.84746\mathbf{j} + 0.152542\mathbf{k})$$

and

$$\overrightarrow{AB} = -(6\text{ m})\mathbf{i} - (30\text{ m})\mathbf{j} + (7.5\text{ m})\mathbf{k}$$

$$AB = \sqrt{(-6\text{ m})^2 + (-30\text{ m})^2 + (7.5\text{ m})^2} = 31.5\text{ m}$$

$$\mathbf{T}_{AB} = T\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = \frac{T_{AB}}{31.5\text{ m}}\left[-(6\text{ m})\mathbf{i} - (30\text{ m})\mathbf{j} + (7.5\text{ m})\mathbf{k}\right]$$

$$\mathbf{T}_{AB} = T_{AB}(-0.190476\mathbf{i} - 0.95238\mathbf{j} + 0.23810\mathbf{k})$$

Finally

$$\overrightarrow{AD} = -(6\text{ m})\mathbf{i} - (30\text{ m})\mathbf{j} - (22.2\text{ m})\mathbf{k}$$

$$AD = \sqrt{(-6\text{ m})^2 + (-30\text{ m})^2 + (-22.2\text{ m})^2} = 37.8\text{ m}$$

$$\mathbf{T}_{AD} = T\boldsymbol{\lambda}_{AD} = T_{AD}\frac{\overrightarrow{AD}}{AD} = \frac{T_{AD}}{37.8\text{ m}}\left[-(6\text{ m})\mathbf{i} - (30\text{ m})\mathbf{j} - (22.2\text{ m})\mathbf{k}\right]$$

$$\mathbf{T}_{AD} = T_{AD}(-0.158730\mathbf{i} - 0.79365\mathbf{j} - 0.58730\mathbf{k})$$

continued

With $\mathbf{P} = P\mathbf{j}$, at A:

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

Equating the factors of **i**, **j**, and **k** to zero, we obtain the linear algebraic equations:

$$\mathbf{i}: \quad -0.190476T_{AB} + 0.50847T_{AC} - 0.158730T_{AD} = 0 \qquad (1)$$

$$\mathbf{j}: \quad -0.95238T_{AB} - 0.84746T_{AC} - 0.79365T_{AD} + P = 0 \qquad (2)$$

$$\mathbf{k}: \quad 0.23810T_{AB} + 0.152542T_{AC} - 0.58730T_{AD} = 0 \qquad (3)$$

In Equations (1), (2) and (3), set $T_{AB} = 3.6$ kN, and, using conventional methods for solving Linear Algebraic Equations (MATLAB or Maple, for example), we obtain:

$$T_{AC} = 1.963 \text{ kN}$$

$$T_{AD} = 1.969 \text{ kN}$$

$\mathbf{P} = 6.66$ kN ↑ ◀

Chapter 2, Solution 108.

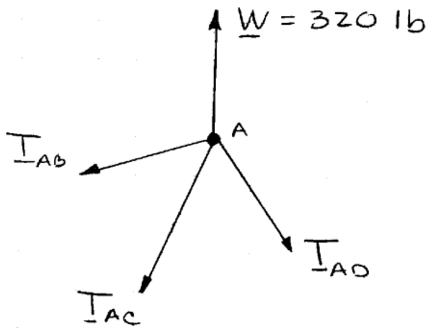
Based on the results of Problem 2.107, particularly Equations (1), (2) and (3), we substitute $T_{AC} = 2.6\text{ kN}$ and solve the three resulting linear equations using conventional tools for solving Linear Algebraic Equations (MATLAB or Maple, for example), to obtain

$$T_{AB} = 4.77\text{ kN}$$

$$T_{AD} = 2.61\text{ kN}$$

$\mathbf{P} = 8.81\text{ kN}\uparrow$ ◀

Chapter 2, Solution 109.



$$\overrightarrow{AB} = -(6.5 \text{ ft})\mathbf{i} - (8 \text{ ft})\mathbf{j} + (2 \text{ ft})\mathbf{k}$$

$$AB = \sqrt{(-6.5 \text{ ft})^2 + (-8 \text{ ft})^2 + (2 \text{ ft})^2} = 10.5 \text{ ft}$$

$$\mathbf{T}_{AB} = \frac{T_{AB}}{10.5 \text{ ft}}\left[-(6.5 \text{ ft})\mathbf{i} - (8 \text{ ft})\mathbf{j} + (2 \text{ ft})\mathbf{k}\right]$$

$$= T_{AB}(-0.61905\mathbf{i} - 0.76190\mathbf{j} + 0.190476\mathbf{k})$$

$$\overrightarrow{AC} = (1 \text{ ft})\mathbf{i} - (8 \text{ ft})\mathbf{j} + (4 \text{ ft})\mathbf{k}$$

$$AC = \sqrt{(1 \text{ ft})^2 + (-8 \text{ ft})^2 + (4 \text{ ft})^2} = 9 \text{ ft}$$

$$\mathbf{T}_{AC} = \frac{T_{AC}}{9 \text{ ft}}\left[(1 \text{ ft})\mathbf{i} - (8 \text{ ft})\mathbf{j} + (4 \text{ ft})\mathbf{k}\right]$$

$$= T_{AC}(0.111111\mathbf{i} - 0.88889\mathbf{j} + 0.44444\mathbf{k})$$

$$\overrightarrow{AD} = (1.75 \text{ ft})\mathbf{i} - (8 \text{ ft})\mathbf{j} - (1 \text{ ft})\mathbf{k}$$

$$AD = \sqrt{(1.75 \text{ ft})^2 + (-8 \text{ ft})^2 + (-1 \text{ ft})^2} = 8.25 \text{ ft}$$

$$\mathbf{T}_{AD} = \frac{T_{AD}}{8.25 \text{ ft}}\left[(1.75 \text{ ft})\mathbf{i} - (8 \text{ ft})\mathbf{j} - (1 \text{ ft})\mathbf{k}\right]$$

$$= T_{AD}(0.21212\mathbf{i} - 0.96970\mathbf{j} - 0.121212\mathbf{k})$$

At A $\Sigma\mathbf{F} = 0$

$$\Sigma F_x = 0: \quad -0.61905T_{AB} + 0.111111T_{AC} + 0.21212T_{AD} = 0 \quad (1)$$

$$\Sigma F_y = 0: \quad -0.76190T_{AB} - 0.88889T_{AC} - 0.96970T_{AD} + W = 0 \quad (2)$$

$$\Sigma F_z = 0: \quad 0.190476T_{AB} + 0.44444T_{AC} - 0.121212T_{AD} = 0 \quad (3)$$

Substituting for $W = 320$ lb and Solving Equations (1), (2), (3) simultaneously yields:

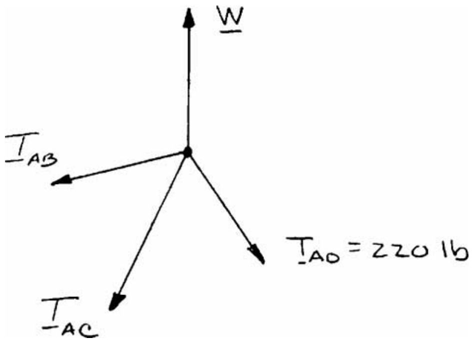
$T_{AB} = 86.2$ lb ◀

$T_{AC} = 27.7$ lb ◀

$T_{AD} = 237$ lb ◀

Chapter 2, Solution 110.

See Problem 2.109 for the analysis leading to the linear algebraic Equations (1), (2), and (3) shown below.



$$-0.61905T_{AB} + 0.111111T_{AC} + 0.21212T_{AD} = 0 \quad (1)$$

$$-0.76190T_{AB} - 0.88889T_{AC} - 0.96970T_{AD} + W = 0 \quad (2)$$

$$0.190476T_{AB} + 0.44444T_{AC} - 0.121212T_{AD} = 0 \quad (3)$$

Now substituting for $T_{AD} = 220$ lb Gives:

$$-0.61905T_{AB} + 0.111111T_{AC} + 46.662 = 0 \quad (4)$$

$$-0.76190T_{AB} - 0.88889T_{AC} - 213.33 + W = 0 \quad (5)$$

$$0.190476T_{AB} + 0.44444T_{AC} - 26.666 = 0 \quad (6)$$

Solving Equations (4) and (6) simultaneously gives

$$T_{AB} = 79.992 \text{ lb} \text{ and } T_{AC} = 25.716 \text{ lb}$$

Substituting into Equation (5) yields

$W = 297$ lb ◀

Chapter 2, Solution 111.

Note that because the line of action of each of the cords passes through the vertex A of the cone, the cords all have the same length, and the unit vectors lying along the cords are parallel to the unit vectors lying along the generators of the cone.

Thus, for example, the unit vector along BE is identical to the unit vector along the generator AB.

Hence: $$\boldsymbol{\lambda}_{AB} = \boldsymbol{\lambda}_{BE} = \frac{\cos 45°\mathbf{i} + 8\mathbf{j} - \sin 45°\mathbf{k}}{\sqrt{65}}$$

It follows that: $$\mathbf{T}_{BE} = T_{BE}\boldsymbol{\lambda}_{BE} = T_{BE}\left(\frac{\cos 45°\mathbf{i} + 8\mathbf{j} - \sin 45°\mathbf{k}}{\sqrt{65}}\right)$$

$$\mathbf{T}_{CF} = T_{CF}\boldsymbol{\lambda}_{CF} = T_{CF}\left(\frac{\cos 30°\mathbf{i} + 8\mathbf{j} + \sin 30°\mathbf{k}}{\sqrt{65}}\right)$$

$$\mathbf{T}_{DG} = T_{DG}\boldsymbol{\lambda}_{DG} = T_{DG}\left(\frac{-\cos 15°\mathbf{i} + 8\mathbf{j} - \sin 15°\mathbf{k}}{\sqrt{65}}\right)$$

At A: $$\Sigma\mathbf{F} = 0: \quad \mathbf{T}_{BE} + \mathbf{T}_{CF} + \mathbf{T}_{DG} + \mathbf{W} + \mathbf{P} = 0$$

Then, isolating the factors of **i**, **j**, and **k**, we obtain three algebraic equations:

$$\mathbf{i}: \quad \frac{T_{BE}}{\sqrt{65}}\cos 45° + \frac{T_{CF}}{\sqrt{65}}\cos 30° - \frac{T_{DG}}{\sqrt{65}}\cos 15° + P = 0$$

or $$T_{BE}\cos 45° + T_{CF}\cos 30° - T_{DG}\cos 15° + P\sqrt{65} = 0 \qquad (1)$$

$$\mathbf{j}: \quad T_{BE}\frac{8}{\sqrt{65}} + T_{CF}\frac{8}{\sqrt{65}} + T_{DG}\frac{8}{\sqrt{65}} - W = 0$$

or $$T_{BE} + T_{CF} + T_{DG} - W\frac{\sqrt{65}}{8} = 0 \qquad (2)$$

$$\mathbf{k}: \quad -\frac{T_{BE}}{\sqrt{65}}\sin 45° + \frac{T_{CF}}{\sqrt{65}}\sin 30° - \frac{T_{DG}}{\sqrt{65}}\sin 15° = 0$$

or $$-T_{BE}\sin 45° + T_{CF}\sin 30° - T_{DG}\sin 15° = 0 \qquad (3)$$

With $P = 0$ and the tension in cord $BE = 0.2$ lb:

Solving the resulting Equations (1), (2), and (3) using conventional methods in Linear Algebra (elimination, matrix methods or iteration – with MATLAB or Maple, for example), we obtain:

$$T_{CF} = 0.669 \text{ lb}$$

$$T_{DG} = 0.746 \text{ lb}$$

$W = 1.603$ lb ◀

Chapter 2, Solution 112.

See Problem 2.111 for the Figure and the analysis leading to the linear algebraic Equations (1), (2), and (3) below:

$$\mathbf{i}: \quad T_{BE}\cos 45° + T_{CF}\cos 30° - T_{DG}\cos 15° + \sqrt{65}P = 0 \qquad (1)$$

$$\mathbf{j}: \quad T_{BE} + T_{CF} + T_{DG} - W\frac{\sqrt{65}}{8} = 0 \qquad (2)$$

$$\mathbf{k}: \quad -T_{BE}\sin 45° + T_{CF}\sin 30° - T_{DG}\sin 15° = 0 \qquad (3)$$

With $W = 1.6$ lb , the range of values of P for which the cord CF is taut can found by solving Equations (1), (2), and (3) for the tension T_{CF} as a function of P and requiring it to be positive (>0).

Solving (1), (2), and (3) with unknown P, using conventional methods in Linear Algebra (elimination, matrix methods or iteration – with MATLAB or Maple, for example), we obtain:

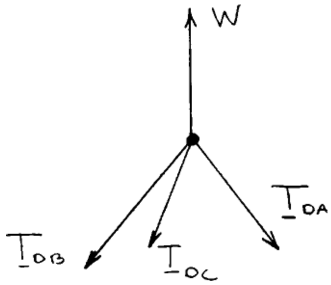
$$T_{CF} = (-1.729P + 0.668)\text{ lb}$$

Hence, for $T_{CF} > 0$ $\qquad -1.729P + 0.668 > 0$

or $\qquad P < 0.386$ lb

$$\therefore \quad \phi \le P < 0.386 \text{ lb} ◀$$

Chapter 2, Solution 113.



$$d_{DA} = \sqrt{(400\text{ mm})^2 + (-600\text{ mm})^2} = 721.11\text{ mm}$$

$$d_{DB} = \sqrt{(-200\text{ mm})^2 + (-600\text{ mm})^2 + (150\text{ mm})^2} = 650\text{ mm}$$

$$d_{DC} = \sqrt{(-200\text{ mm})^2 + (-600\text{ mm})^2 + (-150\text{ mm})^2} = 650\text{ mm}$$

$$\mathbf{T}_{DA} = T_{DA}\lambda_{DA}$$

$$= \frac{T_{DA}}{721.11\text{ mm}}\left[(400\text{ mm})\mathbf{i} - (600\text{ mm})\mathbf{j}\right]$$

$$= T_{DA}(0.55470\mathbf{i} - 0.83205\mathbf{j})$$

$$\mathbf{T}_{DB} = T_{DB}\lambda_{DB}$$

$$= \frac{T_{DB}}{650\text{ mm}}\left[-(200\text{ mm})\mathbf{i} - (600\text{ mm})\mathbf{j} + (150\text{ mm})\mathbf{k}\right]$$

$$= T_{DB}\left(-\frac{4}{13}\mathbf{i} - \frac{12}{13}\mathbf{j} + \frac{3}{13}\mathbf{k}\right)$$

$$\mathbf{T}_{DC} = T_{DC}\lambda_{DC}$$

$$\mathbf{T}_{DC} = \frac{T_{DC}}{650\text{ mm}}\left[-(200\text{ mm})\mathbf{i} - (600\text{ mm})\mathbf{j} - (150\text{ mm})\mathbf{k}\right]$$

$$= T_{DC}\left(-\frac{4}{13}\mathbf{i} - \frac{12}{13}\mathbf{j} - \frac{3}{13}\mathbf{k}\right)$$

$$\mathbf{W} = W\mathbf{j}$$

At point D $\Sigma\mathbf{F} = 0$: $\mathbf{T}_{DA} + \mathbf{T}_{DB} + \mathbf{T}_{DC} + \mathbf{W} = 0$

i component: $$0.55470T_{DA} - \frac{4}{13}T_{DB} - \frac{4}{13}T_{DC} = 0 \quad (1)$$

j component: $$-0.83205T_{DA} - \frac{12}{13}T_{DB} - \frac{12}{13}T_{DC} + W = 0 \quad (2)$$

k component: $$\frac{3}{13}T_{DB} - \frac{3}{13}T_{DC} = 0 \quad (3)$$

Setting $W = (16\text{ kg})(9.81\text{ m/s}^2) = 156.96\text{ N}$

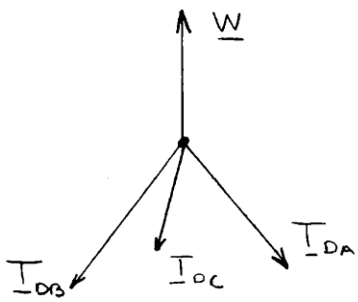
And Solving Equations (1), (2), and (3) simultaneously:

$T_{DA} = 62.9$ N ◀

$T_{DB} = 56.7$ N ◀

$T_{DC} = 56.7$ N ◀

Chapter 2, Solution 114.



$$d_{DA} = \sqrt{(400 \text{ mm})^2 + (-600 \text{ mm})^2} = 721.11 \text{ mm}$$

$$d_{DB} = \sqrt{(-200 \text{ mm})^2 + (-600 \text{ mm})^2 + (200 \text{ mm})^2} = 663.32 \text{ mm}$$

$$d_{DC} = \sqrt{(-200 \text{ mm})^2 + (-600 \text{ mm})^2 + (-200 \text{ mm})^2} = 663.32 \text{ mm}$$

$$\mathbf{T}_{DA} = T_{DA}\lambda_{DA}$$

$$= \frac{T_{DA}}{721.11 \text{ mm}}\left[(400 \text{ mm})\mathbf{i} - (600 \text{ mm})\mathbf{j}\right]$$

$$= T_{DA}(0.55470\mathbf{i} - 0.83205\mathbf{j})$$

$$\mathbf{T}_{DB} = T_{DB}\lambda_{DB}$$

$$= \frac{T_{DB}}{663.32 \text{ mm}}\left[-(200 \text{ mm})\mathbf{i} - (600 \text{ mm})\mathbf{j} + (200 \text{ mm})\mathbf{k}\right]$$

$$= T_{DB}(-0.30151\mathbf{i} - 0.90454\mathbf{j} + 0.30151\mathbf{k})$$

$$\mathbf{T}_{DC} = T_{DC}\lambda_{DC}$$

$$= \frac{T_{DC}}{663.32 \text{ mm}}\left[-(200 \text{ mm})\mathbf{i} - (600 \text{ mm})\mathbf{j} - (200 \text{ mm})\mathbf{k}\right]$$

$$= T_{DC}(-0.30151\mathbf{i} - 0.90454\mathbf{j} - 0.30151\mathbf{k})$$

At point D $\quad \Sigma\mathbf{F} = 0: \quad \mathbf{T}_{DA} + \mathbf{T}_{DB} + \mathbf{T}_{DC} + \mathbf{W} = 0$

i component: $\quad 0.55470T_{DA} - 0.30151T_{DB} - 0.30151T_{DC} = 0 \quad (1)$

j component: $\quad -0.83205T_{DA} - 0.90454T_{DB} - 0.90454T_{DC} + W = 0 \quad (2)$

k component: $\quad 0.30151T_{DB} - 0.30151T_{DC} = 0 \quad (3)$

Setting $W = (16 \text{ kg})(9.81 \text{ m/s}^2) = 156.96 \text{ N}$

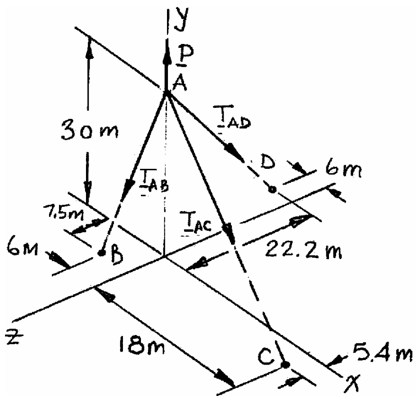
And Solving Equations (1), (2), and (3) simultaneously:

$T_{DA} = 62.9 \text{ N}$ ◀

$T_{DB} = 57.8 \text{ N}$ ◀

$T_{DC} = 57.8 \text{ N}$ ◀

Chapter 2, Solution 115.



From the solutions of 2.107 and 2.108:

$$T_{AB} = 0.5409P$$

$$T_{AC} = 0.295P$$

$$T_{AD} = 0.2959P$$

Using $P = 8$ kN:

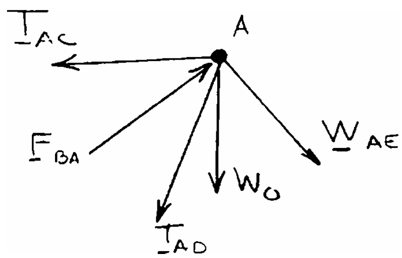
$T_{AB} = 4.33$ kN ◀

$T_{AC} = 2.36$ kN ◀

$T_{AD} = 2.37$ kN ◀

Vector Mechanics for Engineers: Statics and Dynamics, 8/e, Ferdinand P. Beer, E. Russell Johnston, Jr.,
Elliot R. Eisenberg, William E. Clausen, David Mazurek, Phillip J. Cornwell

Chapter 2, Solution 116.



$$d_{BA} = \sqrt{(6\text{ m})^2 + (6\text{ m})^2 + (3\text{ m})^2} = 9\text{ m}$$

$$d_{AC} = \sqrt{(-10.5\text{ m})^2 + (-6\text{ m})^2 + (-8\text{ m})^2} = 14.5\text{ mm}$$

$$d_{AD} = \sqrt{(-6\text{ m})^2 + (-6\text{ m})^2 + (7\text{ m})^2} = 11\text{ mm}$$

$$d_{AE} = \sqrt{(6\text{ m})^2 + (-4.5\text{ m})^2} = 7.5\text{ m}$$

$$\mathbf{F}_{BA} = F_{BA}\lambda_{BA} = \frac{F_{BA}}{9\text{ m}}\left[(6\text{ m})\mathbf{i} + (6\text{ m})\mathbf{j} + (3\text{ m})\mathbf{k}\right]$$

$$= F_{BA}\left(\frac{2}{3}\mathbf{i} + \frac{2}{3}\mathbf{j} + \frac{1}{3}\mathbf{k}\right)$$

$$\mathbf{T}_{AC} = T_{AC}\lambda_{AC} = \frac{T_{AC}}{14.5\text{ m}}\left[-(10.5\text{ m})\mathbf{i} - (6\text{ m})\mathbf{j} - (8\text{ m})\mathbf{k}\right]$$

$$= T_{AC}\left(-\frac{21}{29}\mathbf{i} - \frac{12}{29}\mathbf{j} - \frac{16}{29}\mathbf{k}\right)$$

$$\mathbf{T}_{AD} = T_{AD}\lambda_{AD} = \frac{T_{AD}}{11\text{ m}}\left[-(6\text{ m})\mathbf{i} - (6\text{ m})\mathbf{j} + (7\text{ m})\mathbf{k}\right]$$

$$= T_{AD}\left(-\frac{6}{11}\mathbf{i} - \frac{6}{11}\mathbf{j} + \frac{7}{11}\mathbf{k}\right)$$

$$\mathbf{W}_{AE} = W_{AE}\lambda_{AE} = \frac{W}{7.5\text{ m}}\left[(6\text{ m})\mathbf{i} - (4.5\text{ m})\mathbf{j}\right]$$

$$= W(0.8\mathbf{i} - 0.6\mathbf{j})$$

$$\mathbf{W}_O = -W\mathbf{j}$$

At point A: $\Sigma\mathbf{F} = 0$: $\mathbf{F}_{BA} + \mathbf{T}_{AC} + \mathbf{T}_{AD} + \mathbf{W}_{AE} + \mathbf{W}_O = 0$

i component: $\frac{2}{3}F_{BA} - \frac{21}{29}T_{AC} - \frac{6}{11}T_{AD} + 0.8W = 0$ (1)

continued

j component: $\frac{2}{3}F_{BA} - \frac{12}{29}T_{AC} - \frac{6}{11}T_{AD} - 1.6W = 0$ (2)

k component: $\frac{1}{3}F_{BA} - \frac{16}{29}T_{AC} + \frac{7}{11}T_{AD} = 0$ (3)

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

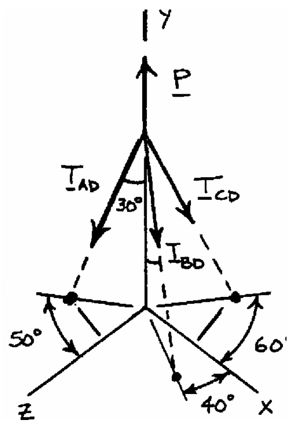
And Solving Equations (1), (2), and (3) simultaneously:

$F_{BA} = 1742\text{ N}$ ◀

$T_{AC} = 1517\text{ N}$ ◀

$T_{AD} = 403\text{ N}$ ◀

Chapter 2, Solution 117.



$\Sigma F_x = 0$:

$$-T_{AD}(\sin 30°)(\sin 50°) + T_{BD}(\sin 30°)(\cos 40°) + T_{CD}(\sin 30°)(\cos 60°) = 0$$

Dividing through by $\sin 30°$ and evaluating:

$$-0.76604T_{AD} + 0.76604T_{BD} + 0.5T_{CD} = 0 \qquad (1)$$

$\Sigma F_y = 0$:

$$-T_{AD}(\cos 30°) - T_{BD}(\cos 30°) - T_{CD}(\cos 30°) + 62 \text{ lb} = 0$$

or $T_{AD} + T_{BD} + T_{CD} = 71.591 \text{ lb} \qquad (2)$

$\Sigma F_z = 0$:

$$T_{AD}\sin 30°\cos 50° + T_{BD}\sin 30°\sin 40° - T_{CD}\sin 30°\sin 60° = 0$$

or $\quad 0.64279T_{AD} + 0.64279T_{BD} - 0.86603T_{CD} = 0 \qquad (3)$

Solving Equations (1), (2), and (3) simultaneously:

$T_{AD} = 30.5 \text{ lb}$ ◀

$T_{BD} = 10.59 \text{ lb}$ ◀

$T_{CD} = 30.5 \text{ lb}$ ◀

Chapter 2, Solution 118.

From the solutions to Problems 2.111 and 2.112, have

$$T_{BE} + T_{CF} + T_{DG} = 0.2\sqrt{65} \quad (2')$$

$$-T_{BE}\sin 45° + T_{CF}\sin 30° - T_{DG}\sin 15° = 0 \quad (3)$$

$$T_{BE}\cos 45° + T_{CF}\cos 30° - T_{DG}\cos 15° - P\sqrt{65} = 0 \quad (1')$$

Applying the method of elimination to obtain a desired result:

Multiplying $(2')$ by $\sin 45°$ and adding the result to (3):

$$T_{CF}\left(\sin 45° + \sin 30°\right) + T_{DG}\left(\sin 45° - \sin 15°\right) = 0.2\sqrt{65}\sin 45°$$

or

$$T_{CF} = 0.94455 - 0.37137 T_{DG}$$

Multiplying $(2')$ by $\sin 30°$ and subtracting (3) from the result:

$$T_{BE}\left(\sin 30° + \sin 45°\right) + T_{DG}\left(\sin 30° + \sin 15°\right) = 0.2\sqrt{65}\sin 30°$$

or

$$T_{BE} = 0.66790 - 0.62863 T_{DG} \quad (5)$$

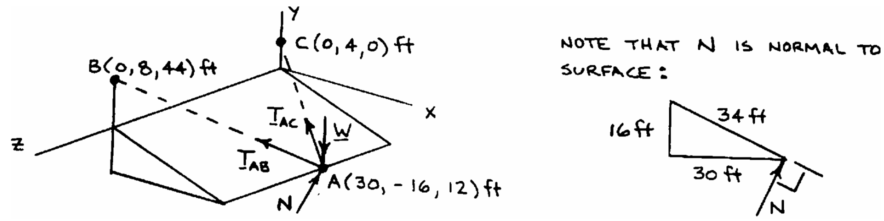
Substituting (4) and (5) into $(1')$:

$$1.29028 - 1.73205 T_{DG} - P\sqrt{65} = 0$$

$$\therefore \quad T_{DG} \text{ is taut for } P < \frac{1.29028}{\sqrt{65}} \text{ lb}$$

$$\text{or} \quad 0 \le P \le 0.1600 \text{ lb} \blacktriangleleft$$

Chapter 2, Solution 119.



$$d_{AB} = \sqrt{(-30 \text{ ft})^2 + (24 \text{ ft})^2 + (32 \text{ ft})^2} = 50 \text{ ft}$$

$$d_{AC} = \sqrt{(-30 \text{ ft})^2 + (20 \text{ ft})^2 + (-12 \text{ ft})^2} = 38 \text{ ft}$$

$$\mathbf{T}_{AB} = T_{AB}\lambda_{AB} = \frac{T_{AB}}{50 \text{ ft}}\left[-(30 \text{ ft})\mathbf{i} + (24 \text{ ft})\mathbf{j} + (32 \text{ ft})\mathbf{k}\right]$$

$$= T_{AB}\left(-0.6\mathbf{i} + 0.48\mathbf{j} + 0.64\mathbf{k}\right)$$

$$\mathbf{T}_{AC} = T_{AC}\lambda_{AC} = \frac{T_{AC}}{38 \text{ ft}}\left[-(30 \text{ ft})\mathbf{i} + (20 \text{ ft})\mathbf{j} - (12 \text{ ft})\mathbf{k}\right]$$

$$= T_{AC}\left(-\frac{30}{38}\mathbf{i} + \frac{20}{38}\mathbf{j} - \frac{12}{38}\mathbf{k}\right)$$

$$\mathbf{N} = \frac{16}{34}\text{N}\mathbf{i} + \frac{30}{34}\text{N}\mathbf{j}$$

$$\mathbf{W} = -(175 \text{ lb})\mathbf{j}$$

At point A: $\Sigma\mathbf{F} = 0$: $\mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{N} + \mathbf{W} = 0$

i component: $-0.6T_{AB} - \frac{30}{38}T_{AC} + \frac{16}{34}\text{N} = 0$ (1)

j component: $0.48T_{AB} + \frac{20}{38}T_{AC} + \frac{30}{34}\text{N} - 175 \text{ lb} = 0$ (2)

k component: $0.64T_{AB} - \frac{12}{38}T_{AC} = 0$ (3)

Solving Equations (1), (2), and (3) simultaneously:

$T_{AB} = 30.9$ lb ◀

$T_{AC} = 62.5$ lb ◀

Chapter 2, Solution 120.

Refer to the solution of problem 2.119 and the resulting linear algebraic Equations (1), (2), (3). Include force $\mathbf{P} = -(45 \text{ lb})\mathbf{k}$ with other forces of Problem 2.119.

Now at point A: $\Sigma\mathbf{F} = 0$: $\mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{N} + \mathbf{W} + \mathbf{P} = 0$

i component: $$-0.6T_{AB} - \frac{30}{38}T_{AC} + \frac{16}{34}\text{N} = 0 \quad (1)$$

j component: $$0.48T_{AB} + \frac{20}{38}T_{AC} + \frac{30}{34}\text{N} - 175 \text{ lb} = 0 \quad (2)$$

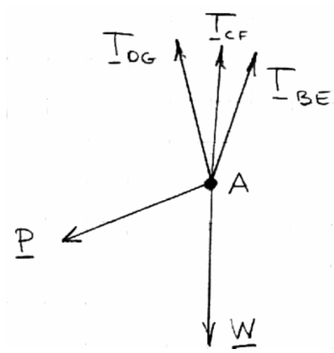
k component: $$0.64T_{AB} - \frac{12}{38}T_{AC} - 45 \text{ lb} = 0 \quad (3)$$

Solving (1), (2), and (3) simultaneously:

$T_{AB} = 81.3$ lb ◀

$T_{AC} = 22.2$ lb ◀

Chapter 2, Solution 121.



Note: *BE* shares the same unit vector as *AB*.

Thus:

$$\lambda_{BE} = \lambda_{AB} = \frac{(25\text{ mm})\cos 45°\mathbf{i} + (200\text{ mm})\mathbf{j} - (25\text{ mm})\sin 45°\mathbf{k}}{201.56\text{ mm}}$$

$$\mathbf{T}_{BE} = T_{BE}\lambda_{BE} = \frac{T_{BE}}{201.56\text{ mm}}\left[(25\text{ mm})\cos 45°\mathbf{i} + (200\text{ mm})\mathbf{j} - (25\text{ mm})\sin 45°\mathbf{k}\right]$$

$$\mathbf{T}_{CF} = T_{CF}\lambda_{CF} = \frac{T_{CF}}{201.56\text{ mm}}\left[(25\text{ mm})\cos 30°\mathbf{i} + (200\text{ mm})\mathbf{j} + (25\text{ mm})\sin 30°\mathbf{k}\right]$$

$$\mathbf{T}_{DG} = T_{DG}\lambda_{DG} = \frac{T_{DG}}{201.56\text{ mm}}\left[-(25\text{ mm})\cos 15°\mathbf{i} + (200\text{ mm})\mathbf{j} - (25\text{ mm})\sin 15°\mathbf{k}\right]$$

$$\mathbf{W} = -W\mathbf{j}; \qquad \mathbf{P} = P\mathbf{k}$$

At point A: $\Sigma\mathbf{F} = 0$: $\mathbf{T}_{BE} + \mathbf{T}_{CE} + \mathbf{T}_{DG} + \mathbf{W} + \mathbf{P} = 0$

i component: $0.087704T_{BE} + 0.107415T_{CF} - 0.119806T_{DG} = 0$ (1)

j component: $0.99226T_{BE} + 0.99226T_{CF} + 0.99226T_{DG} - W = 0$ (2)

k component: $-0.087704T_{BE} + 0.062016T_{CF} - 0.032102T_{DG} + P = 0$ (3)

Setting $W = 10.5$ N and $P = 0$, and solving (1), (2), (3) simultaneously:

$T_{BE} = 1.310$ N ◀

$T_{CF} = 4.38$ N ◀

$T_{DG} = 4.89$ N ◀

Chapter 2, Solution 122.

See Problem 2.121 for the analysis leading to the linear algebraic Equations (1), (2), and (3) below:

i component: $0.087704T_{BE} + 0.107415T_{CF} - 0.119806T_{DG} = 0$ (1)

j component: $0.99226\ T_{BE} + 0.99226\ T_{CF} + 0.99226\ T_{DG} - W = 0$ (2)

k component: $-0.087704T_{BE} + 0.062016T_{CF} - 0.032102T_{DG} + P = 0$ (3)

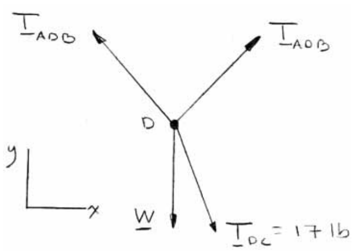
Setting W = 10.5 N and P = 0.5 N, and solving (1), (2), (3) simultaneously:

$T_{BE} = 4.84$ N ◀

$T_{CF} = 1.157$ N ◀

$T_{DG} = 4.58$ N ◀

Chapter 2, Solution 123.



$$\overline{DA} = -(8\text{ ft})\mathbf{i} + (40\text{ ft})\mathbf{j} + (10\text{ ft})\mathbf{k}$$

$$DA = \sqrt{(-8\text{ ft})^2 + (40\text{ ft})^2 + (10\text{ ft})^2} = 42\text{ ft}$$

$$\mathbf{T}_{DA} = \frac{T_{ADB}}{42\text{ ft}}\left[-(8\text{ ft})\mathbf{i} + (40\text{ ft})\mathbf{j} + (10\text{ ft})\mathbf{k}\right]$$

$$= T_{ADB}(-0.190476\mathbf{i} + 0.95238\mathbf{j} + 0.23810\mathbf{k})$$

$$\overline{DB} = (3\text{ ft})\mathbf{i} + (36\text{ ft})\mathbf{j} - (8\text{ ft})\mathbf{k}$$

$$DB = \sqrt{(3\text{ ft})^2 + (36\text{ ft})^2 + (-8\text{ ft})^2} = 37\text{ ft}$$

$$\mathbf{T}_{DB} = \frac{T_{ADB}}{37\text{ ft}}\left[(3\text{ ft})\mathbf{i} + (36\text{ ft})\mathbf{j} - (8\text{ ft})\mathbf{k}\right]$$

$$= T_{ADB}(0.081081\mathbf{i} + 0.97297\mathbf{j} - 0.21622\mathbf{k})$$

$$\overline{DC} = (a - 8\text{ ft})\mathbf{i} - (24\text{ ft})\mathbf{j} - (3\text{ ft})\mathbf{k}$$

$$DC = \sqrt{(a - 8\text{ ft})^2 + (-24\text{ ft})^2 + (-3\text{ ft})^2} = \sqrt{(a-8)^2 + 585}\text{ ft}$$

$$\mathbf{T}_{DC} = \frac{T_{DC}}{\sqrt{(a-8)^2 + 585}}\left[(a - 8\text{ ft})\mathbf{i} - (24\text{ ft})\mathbf{j} - (3\text{ ft})\mathbf{k}\right]$$

At D $\quad \Sigma\mathbf{F} = 0$:

$$\Sigma F_x = 0: \quad -0.190476T_{ADB} + 0.081081T_{ADB} + \frac{(a-8)}{\sqrt{(a-8)^2 + 585}}T_{DC} = 0 \qquad (1)$$

$$\Sigma F_z = 0: \quad 0.23810T_{ADB} - 0.21622T_{ADB} - \frac{3}{\sqrt{(a-8)^2 + 585}}T_{DC} = 0 \qquad (2)$$

Dividing equation (1) by equation (2) gives

$$\frac{(a-8)}{-3} = \frac{0.190476 - 0.081081}{-0.23810 + 0.21622}$$

or $\quad a = 23$ ft

Substituting into equation (1) for $a = 23$ ft and combining the coefficients for T_{ADB} gives:

$$\Sigma F_x = 0: \qquad -0.109395T_{ADB} + 0.52705T_{DC} = 0 \qquad (3)$$

continued

And writing $\Sigma F_y = 0$ gives:

$$1.92535T_{ADB} - 0.84327T_{DC} - W = 0 \qquad (4)$$

Substituting into equation (3) for $T_{DC} = 17$ lb gives:

$$-0.109395T_{ADB} + 0.52705(17 \text{ lb}) = 0$$

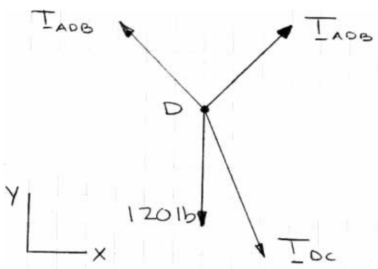
or $T_{ADB} = 81.9$ lb ◀

Substituting into equation (4) for $T_{DC} = 17$ lb and $T_{ADB} = 81.9$ lb gives:

$$1.92535\,(81.9 \text{ lb}) - 0.84327\,(17 \text{ lb}) - W = 0$$

or $W = 143.4$ lb ◀

Chapter 2, Solution 124.



See Problem 2.123 for the analysis leading to the linear algebraic Equations (3) and (4) below:

$$-0.109395T_{ADB} + 0.52705T_{DC} = 0 \quad (3)$$

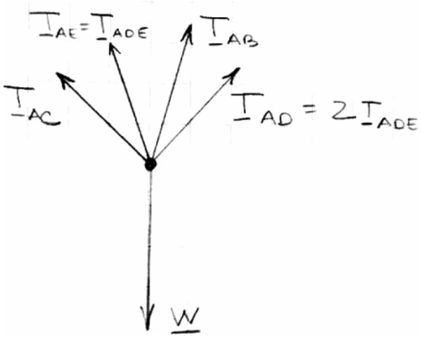
$$1.92535T_{ADB} - 0.84327T_{DC} - W = 0 \quad (4)$$

Substituting for $W = 120$ lb and solving equations (3) and (4) simultaneously yields

$T_{ADB} = 68.6$ lb ◀

$T_{DC} = 14.23$ lb ◀

Chapter 2, Solution 125.



$$d_{AB} = \sqrt{(-2.7\text{ m})^2 + (2.4\text{ m})^2 + (-3.6\text{ m})^2} = 5.1\text{ m}$$

$$d_{AC} = \sqrt{(2.4\text{ m})^2 + (1.8\text{ m})^2} = 3\text{ m}$$

$$d_{AD} = \sqrt{(1.2\text{ m})^2 + (2.4\text{ m})^2 + (-0.3\text{ m})^2} = 2.7\text{ m}$$

$$d_{AE} = \sqrt{(-2.4\text{ m})^2 + (2.4\text{ m})^2 + (1.2\text{ m})^2} = 3.6\text{ m}$$

$$\mathbf{T}_{AB} = T_{AB}\lambda_{AB}$$

$$= \frac{T_{AB}}{5.1\text{ m}}\left[-(2.7\text{ m})\mathbf{i} + (2.4\text{ m})\mathbf{j} - (3.6\text{ m})\mathbf{k}\right]$$

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

$$\mathbf{T}_{AC} = T_{AC}\lambda_{AC}$$

$$= \frac{T_{AC}}{3\text{ m}}\left[(2.4\text{ m})\mathbf{j} + (1.8\text{ m})\mathbf{k}\right]$$

$$= T_{AC}(0.8\mathbf{j} + 0.6\mathbf{k})$$

$$\mathbf{T}_{AD} = 2T_{ADE}\lambda_{AD}$$

$$= \frac{2T_{ADE}}{2.7\text{ m}}\left[(1.2\text{ m})\mathbf{i} + (2.4\text{ m})\mathbf{j} - (0.3\text{ m})\mathbf{k}\right]$$

$$= T_{ADE}\left(\frac{8}{9}\mathbf{i} + \frac{16}{9}\mathbf{j} - \frac{2}{9}\mathbf{k}\right)$$

continued

$$\mathbf{T}_{AE} = T_{AE}\lambda_{AE}$$

$$= \frac{T_{ADE}}{3.6\text{ m}}\left[-(2.4\text{ m})\mathbf{i} + (2.4\text{ m})\mathbf{j} + (1.2\text{ m})\mathbf{k}\right]$$

$$= T_{ADE}\left(-\frac{2}{3}\mathbf{i} + \frac{2}{3}\mathbf{j} + \frac{1}{3}\mathbf{k}\right)$$

$$\mathbf{W} = -W\mathbf{j}$$

At point A: $\Sigma\mathbf{F} = 0$: $\mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{T}_{AD} + \mathbf{T}_{AE} + \mathbf{W} = 0$

i component: $-\frac{9}{17}T_{AB} + \frac{8}{9}T_{ADE} - \frac{2}{3}T_{ADE} = 0$ (1)

j component: $\frac{8}{17}T_{AB} + 0.8\,T_{AC} + \frac{16}{9}T_{ADE} + \frac{2}{3}T_{ADE} - W = 0$ (2)

k component: $-\frac{12}{17}T_{AB} + 0.6\,T_{AC} - \frac{2}{9}T_{ADE} + \frac{1}{3}T_{ADE} = 0$ (3)

Simplifying (1), (2), (3):

$$-81T_{AB} + 34T_{ADE} = 0 \qquad (1')$$

$$72T_{AB} + 122.4T_{AC} + 374T_{ADE} = 153\,W \qquad (2')$$

$$-108T_{AB} + 91.8T_{AC} + 17T_{ADE} = 0 \qquad (3')$$

Setting $W = 1400$ N and solving (1), (2), (3) simultaneously:

$T_{AB} = 203$ N ◀

$T_{AC} = 149.6$ N ◀

$T_{ADE} = 485$ N ◀

Chapter 2, Solution 126.

See Problem 2.125 for the analysis leading to the linear algebraic Equations $(1')$, $(2')$, and $(3')$ below:

i component: $-81\,T_{AB} + 34\,T_{ADE} = 0$ $(1')$

j component: $72\,T_{AB} + 122.4\,T_{AC} + 37.4\,T_{ADE} = 153\,W$ $(2')$

k component: $-108\,T_{AB} + 91.8\,T_{AC} + 17\,T_{ADE} = 0$ $(3')$

Setting T_{AB} = 300 N and solving (1), (2), (3) simultaneously:

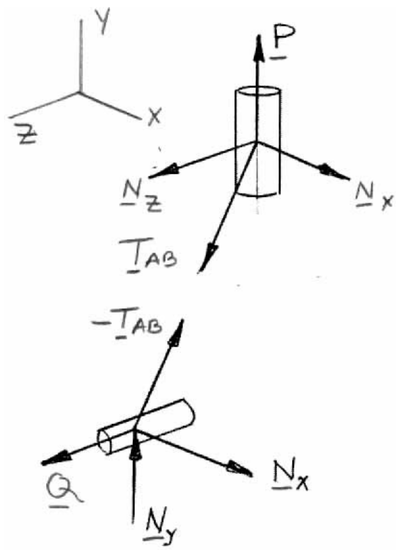
(*a*) $T_{AC} = 221$ N ◀

(*b*) $T_{ADE} = 715$ N ◀

(*c*) $W = 2060$ N ◀

Chapter 2, Solution 127.

Free-Body Diagrams of collars



For both Problems 2.127 and 2.128:

$$(AB)^2 = x^2 + y^2 + z^2$$

Here $\qquad (1\text{ m})^2 = (0.40\text{ m})^2 + y^2 + z^2$

or $\qquad y^2 + z^2 = 0.84\text{ m}^2$

Thus, with y given, z is determined.

Now

$$\boldsymbol{\lambda}_{AB} = \frac{\overrightarrow{AB}}{AB} = \frac{1}{1\text{ m}}(0.40\mathbf{i} - y\mathbf{j} + z\mathbf{k})\text{m} = 0.4\mathbf{i} - y\mathbf{k} + z\mathbf{k}$$

Where y and z are in units of meters, m.

From the F.B. Diagram of collar A:

$$\Sigma\mathbf{F} = 0: \quad N_x\mathbf{i} + N_z\mathbf{k} + P\mathbf{j} + T_{AB}\boldsymbol{\lambda}_{AB} = 0$$

Setting the $\mathbf{j}$ coefficient to zero gives:

$$P - yT_{AB} = 0$$

With $P = 680$ N,

$$T_{AB} = \frac{680\text{ N}}{y}$$

Now, from the free body diagram of collar B:

$$\Sigma\mathbf{F} = 0: \quad N_x\mathbf{i} + N_y\mathbf{j} + Q\mathbf{k} - T_{AB}\boldsymbol{\lambda}_{AB} = 0$$

continued

Setting the **k** coefficient to zero gives:

$$Q - T_{AB}z = 0$$

And using the above result for T_{AB} we have

$$Q = T_{AB}z = \frac{680\text{ N}}{y}z$$

Then, from the specifications of the problem, $y = 300\text{ mm} = 0.3\text{ m}$

$$z^2 = 0.84\text{ m}^2 - (0.3\text{ m})^2$$

$$\therefore\ z = 0.866\text{ m}$$

and

(*a*) $$T_{AB} = \frac{680\text{ N}}{0.30} = 2266.7\text{ N}$$

or $T_{AB} = 2.27\text{ kN}$ ◀

and

(*b*) $$Q = 2266.7(0.866) = 1963.2\text{ N}$$

or $Q = 1.963\text{ kN}$ ◀

Chapter 2, Solution 128.

From the analysis of Problem 2.127, particularly the results:

$$y^2 + z^2 = 0.84 \text{ m}^2$$

$$T_{AB} = \frac{680 \text{ N}}{y}$$

$$Q = \frac{680 \text{ N}}{y} z$$

With $y = 550 \text{ mm} = 0.55 \text{ m}$, we obtain:

$$z^2 = 0.84 \text{ m}^2 - (0.55 \text{ m})^2$$

$$\therefore \; z = 0.73314 \text{ m}$$

and

(*a*) $$T_{AB} = \frac{680 \text{ N}}{0.55} = 1236.36 \text{ N}$$

or $$T_{AB} = 1.236 \text{ kN} \blacktriangleleft$$

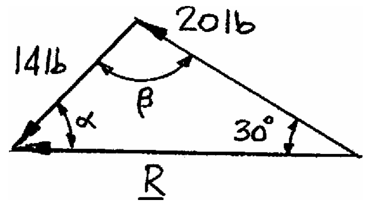
and

(*b*) $$Q = 1236.36(0.73314) \text{ N} = 906 \text{ N}$$

or $$Q = 0.906 \text{ kN} \blacktriangleleft$$

Chapter 2, Solution 129.

Using the triangle rule and the Law of Sines



(*a*) Have:

$$\frac{20 \text{ lb}}{\sin\alpha} = \frac{14 \text{ lb}}{\sin 30°}$$

$$\sin\alpha = 0.71428$$

$$\alpha = 45.6° ◀$$

(*b*)

$$\beta = 180° - (30° + 45.6°)$$

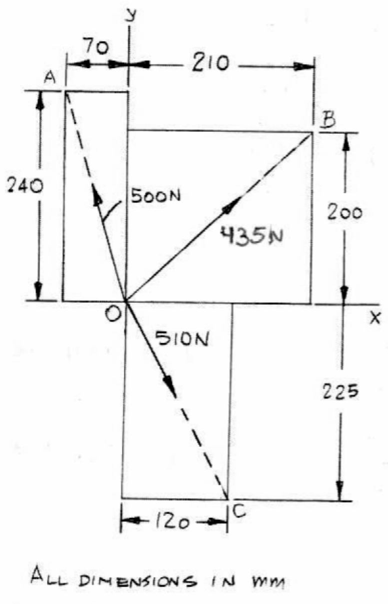
$$= 104.4°$$

Then:

$$\frac{R}{\sin 104.4°} = \frac{14 \text{ lb}}{\sin 30°}$$

$$R = 27.1 \text{ lb} ◀$$

Chapter 2, Solution 130.



We compute the following distances:

$$OA = \sqrt{(70)^2 + (240)^2} = 250 \text{ mm}$$

$$OB = \sqrt{(210)^2 + (200)^2} = 290 \text{ mm}$$

$$OC = \sqrt{(120)^2 + (225)^2} = 255 \text{ mm}$$

500 N Force:

$$F_x = -500 \text{ N}\left(\frac{70}{250}\right) \qquad F_x = -140.0 \text{ N} \blacktriangleleft$$

$$F_y = +500 \text{ N}\left(\frac{240}{250}\right) \qquad F_y = 480 \text{ N} \blacktriangleleft$$

435 N Force:

$$F_x = +435 \text{ N}\left(\frac{210}{290}\right) \qquad F_x = 315 \text{ N} \blacktriangleleft$$

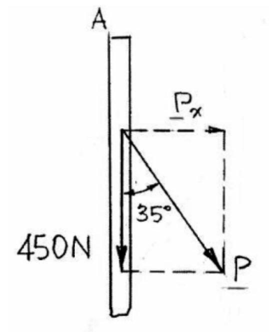
$$F_y = +435 \text{ N}\left(\frac{200}{290}\right) \qquad F_y = 300 \text{ N} \blacktriangleleft$$

510 N Force:

$$F_x = +510 \text{ N}\left(\frac{120}{255}\right) \qquad F_x = 240 \text{ N} \blacktriangleleft$$

$$F_y = -510 \text{ N}\left(\frac{225}{255}\right) \qquad F_y = -450 \text{ N} \blacktriangleleft$$

Chapter 2, Solution 131.



Note that the force exerted by *BD* on the pole is directed along *BD*, and the component of *P* along *AC* is 450 N.

Then:

(*a*) $$P = \frac{450 \text{ N}}{\cos 35°} = 549.3 \text{ N}$$

$$P = 549 \text{ N} \blacktriangleleft$$

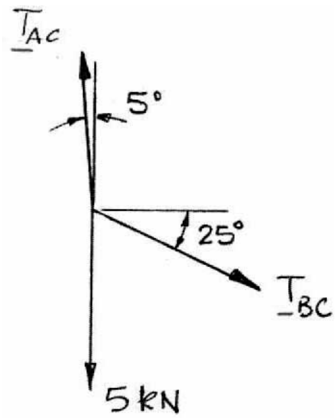
(*b*) $$P_x = (450 \text{ N}) \tan 35°$$

$$= 315.1 \text{ N}$$

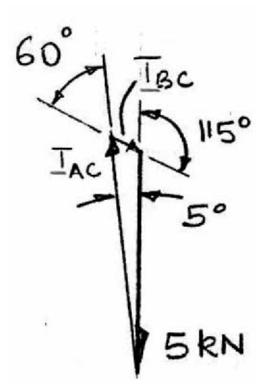
$P_x = 315 \text{ N} \blacktriangleleft$

Chapter 2, Solution 132.

Free-Body Diagram



Force Triangle



Law of Sines:

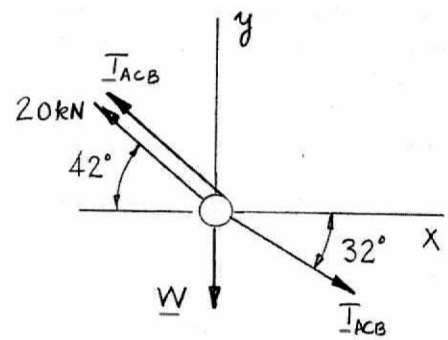
$$\frac{T_{AC}}{\sin 115^\circ} = \frac{T_{BC}}{\sin 5^\circ} = \frac{5\text{ kN}}{\sin 60^\circ}$$

(*a*) $$T_{AC} = \frac{5\text{ kN}}{\sin 60^\circ}\sin 115^\circ = 5.23\text{ kN}$$ $T_{AC} = 5.23\text{ kN}$ ◀

(*b*) $$T_{BC} = \frac{5\text{ kN}}{\sin 60^\circ}\sin 5^\circ = 0.503\text{ kN}$$ $T_{BC} = 0.503\text{ kN}$ ◀

Chapter 2, Solution 133.

Free-Body Diagram



First, consider the sum of forces in the x-direction because there is only one unknown force:

$$\xrightarrow{+} \Sigma F_x = 0: \quad T_{ACB}\left(\cos 32° - \cos 42°\right) - \left(20 \text{ kN}\right)\cos 42° = 0$$

or

$$0.104903 T_{ACB} = 14.8629 \text{ kN}$$

$$T_{ACB} = 141.682 \text{ kN}$$

(b) $T_{ACB} = 141.7 \text{ kN}$ ◀

Now

$$+\uparrow \Sigma F_y = 0: \quad T_{ACB}\left(\sin 42° - \sin 32°\right) + \left(20 \text{ kN}\right)\sin 42° - W = 0$$

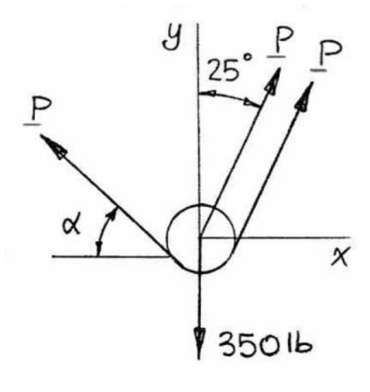
or

$$\left(141.682 \text{ kN}\right)\left(0.139211\right) + \left(20 \text{ kN}\right)\left(0.66913\right) - W = 0$$

(a) $W = 33.1 \text{ kN}$ ◀

Chapter 2, Solution 134.

Free-Body Diagram: Pulley A



$\xrightarrow{+} \Sigma F_x = 0: \quad 2P\sin 25° - P\cos\alpha = 0$

and

$\cos\alpha = 0.8452 \qquad \text{or} \qquad \alpha = \pm 32.3°$

For $\alpha = +32.3°$

$+\uparrow \Sigma F_y = 0: \quad 2P\cos 25° + P\sin 32.3° - 350 \text{ lb} = 0$

or **P** = 149.1 lb ⦪ 32.3° ◀

For $\alpha = -32.3°$

$+\uparrow \Sigma F_y = 0: \quad 2P\cos 25° + P\sin -32.3° - 350 \text{ lb} = 0$

or **P** = 274 lb ⦩ 32.3° ◀

Chapter 2, Solution 135.

(*a*) $F_x = F \sin 30° \sin 50° = 220.6 \text{ N}$ (Given)

$$F = \frac{220.6 \text{ N}}{\sin 30° \sin 50°} = 575.95 \text{ N}$$

$F = 576 \text{ N}$ ◀

(*b*) $$\cos\theta_x = \frac{F_x}{F} = \frac{220.6}{575.95} = 0.38302$$

$\theta_x = 67.5°$ ◀

$$F_y = F \cos 30° = 498.79 \text{ N}$$

$$\cos\theta_y = \frac{F_y}{F} = \frac{498.79}{575.95} = 0.86605$$

$\theta_y = 30.0°$ ◀

$$F_z = -F \sin 30° \cos 50°$$

$$= -(575.95 \text{ N}) \sin 30° \cos 50°$$

$$= -185.107 \text{ N}$$

$$\cos\theta_z = \frac{F_z}{F} = \frac{-185.107}{575.95} = -0.32139$$

$\theta_z = 108.7°$ ◀

Chapter 2, Solution 136.

(*a*) $F_z = F\cos\theta_z = (600\text{ lb})\cos 136.8°$

$= -437.38\text{ lb}$ $\qquad F_z = -437\text{ lb}$ ◀

Then:

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

So: $(600\text{ lb})^2 = (200\text{ lb})^2 + (F_y)^2 + (-437.38\text{ lb})^2$

Hence: $F_y = -\sqrt{(600\text{ lb})^2 - (200\text{ lb})^2 - (-437.38\text{ lb})^2}$

$= -358.75\text{ lb}$ $\qquad F_y = -359\text{ lb}$ ◀

(*b*) $\cos\theta_x = \dfrac{F_x}{F} = \dfrac{200}{600} = 0.33333$ $\qquad \theta_x = 70.5°$ ◀

$\cos\theta_y = \dfrac{F_y}{F} = \dfrac{-358.75}{600} = -0.59792$ $\qquad \theta_y = 126.7°$ ◀

Chapter 2, Solution 137.

$$\mathbf{P} = (500 \text{ lb})[-\cos 30° \sin 15° \mathbf{i} + \sin 30° \mathbf{j} + \cos 30° \cos 15° \mathbf{k}]$$

$$= (500 \text{ lb})[-0.2241\mathbf{i} + 0.50\mathbf{j} + 0.8365\mathbf{k}]$$

$$= -(112.05 \text{ lb})\mathbf{i} + (250 \text{ lb})\mathbf{j} + (418.25 \text{ lb})\mathbf{k}$$

$$\mathbf{Q} = (600 \text{ lb})[\cos 40° \cos 20° \mathbf{i} + \sin 40° \mathbf{j} - \cos 40° \sin 20° \mathbf{k}]$$

$$= (600 \text{ lb})[0.71985\mathbf{i} + 0.64278\mathbf{j} - 0.26201\mathbf{k}]$$

$$= (431.91 \text{ lb})\mathbf{i} + (385.67 \text{ lb})\mathbf{j} - (157.206 \text{ lb})\mathbf{k}$$

$$\mathbf{R} = \mathbf{P} + \mathbf{Q} = (319.86 \text{ lb})\mathbf{i} + (635.67 \text{ lb})\mathbf{j} + (261.04 \text{ lb})\mathbf{k}$$

$$R = \sqrt{(319.86 \text{ lb})^2 + (635.67 \text{ lb})^2 + (261.04 \text{ lb})^2} = 757.98 \text{ lb}$$

$$R = 758 \text{ lb} \blacktriangleleft$$

$$\cos\theta_x = \frac{R_x}{R} = \frac{319.86 \text{ lb}}{757.98 \text{ lb}} = 0.42199$$

$$\theta_x = 65.0° \blacktriangleleft$$

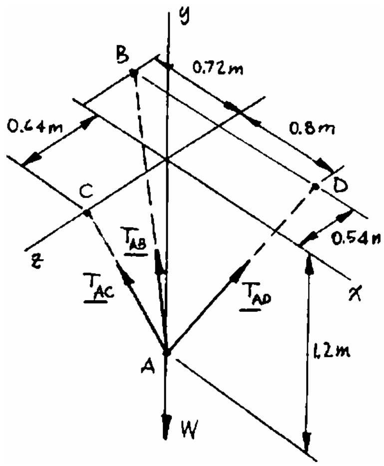
$$\cos\theta_y = \frac{R_y}{R} = \frac{635.67 \text{ lb}}{757.98 \text{ lb}} = 0.83864$$

$$\theta_y = 33.0° \blacktriangleleft$$

$$\cos\theta_z = \frac{R_z}{R} = \frac{261.04 \text{ lb}}{757.98 \text{ lb}} = 0.34439$$

$$\theta_z = 69.9° \blacktriangleleft$$

Chapter 2, Solution 138.



The forces applied at A are:

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

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

$$\overrightarrow{AB} = -(0.72\text{ m})\mathbf{i} + (1.2\text{ m})\mathbf{j} - (0.54\text{ m})\mathbf{k}, \qquad AB = 1.5\text{ m}$$

$$\overrightarrow{AC} = (1.2\text{ m})\mathbf{j} + (0.64\text{ m})\mathbf{k}, \qquad AC = 1.36\text{ m}$$

$$\overrightarrow{AD} = (0.8\text{ m})\mathbf{i} + (1.2\text{ m})\mathbf{j} - (0.54\text{ m})\mathbf{k}, \qquad AD = 1.54\text{ m}$$

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**:

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

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

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

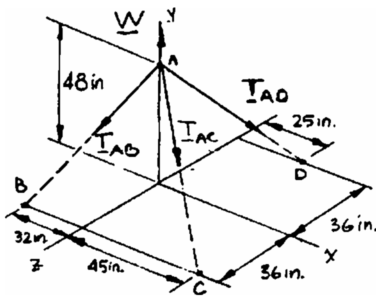
Substituting $T_{AB} = 3\text{ kN}$ in Equations (1), (2) and (3) and solving the resulting set of equations, using conventional algorithms for solving linear algebraic equations, gives

$$T_{AC} = 4.3605\text{ kN}$$

$$T_{AD} = 2.7720\text{ kN}$$

$W = 8.41\text{ kN}$ ◀

Chapter 2, Solution 139.



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

$$\overrightarrow{AB} = (32 \text{ in.})\mathbf{i} - (48 \text{ in.})\mathbf{j} + (36 \text{ in.})\mathbf{k}$$

$$AB = \sqrt{(-32 \text{ in.})^2 + (-48 \text{ in.})^2 + (36 \text{ in.})^2} = 68 \text{ in.}$$

$$\mathbf{T}_{AB} = T\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = \frac{T_{AB}}{68 \text{ in.}}\left[-(32 \text{ in.})\mathbf{i} - (48 \text{ in.})\mathbf{j} + (36 \text{ in.})\mathbf{k}\right]$$

$$\mathbf{T}_{AB} = T_{AB}\left(-0.47059\mathbf{i} - 0.70588\mathbf{j} + 0.52941\mathbf{k}\right)$$

and $$\overrightarrow{AC} = (45 \text{ in.})\mathbf{i} - (48 \text{ in.})\mathbf{j} + (36 \text{ in.})\mathbf{k}$$

$$AC = \sqrt{(45 \text{ in.})^2 + (-48 \text{ in.})^2 + (36 \text{ in.})^2} = 75 \text{ in.}$$

$$\mathbf{T}_{AC} = T\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = \frac{T_{AC}}{75 \text{ in.}}\left[(45 \text{ in.})\mathbf{i} - (48 \text{ in.})\mathbf{j} + (36 \text{ in.})\mathbf{k}\right]$$

$$\mathbf{T}_{AC} = T_{AC}\left(0.60\mathbf{i} - 0.64\mathbf{j} + 0.48\mathbf{k}\right)$$

Finally, $$\overrightarrow{AD} = (25 \text{ in.})\mathbf{i} - (48 \text{ in.})\mathbf{j} - (36 \text{ in.})\mathbf{k}$$

$$AD = \sqrt{(25 \text{ in.})^2 + (-48 \text{ in.})^2 + (-36 \text{ in.})^2} = 65 \text{ in.}$$

continued

$$\mathbf{T}_{AD} = T\boldsymbol{\lambda}_{AD} = T_{AD}\frac{\overrightarrow{AD}}{AD} = \frac{T_{AD}}{65 \text{ in.}}\left[(25 \text{ in.})\mathbf{i} - (48 \text{ in.})\mathbf{j} - (36 \text{ in.})\mathbf{k}\right]$$

$$\mathbf{T}_{AD} = T_{AD}\left(0.38461\mathbf{i} - 0.73846\mathbf{j} - 0.55385\mathbf{k}\right)$$

With $\mathbf{W} = W\mathbf{j}$, at A we have:

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

Equating the factors of **i**, **j**, and **k** to zero, we obtain the linear algebraic equations:

$$\mathbf{i}: \quad -0.47059T_{AB} + 0.60T_{AC} - 0.38461T_{AD} = 0 \qquad (1)$$

$$\mathbf{j}: \quad -0.70588T_{AB} - 0.64T_{AC} - 0.73846T_{AD} + W = 0 \qquad (2)$$

$$\mathbf{k}: \quad 0.52941T_{AB} + 0.48T_{AC} - 0.55385T_{AD} = 0 \qquad (3)$$

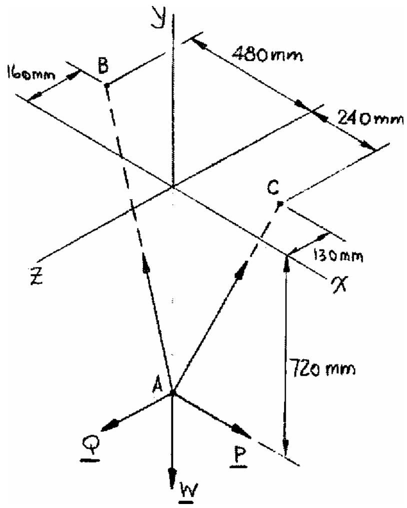
In Equations (1), (2) and (3), set $T_{AD} = 120$ lb, and, using conventional methods for solving Linear Algebraic Equations (MATLAB or Maple, for example), we obtain:

$$T_{AB} = 32.6 \text{ lb}$$

$$T_{AC} = 102.5 \text{ lb}$$

$$W = 177.2 \text{ lb} \blacktriangleleft$$

Chapter 2, Solution 140.



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

$$\overrightarrow{AB} = -(0.48\text{ m})\mathbf{i} + (0.72\text{ m})\mathbf{j} - (0.16\text{ m})\mathbf{k}$$

$$AB = \sqrt{(-0.48\text{ m})^2 + (0.72\text{ m})^2 + (-0.16\text{ m})^2} = 0.88\text{ m}$$

$$\mathbf{T}_{AB} = T\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = \frac{T_{AB}}{0.88\text{ m}}\left[-(0.48\text{ m})\mathbf{i} + (0.72\text{ m})\mathbf{j} - (0.16\text{ m})\mathbf{k}\right]$$

$$\mathbf{T}_{AB} = T_{AB}(-0.54545\mathbf{i} + 0.81818\mathbf{j} - 0.181818\mathbf{k})$$

and

$$\overrightarrow{AC} = (0.24\text{ m})\mathbf{i} + (0.72\text{ m})\mathbf{j} - (0.13\text{ m})\mathbf{k}$$

$$AC = \sqrt{(0.24\text{ m})^2 + (0.72\text{ m})^2 - (0.13\text{ m})^2} = 0.77\text{ m}$$

$$\mathbf{T}_{AC} = T\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = \frac{T_{AC}}{0.77\text{ m}}\left[(0.24\text{ m})\mathbf{i} + (0.72\text{ m})\mathbf{j} - (0.13\text{ m})\mathbf{k}\right]$$

$$\mathbf{T}_{AC} = T_{AC}(0.31169\mathbf{i} + 0.93506\mathbf{j} - 0.16883\mathbf{k})$$

At *A*: $\Sigma\mathbf{F} = 0\text{:} \quad \mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{P} + \mathbf{Q} + \mathbf{W} = 0$

Noting that $T_{AB} = T_{AC}$ because of the ring *A*, we equate the factors of **i**, **j**, and **k** to zero to obtain the linear algebraic equations:

$$\mathbf{i}\text{:} \quad (-0.54545 + 0.31169)T + P = 0$$

or $\qquad P = 0.23376T$

$$\mathbf{j}\text{:} \quad (0.81818 + 0.93506)T - W = 0$$

continued

or $$W = 1.75324T$$

$$\mathbf{k}: \quad (-0.181818 - 0.16883)T + Q = 0$$

or $$Q = 0.35065T$$

With $W = 1200$ N:

$$T = \frac{1200 \text{ N}}{1.75324} = 684.45 \text{ N}$$

$P = 160.0$ N ◀

$Q = 240$ N ◀