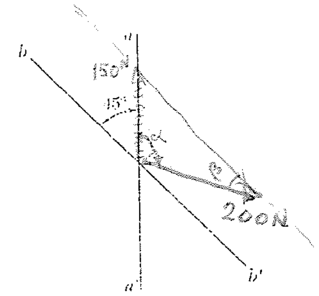
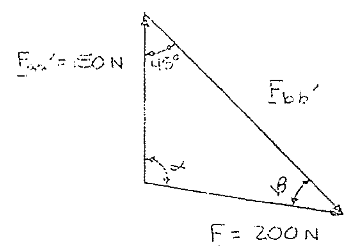


PROBLEM 2.5

The 200-N force is to be resolved into components along lines a-a' and b-b'. (a) Determine the angle α using trigonometry knowing that the component along a-a' is to be 150 N. (b) What is the corresponding value of the component along b-b'?

SOLUTION



Using the triangle rule and the Law of Sines

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

$$\sin\beta = 0.53033$$

$$\beta = 32.028^\circ$$

$$\alpha + \beta + 45^\circ = 180^\circ \implies \alpha = 103^\circ$$

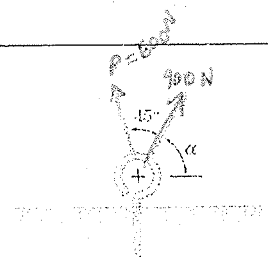
$\alpha = 103.0^\circ$ ◀

(b) Using the Law of Sines

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

103°

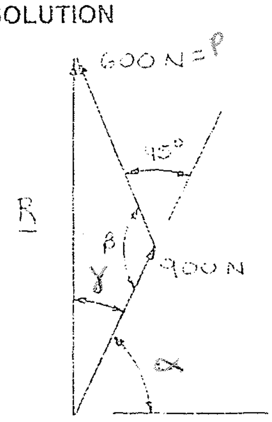
$F_{bb'} = 276$ N ◀



PROBLEM 2.7

Two forces are applied as shown to a hook support. Using trigonometry and knowing that the magnitude of **P** is 600 N, determine (*a*) the required angle α if the resultant **R** of the two forces applied to the support is to be vertical, (*b*) the corresponding magnitude of **R**.

SOLUTION



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 $\gamma = 17.7642°$

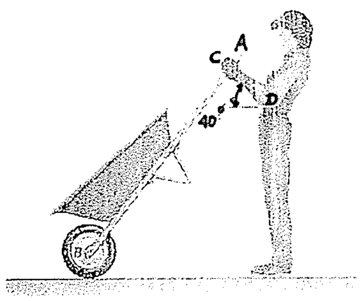
and $\alpha = 90° - 17.7642°$

$\alpha = 72.236°$

(*a*) $\alpha = 72.2°$ ◀

(*b*) $R = 1.391$ kN ◀

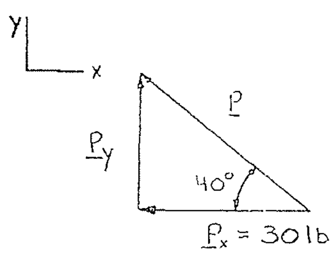
OK



PROBLEM 2.26

While emptying a wheelbarrow, a gardener exerts on each handle AB a force **P** directed along line CD. Knowing that **P** must have a 30-lb horizontal component, determine (*a*) the magnitude of the force **P**, (*b*) its vertical component.

SOLUTION



(*a*) $$P = \frac{P_x}{\cos 40^\circ}$$

$$P = \frac{30 \text{ lb}}{\cos 40^\circ}$$

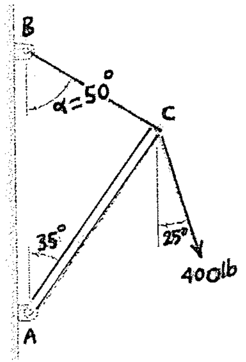
or $P = 39.2$ lb ◀

(*b*) $$P_y = P_x \tan 40^\circ$$

$$P_y = (30 \text{ lb}) \tan 40^\circ$$

or $P_y = 25.2$ lb ◀

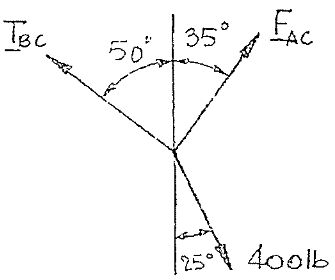
PROBLEM 2.43



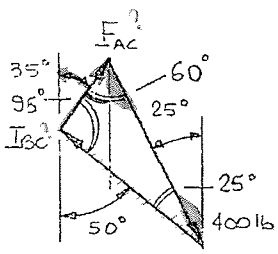
Knowing that $\alpha = 50°$ and that boom AC exerts on pin C a force directed along line AC, determine (a) the magnitude of that force, (b) the tension in cable BC.

SOLUTION

Free-Body Diagram



Force Triangle



Law of Sines:

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

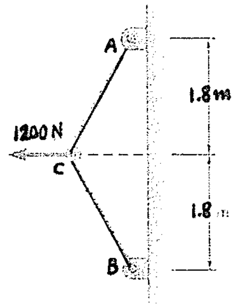
(a) $$F_{AC} = \frac{400 \text{ lb}}{\sin 95°} \sin 25° = 169.691 \text{ lb}$$ $F_{AC} = 169.7 \text{ lb}$ ◄

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

Alternative (Preferable) $\Sigma F_x = 0$, $\Sigma F_y = 0$ } ⇒ solves for F_{AC} & T_{BC}

ØK

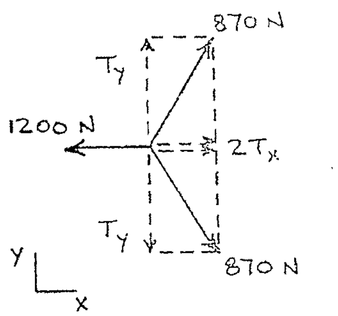
PROBLEM 2.62



Knowing that portions AC and BC of cable ACB must be equal, determine the shortest length of cable that can be used to support the load shown if the tension in the cable is not to exceed 870 N.

SOLUTION

Free-Body Diagram At C:



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

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

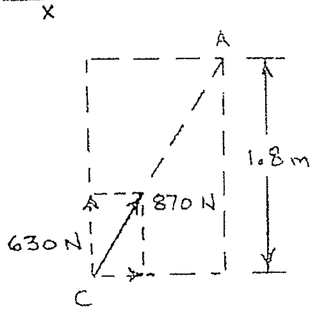
$$T_x = 600\text{ N}$$

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

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

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

By similar triangles:



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

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

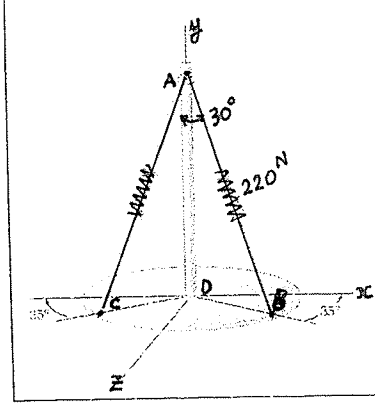
$$L = 2(AC)$$

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

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

$L = 4.97$ m ◀

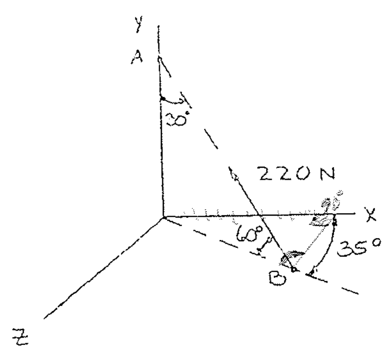
PROBLEM 2.79



The angle between the spring AB and the post DA is 30°. Knowing that the tension in the spring is 220 N, determine (*a*) the x, y, and z components of the force exerted by this spring on the plate, (*b*) the angles θ_x, θ_y, and θ_z that the force forms with the coordinate axes.

SOLUTION

(*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*)

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

$\theta_x = 114.2°$ ◀

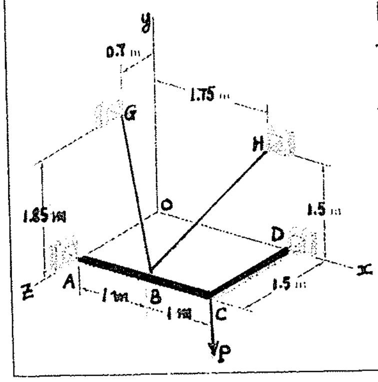
$$\cos\theta_y = \frac{190.526\text{ N}}{220\text{ N}}$$

$\theta_y = 30.0°$ ◀

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

$\theta_z = 106.7°$ ◀

PROBLEM 2.91



Two cables BG and BH are attached to the frame ACD as shown. Knowing that the tension in cable BG is 450 N, determine the components of the force exerted by cable BG on the frame at B.

SOLUTION

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

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

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

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

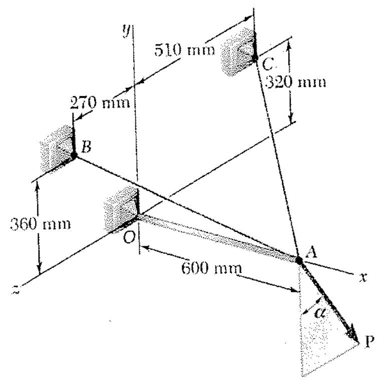
$$\mathbf{T}_{BG} = \frac{450\text{ N}}{2.25\text{ m}}\left[-(1\text{ m})\mathbf{i} + (1.85\text{ m})\mathbf{j} - (0.8\text{ m})\mathbf{k}\right]$$

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

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

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

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



PROBLEM 2.95

The boom OA carries a load **P** and is supported by two cables as shown. Knowing that the tension is 510 N in cable AB and 765 N in cable AC, determine the magnitude and direction of the resultant of the forces exerted at A by the two cables.

SOLUTION

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

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

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

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

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

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

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

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

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

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

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

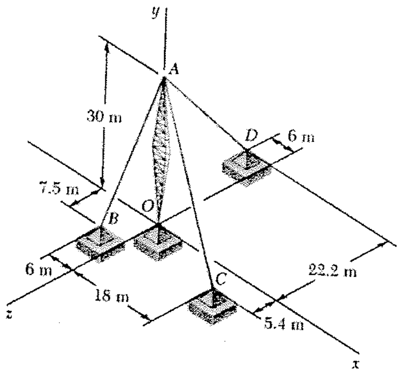
Then $\quad R = 1121.80 \text{ N} \qquad\qquad R = 1122 \text{ N}$ ◀

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

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

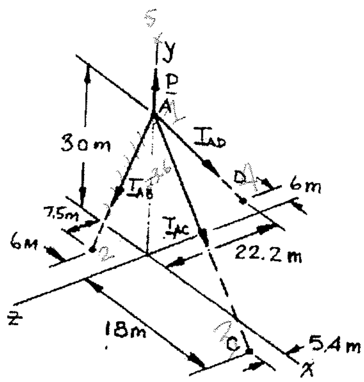
$$\cos\theta_z = \frac{-275.4 \text{ N}}{1121.80 \text{ N}} \qquad\qquad \theta_z = 104.2° \text{ ◀}$$

PROBLEM 2.107



A transmission tower is held by three guy wires attached to a pin at A and anchored by bolts at B, C, and D. If the tension in wire AB is 3.6 kN, determine the vertical force $\mathbf{P}$ exerted by the tower on the pin at A.

SOLUTION



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

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

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

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

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

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

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

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

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

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

PROBLEM 2.107 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 ↑ ◀