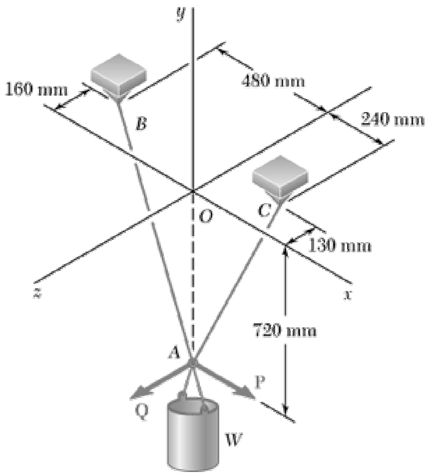
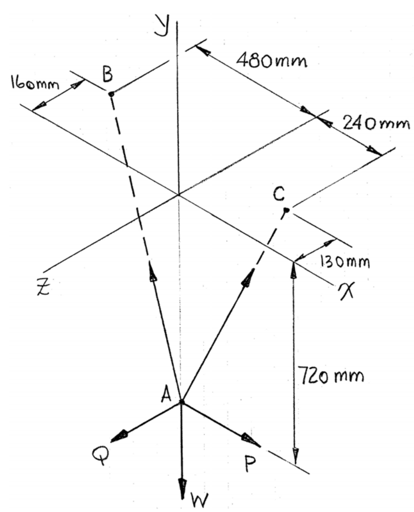
PROBLEM 2.125



A container of weight W is suspended from ring A. Cable BAC passes through the ring and is attached to fixed supports at B and C. Two forces $\mathbf{P} = P\mathbf{i}$ and $\mathbf{Q} = Q\mathbf{k}$ are applied to the ring to maintain the container is the position shown. Knowing that $W = 1200$ N, determine P and Q. (*Hint:* The tension is the same in both portions of cable BAC.)

SOLUTION



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

$$\overrightarrow{AB} = -(0.48\text{ m})\mathbf{i} + (0.72\text{ m})\mathbf{j} - (0.16\text{ m})\mathbf{k}$$

$$AB = \sqrt{(-0.48\text{ m})^2 + (0.72\text{ m})^2 + (-0.16\text{ m})^2} = 0.88\text{ m}$$

$$\mathbf{T}_{AB} = T\boldsymbol{\lambda}_{AB} = T_{AB}\frac{\overrightarrow{AB}}{AB} = \frac{T_{AB}}{0.88\text{ m}}\left[-(0.48\text{ m})\mathbf{i} + (0.72\text{ m})\mathbf{j} - (0.16\text{ m})\mathbf{k}\right]$$

$$\mathbf{T}_{AB} = T_{AB}(-0.5455\mathbf{i} + 0.8182\mathbf{j} - 0.1818\mathbf{k})$$

and

$$\overrightarrow{AC} = (0.24\text{ m})\mathbf{i} + (0.72\text{ m})\mathbf{j} - (0.13\text{ m})\mathbf{k}$$

$$AC = \sqrt{(0.24\text{ m})^2 + (0.72\text{ m})^2 - (0.13\text{ m})^2} = 0.77\text{ m}$$

$$\mathbf{T}_{AC} = T\boldsymbol{\lambda}_{AC} = T_{AC}\frac{\overrightarrow{AC}}{AC} = \frac{T_{AC}}{0.77\text{ m}}\left[(0.24\text{ m})\mathbf{i} + (0.72\text{ m})\mathbf{j} - (0.13\text{ m})\mathbf{k}\right]$$

$$\mathbf{T}_{AC} = T_{AC}(0.3177\mathbf{i} + 0.9351\mathbf{j} - 0.1688\mathbf{k})$$

At A: $\quad \Sigma\mathbf{F} = 0: \quad \mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{P} + \mathbf{Q} + \mathbf{W} = 0$

PROBLEM 2.125 CONTINUED

Noting that $T_{AB} = T_{AC}$ because of the ring A, we equate the factors of $\mathbf{i}$, $\mathbf{j}$, and $\mathbf{k}$ to zero to obtain the linear algebraic equations:

$$\mathbf{i}: \quad (-0.5455 + 0.3177)T + P = 0$$

or $$P = 0.2338T$$

$$\mathbf{j}: \quad (0.8182 + 0.9351)T - W = 0$$

or $$W = 1.7532T$$

$$\mathbf{k}: \quad (-0.1818 - 0.1688)T + Q = 0$$

or $$Q = 0.356T$$

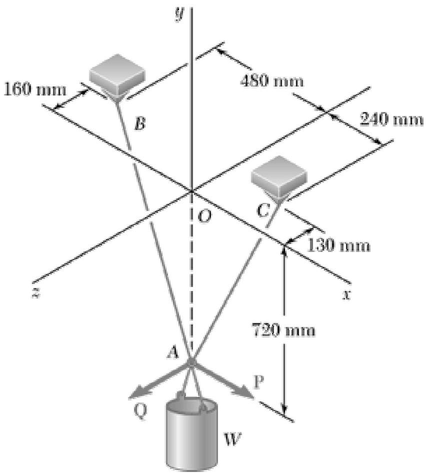
With $W = 1200\text{ N}$:

$$T = \frac{1200\text{ N}}{1.7532} = 684.5\text{ N}$$

$P = 160.0\text{ N}$ ◀

$Q = 240\text{ N}$ ◀

PROBLEM 2.126



For the system of Problem 2.125, determine W and P knowing that $Q = 160$ N.

Problem 2.125: A container of weight W is suspended from ring A. Cable BAC passes through the ring and is attached to fixed supports at B and C. Two forces $\mathbf{P} = P\mathbf{i}$ and $\mathbf{Q} = Q\mathbf{k}$ are applied to the ring to maintain the container is the position shown. Knowing that $W = 1200$ N, determine P and Q. (*Hint:* The tension is the same in both portions of cable BAC.)

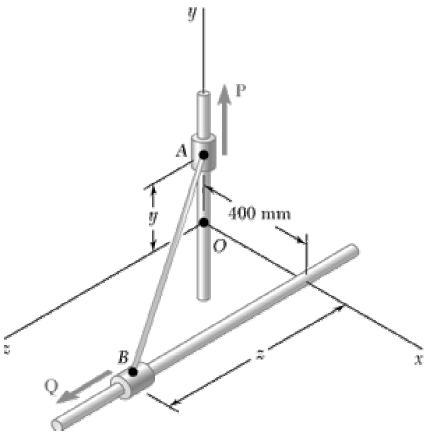
SOLUTION

Based on the results of Problem 2.125, particularly the three equations relating P, Q, W, and T we substitute $Q = 160$ N to obtain

$$T = \frac{160 \text{ N}}{0.3506} = 456.3 \text{ N}$$

$$W = 800 \text{ N} \blacktriangleleft$$

$$P = 107.0 \text{ N} \blacktriangleleft$$

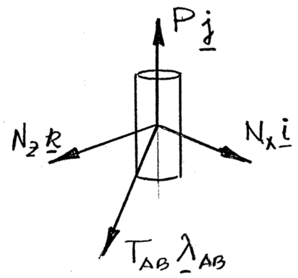


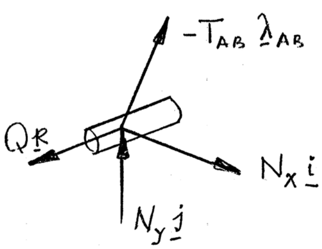
PROBLEM 2.127

Collars A and B are connected by a 1-m-long wire and can slide freely on frictionless rods. If a force $\mathbf{P} = (680\text{ N})\mathbf{j}$ is applied at A, determine (a) the tension in the wire when $y = 300$ mm, (b) the magnitude of the force $\mathbf{Q}$ required to maintain the equilibrium of the system.

SOLUTION

Free-Body Diagrams of collars





For both Problems 2.127 and 2.128:

$$(AB)^2 = x^2 + y^2 + z^2$$

Here $$(1\text{ m})^2 = (0.40\text{ m})^2 + y^2 + z^2$$

or $$y^2 + z^2 = 0.84\text{ m}^2$$

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:

$$\Sigma\mathbf{F} = 0: \quad N_x\mathbf{i} + N_y\mathbf{j} + Q\mathbf{k} - T_{AB}\boldsymbol{\lambda}_{AB} = 0$$

PROBLEM 2.127 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 $$T_{AB} = 2.27\text{ kN} \blacktriangleleft$$

and

(*b*) $$Q = 2266.7(0.866) = 1963.2\text{ N}$$

or $$Q = 1.963\text{ kN} \blacktriangleleft$$