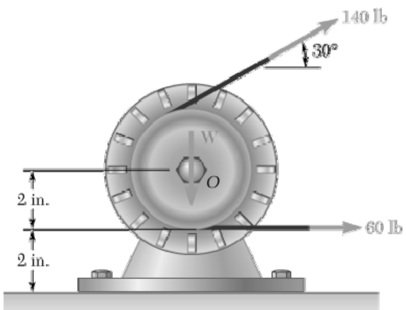
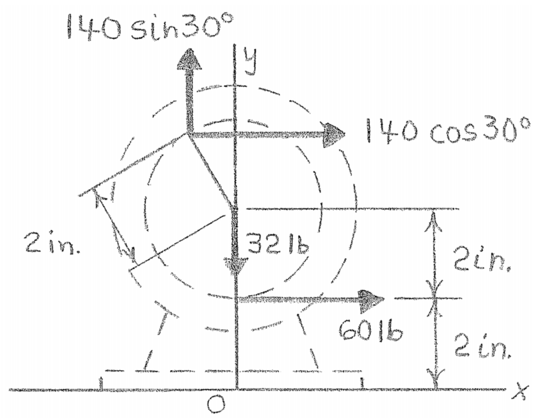
PROBLEM 3.151



A 32-lb motor is mounted on the floor. Find the resultant of the weight and the forces exerted on the belt, and determine where the line of action of the resultant intersects the floor.

SOLUTION



Have $\Sigma\mathbf{F}$: $(60\text{ lb})\mathbf{i} - (32\text{ lb})\mathbf{j} + (140\text{ lb})(\cos 30°\mathbf{i} + \sin 30°\mathbf{j}) = \mathbf{R}$

$$\therefore \quad \mathbf{R} = (181.244\text{ lb})\mathbf{i} + (38.0\text{ lb})\mathbf{j}$$

or $\mathbf{R} = 185.2\text{ lb} \measuredangle 11.84°$ ◀

Have ΣM_O: $\Sigma M_O = xR_y$

$$\therefore \quad -[(140\text{ lb})\cos 30°][(4 + 2\cos 30°)\text{ in.}] - [(140\text{ lb})\sin 30°][(2\text{ in.})\sin 30°]$$

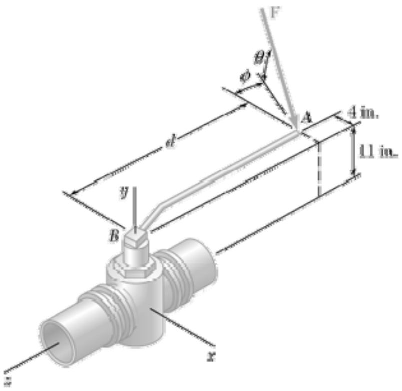
$$-(60\text{ lb})(2\text{ in.}) = x(38.0\text{ lb})$$

$$x = \frac{1}{38.0}(-694.97 - 70.0 - 120)\text{ in.}$$

and $x = -23.289\text{ in.}$

Or, resultant intersects the base (x axis) 23.3 in. to the left of the vertical centerline (y axis) of the motor. ◀

PROBLEM 3.152



To loosen a frozen valve, a force **F** of magnitude 70 lb is applied to the handle of the valve. Knowing that $\theta = 25°$, $M_x = -61\text{ lb}\cdot\text{ft}$, and $M_z = -43\text{ lb}\cdot\text{ft}$, determine θ and d.

SOLUTION

Have

$$\Sigma\mathbf{M}_O: \quad \mathbf{r}_{A/O} \times \mathbf{F} = \mathbf{M}_O$$

where

$$\mathbf{r}_{A/O} = -(4\text{ in.})\mathbf{i} + (11\text{ in.})\mathbf{j} - (d)\mathbf{k}$$

$$\mathbf{F} = F(\cos\theta\cos\phi\mathbf{i} - \sin\theta\mathbf{j} + \cos\theta\sin\phi\mathbf{k})$$

For

$$F = 70\text{ lb},\ \theta = 25°$$

$$\mathbf{F} = (70\text{ lb})\left[(0.90631\cos\phi)\mathbf{i} - 0.42262\mathbf{j} + (0.90631\sin\phi)\mathbf{k}\right]$$

$$\therefore \quad \mathbf{M}_O = (70\text{ lb})\begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ -4 & 11 & -d \\ -0.90631\cos\phi & -0.42262 & 0.90631\sin\phi \end{vmatrix}\text{in.}$$

$$= (70\text{ lb})\left[(9.9694\sin\phi - 0.42262d)\mathbf{i} + (-0.90631d\cos\phi + 3.6252\sin\phi)\mathbf{j}\right.$$

$$\left. + (1.69048 - 9.9694\cos\phi)\mathbf{k}\right]\text{in.}$$

and

$$M_x = (70\text{ lb})(9.9694\sin\phi - 0.42262d)\text{ in.} = -(61\text{ lb}\cdot\text{ft})(12\text{ in./ft}) \qquad (1)$$

$$M_y = (70\text{ lb})(-0.90631d\cos\phi + 3.6252\sin\phi)\text{in.} \qquad (2)$$

$$M_z = (70\text{ lb})(1.69048 - 9.9694\cos\phi)\text{ in.} = -43\text{ lb}\cdot\text{ft}(12\text{ in./ft}) \qquad (3)$$

PROBLEM 3.152 CONTINUED

From Equation (3)

$$\phi = \cos^{-1}\left(\frac{634.33}{697.86}\right) = 24.636°$$

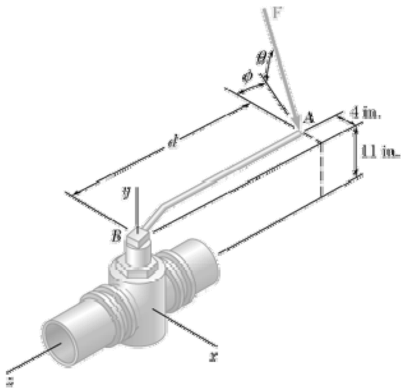
or $\phi = 24.6°$ ◀

From Equation (1)

$$d = \left(\frac{1022.90}{29.583}\right) = 34.577 \text{ in.}$$

or $d = 34.6$ in. ◀

PROBLEM 3.153



When a force **F** is applied to the handle of the valve shown, its moments about the x and z axes are, respectively, $M_x = -77 \text{ lb}\cdot\text{ft}$ and $M_z = -81 \text{ lb}\cdot\text{ft}$. For $d = 27$ in., determine the moment M_y of **F** about the y axis.

SOLUTION

Have $\qquad \Sigma\mathbf{M}_O: \quad \mathbf{r}_{A/O} \times \mathbf{F} = \mathbf{M}_O$

where $\qquad \mathbf{r}_{A/O} = -(4 \text{ in.})\mathbf{i} + (11 \text{ in.})\mathbf{j} - (27 \text{ in.})\mathbf{k}$

$$\mathbf{F} = F(\cos\theta\cos\phi\mathbf{i} - \sin\theta\mathbf{j} + \cos\theta\sin\phi\mathbf{k})$$

$$\therefore \quad \mathbf{M}_O = F\begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ -4 & 11 & -27 \\ \cos\theta\cos\phi & -\sin\theta & \cos\theta\sin\phi \end{vmatrix} \text{lb}\cdot\text{in.}$$

$$= F\big[(11\cos\theta\sin\phi - 27\sin\theta)\mathbf{i} + (-27\cos\theta\cos\phi + 4\cos\theta\sin\phi)\mathbf{j}$$

$$+ (4\sin\theta - 11\cos\theta\cos\phi)\mathbf{k}\big](\text{lb}\cdot\text{in.})$$

and

$$M_x = F(11\cos\theta\sin\phi - 27\sin\theta)(\text{lb}\cdot\text{in.}) \tag{1}$$

$$M_y = F(-27\cos\theta\cos\phi + 4\cos\theta\sin\phi)(\text{lb}\cdot\text{in.}) \tag{2}$$

$$M_z = F(4\sin\theta - 11\cos\theta\cos\phi)(\text{lb}\cdot\text{in.}) \tag{3}$$

Now, Equation (1)

$$\cos\theta\sin\phi = \frac{1}{11}\left(\frac{M_x}{F} + 27\sin\theta\right) \tag{4}$$

and Equation (3)

$$\cos\theta\cos\phi = \frac{1}{11}\left(4\sin\theta - \frac{M_z}{F}\right) \tag{5}$$

Substituting Equations (4) and (5) into Equation (2),

$$M_y = F\left\{-27\left[\frac{1}{11}\left(4\sin\theta - \frac{M_z}{F}\right)\right] + 4\left[\frac{1}{11}\left(\frac{M_x}{F} + 27\sin\theta\right)\right]\right\}$$

or

$$M_y = \frac{1}{11}(27M_z + 4M_x)$$

PROBLEM 3.153 CONTINUED

Noting that the ratios $\frac{27}{11}$ and $\frac{4}{11}$ are the ratios of lengths, have

$$M_y = \frac{27}{11}(-81\text{ lb}\cdot\text{ft}) + \frac{4}{11}(-77\text{ lb}\cdot\text{ft}) = 226.82\text{ lb}\cdot\text{ft}$$

or $M_y = -227\text{ lb}\cdot\text{ft}$ ◀