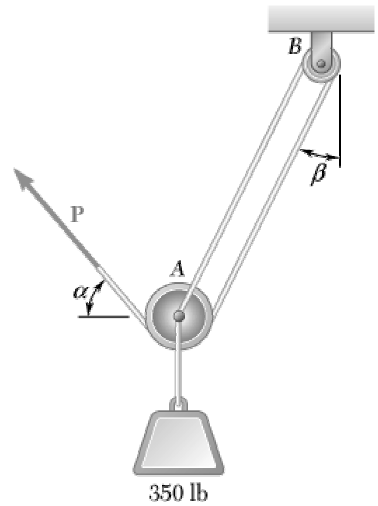
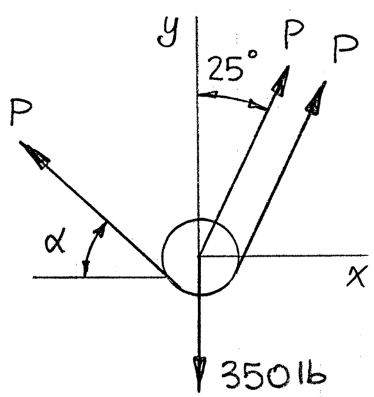


PROBLEM 2.69

A 350-lb load is supported by the rope-and-pulley arrangement shown. Knowing that $\beta = 25°$, determine the magnitude and direction of the force **P** which should be exerted on the free end of the rope to maintain equilibrium. (*Hint:* The tension in the rope is the same on each side of a simple pulley. This can be proved by the methods of Chapter 4.)

SOLUTION

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 $\alpha = +32.3°$

$$+\uparrow \Sigma F_y = 0: \quad 2P\cos 25° + P\sin 32.3° - 350 \text{ lb} = 0$$

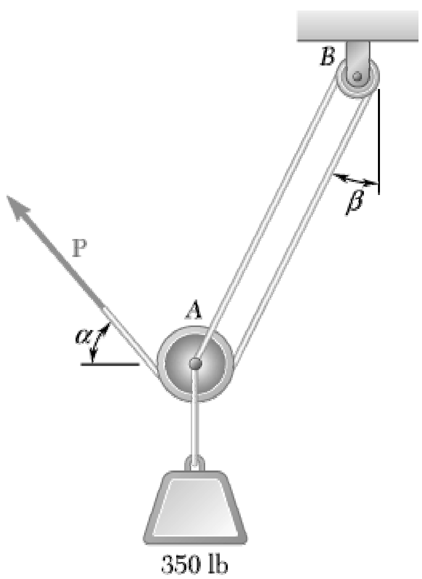
or $\mathbf{P} = 149.1 \text{ lb} \searrow 32.3°$ ◀

For $\alpha = -32.3°$

$$+\uparrow \Sigma F_y = 0: \quad 2P\cos 25° + P\sin -32.3° - 350 \text{ lb} = 0$$

or $\mathbf{P} = 274 \text{ lb} \swarrow 32.3°$ ◀

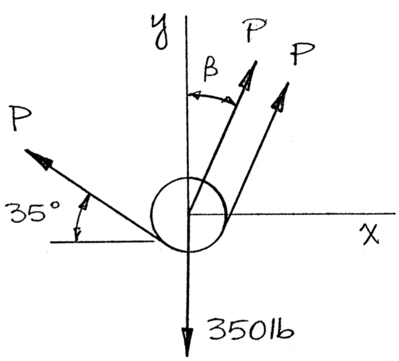
PROBLEM 2.70



A 350-lb load is supported by the rope-and-pulley arrangement shown. Knowing that $\alpha = 35°$, determine (*a*) the angle β, (*b*) the magnitude of the force **P** which should be exerted on the free end of the rope to maintain equilibrium. (*Hint:* The tension in the rope is the same on each side of a simple pulley. This can be proved by the methods of Chapter 4.)

SOLUTION

Free-Body Diagram: Pulley A



$$\xrightarrow{+} \Sigma F_x = 0: \quad 2P\sin\beta - P\cos 25° = 0$$

Hence:

(*a*) $$\sin\beta = \frac{1}{2}\cos 25° \qquad \text{or} \quad \beta = 24.2° \blacktriangleleft$$

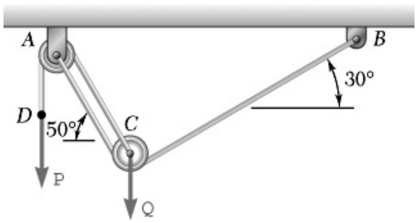
(*b*) $$+\uparrow \Sigma F_y = 0: \quad 2P\cos\beta + P\sin 35° - 350\text{ lb} = 0$$

Hence:

$$2P\cos 24.2° + P\sin 35° - 350\text{ lb} = 0$$

or $$P = 145.97\text{ lb} \qquad P = 146.0\text{ lb} \blacktriangleleft$$

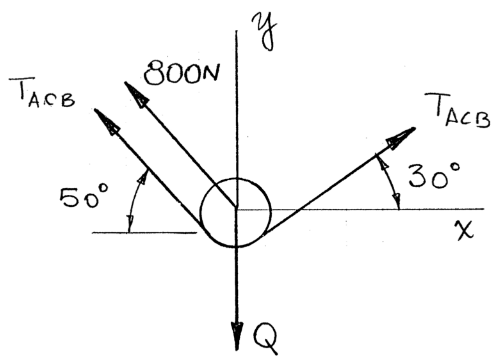
PROBLEM 2.71



A load **Q** is applied to the pulley *C*, which can roll on the cable *ACB*. The pulley is held in the position shown by a second cable *CAD*, which passes over the pulley *A* and supports a load **P**. Knowing that $P = 800$ N, determine (*a*) the tension in cable *ACB*, (*b*) the magnitude of load **Q**.

SOLUTION

Free-Body Diagram: Pulley C



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

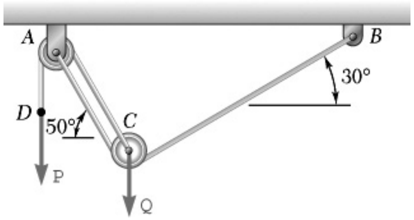
Hence
$$T_{ACB} = 2303.5 \text{ N}$$

$$T_{ACB} = 2.30 \text{ kN} \blacktriangleleft$$

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

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

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

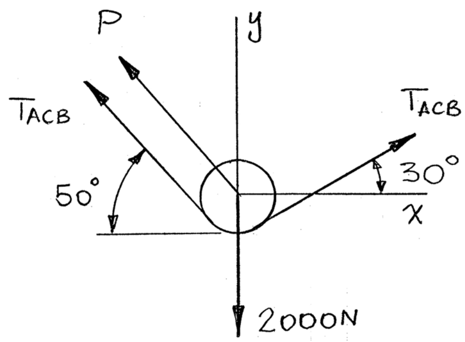


PROBLEM 2.72

A 2000-N load **Q** is applied to the pulley *C*, which can roll on the cable *ACB*. The pulley is held in the position shown by a second cable *CAD*, which passes over the pulley *A* and supports a load **P**. Determine (*a*) the tension in the cable *ACB*, (*b*) the magnitude of load **P**.

SOLUTION

Free-Body Diagram: Pulley C



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

or

$$P = 0.3473T_{ACB} \qquad (1)$$

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

or

$$1.266T_{ACB} + 0.766P = 2000 \text{ N} \qquad (2)$$

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

$$1.266T_{ACB} + 0.766\left(0.3473T_{ACB}\right) = 2000 \text{ N}$$

Hence:

$$T_{ACB} = 1305.5 \text{ N}$$

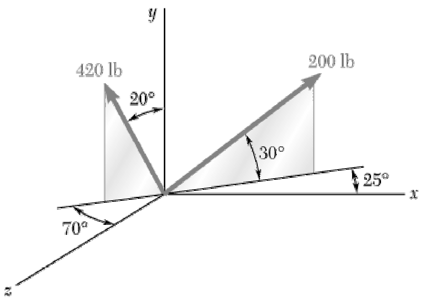
$$T_{ACB} = 1306 \text{ N} \blacktriangleleft$$

(*b*) Using (1)

$$P = 0.3473\left(1306 \text{ N}\right) = 453.57 \text{ N}$$

$$P = 454 \text{ N} \blacktriangleleft$$

PROBLEM 2.73



Determine (*a*) the *x*, *y*, and *z* components of the 200-lb force, (*b*) the angles θ_x, θ_y, and θ_z that the force forms with the coordinate axes.

SOLUTION

(*a*)

$$F_x = (200 \text{ lb})\cos 30° \cos 25° = 156.98 \text{ lb}$$

$$F_x = +157.0 \text{ lb} \blacktriangleleft$$

$$F_y = (200 \text{ lb})\sin 30° = 100.0 \text{ lb}$$

$$F_y = +100.0 \text{ lb} \blacktriangleleft$$

$$F_z = -(200 \text{ lb})\cos 30° \sin 25° = -73.1996 \text{ lb}$$

$$F_z = -73.2 \text{ lb} \blacktriangleleft$$

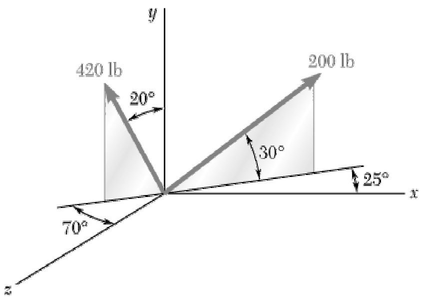
(*b*)

$$\cos\theta_x = \frac{156.98}{200} \qquad \text{or} \quad \theta_x = 38.3° \blacktriangleleft$$

$$\cos\theta_y = \frac{100.0}{200} \qquad \text{or} \quad \theta_y = 60.0° \blacktriangleleft$$

$$\cos\theta_z = \frac{-73.1996}{200} \qquad \text{or} \quad \theta_z = 111.5° \blacktriangleleft$$

PROBLEM 2.74



Determine (*a*) the *x*, *y*, and *z* components of the 420-lb force, (*b*) the angles θ_x, θ_y, and θ_z that the force forms with the coordinate axes.

SOLUTION

(*a*)

$$F_x = -(420 \text{ lb})\sin 20° \sin 70° = -134.985 \text{ lb}$$

$$F_x = -135.0 \text{ lb} \blacktriangleleft$$

$$F_y = (420 \text{ lb})\cos 20° = 394.67 \text{ lb}$$

$$F_y = +395 \text{ lb} \blacktriangleleft$$

$$F_z = (420 \text{ lb})\sin 20° \cos 70° = 49.131 \text{ lb}$$

$$F_z = +49.1 \text{ lb} \blacktriangleleft$$

(*b*)

$$\cos\theta_x = \frac{-134.985}{420}$$

$$\theta_x = 108.7° \blacktriangleleft$$

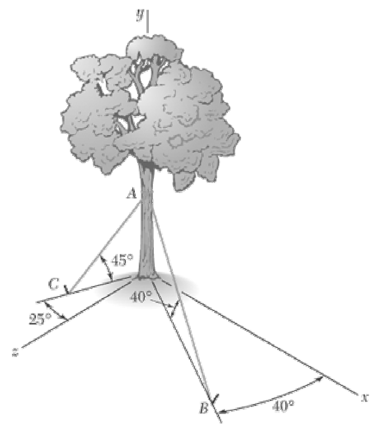
$$\cos\theta_y = \frac{394.67}{420}$$

$$\theta_y = 20.0° \blacktriangleleft$$

$$\cos\theta_z = \frac{49.131}{420}$$

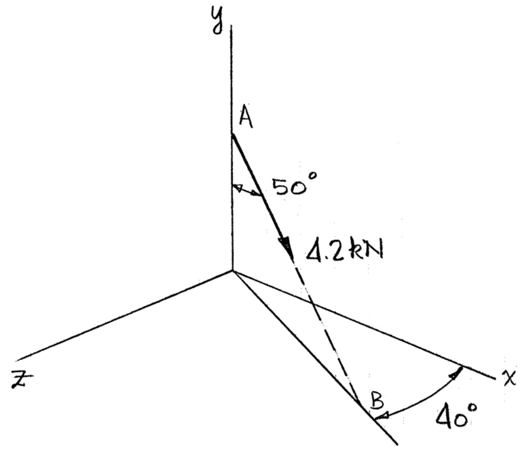
$$\theta_z = 83.3° \blacktriangleleft$$

PROBLEM 2.75



To stabilize a tree partially uprooted in a storm, cables *AB* and *AC* are attached to the upper trunk of the tree and then are fastened to steel rods anchored in the ground. Knowing that the tension in cable *AB* is 4.2 kN, determine (*a*) the components of the force exerted by this cable on the tree, (*b*) the angles θ_x, θ_y, and θ_z that the force forms with axes at *A* which are parallel to the coordinate axes.

SOLUTION



(*a*)

$$F_x = (4.2\text{ kN})\sin 50° \cos 40° = 2.4647\text{ kN}$$

$F_x = +2.46\text{ kN}$ ◀

$$F_y = -(4.2\text{ kN})\cos 50° = -2.6997\text{ kN}$$

$F_y = -2.70\text{ kN}$ ◀

$$F_z = (4.2\text{ kN})\sin 50° \sin 40° = 2.0681\text{ kN}$$

$F_z = +2.07\text{ kN}$ ◀

(*b*)

$$\cos\theta_x = \frac{2.4647}{4.2}$$

$\theta_x = 54.1°$ ◀

PROBLEM 2.75 CONTINUED

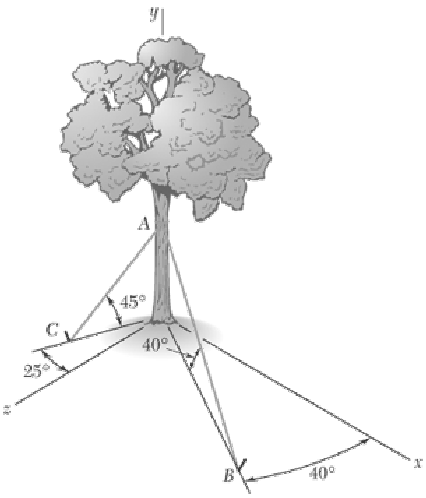
$$\cos\theta_y = \frac{-2.7}{4.2}$$

$$\theta_y = 130.0° \blacktriangleleft$$

$$\cos\theta_z = \frac{2.0681}{4.0}$$

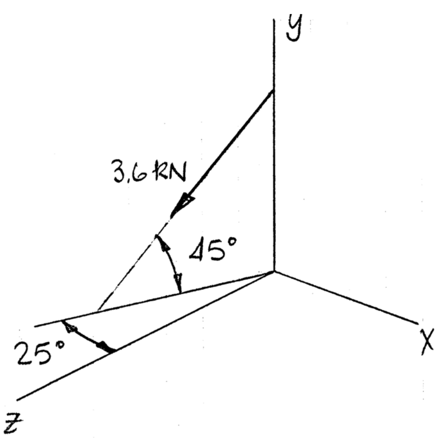
$$\theta_z = 60.5° \blacktriangleleft$$

PROBLEM 2.76



To stabilize a tree partially uprooted in a storm, cables *AB* and *AC* are attached to the upper trunk of the tree and then are fastened to steel rods anchored in the ground. Knowing that the tension in cable *AC* is 3.6 kN, determine (*a*) the components of the force exerted by this cable on the tree, (*b*) the angles θ_x, θ_y, and θ_z that the force forms with axes at *A* which are parallel to the coordinate axes.

SOLUTION



(*a*) $$F_x = -(3.6\text{ kN})\cos 45°\sin 25° = -1.0758\text{ kN}$$

$F_x = -1.076\text{ kN}$ ◀

$$F_y = -(3.6\text{ kN})\sin 45° = -2.546\text{ kN}$$

$F_y = -2.55\text{ kN}$ ◀

$$F_z = (3.6\text{ kN})\cos 45°\cos 25° = 2.3071\text{ kN}$$

$F_z = +2.31\text{ kN}$ ◀

(*b*) $$\cos\theta_x = \frac{-1.0758}{3.6}$$

$\theta_x = 107.4°$ ◀

PROBLEM 2.76 CONTINUED

$$\cos\theta_y = \frac{-2.546}{3.6}$$

$$\theta_y = 135.0° ◀$$

$$\cos\theta_z = \frac{2.3071}{3.6}$$

$$\theta_z = 50.1° ◀$$