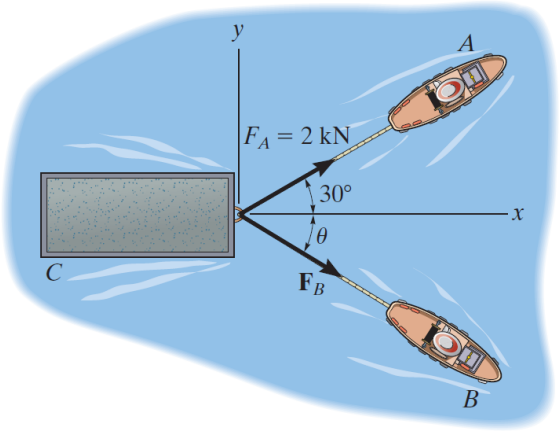
Problem 2-31

If the resultant force of the two tugboats is required to be directed towards the positive x axis, and $\mathbf{F}_B$ is to be a minimum, determine the magnitude of $\mathbf{F}_R$ and $\mathbf{F}_B$ and the angle θ.



Probs. 2–29/30/31

Solution

Write each of the forces in component form.

$$\mathbf{F}_A = 2000\,\langle \cos 30^\circ, \sin 30^\circ \rangle \text{ N}$$

$$\mathbf{F}_B = F_B\,\langle \cos\theta, -\sin\theta \rangle \text{ N}$$

$$\mathbf{F}_R = F_R\,\langle 1, 0 \rangle \text{ N}$$

The two forces, $\mathbf{F}_A$ and $\mathbf{F}_B$, add to the resultant force $\mathbf{F}_R$.

$$\mathbf{F}_R = \mathbf{F}_A + \mathbf{F}_B$$

$$\langle F_R, 0 \rangle \text{ N} = \langle 2000\cos 30^\circ + F_B \cos\theta, 2000\sin 30^\circ - F_B \sin\theta \rangle \text{ N}$$

Match the components.

$$F_R = 2000\cos 30^\circ + F_B \cos\theta$$

$$0 = 2000\sin 30^\circ - F_B \sin\theta$$

Solve the second equation for F_B.

$$F_B = \frac{2000\sin 30^\circ}{\sin\theta}$$

In order to minimize F_B, the denominator must be made as big as possible: $\theta = 90^\circ$.

$$F_B = 2000\sin 30^\circ = 1000 \text{ N}$$

$$F_R = 2000\cos 30^\circ + (1000)\cos 90^\circ \approx 1.73 \times 10^3 \text{ N}$$