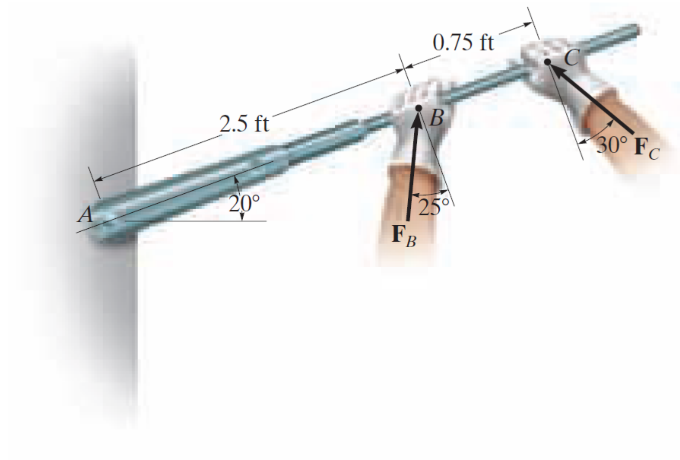
Problem 4-10

If $F_B = 30$ lb and $F_C = 45$ lb, determine the resultant moment about the bolt located at A.

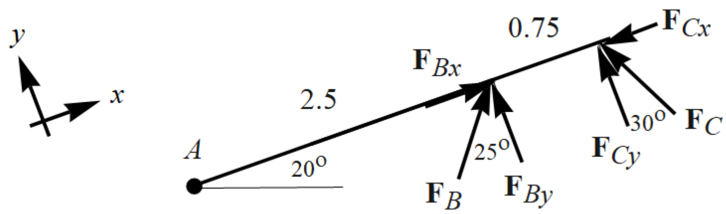


Probs. 4–9/10

Solution

Method Using Varignon's Theorem

Decompose each of the forces into components parallel to and perpendicular to the bar.



In order to get the moment of each force about A, multiply the force component perpendicular to the bar by the moment arm. Add them together to get the resultant moment about A.

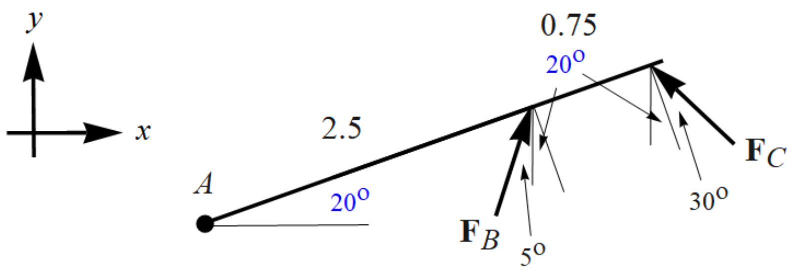
$$\circlearrowleft^{+} \sum_i r_i F_{i\perp} = [(2.5)(30\cos 25^\circ) + (3.25)(45\cos 30^\circ)] \text{ ft} \cdot \text{lb} \approx 195 \text{ ft} \cdot \text{lb}$$

This resultant moment is therefore

$$\mathbf{M}_A \approx (195 \text{ ft} \cdot \text{lb})\hat{\mathbf{z}}.$$

Method Using Vectors

Take point A to be the origin of an xyz-coordinate system.



Then the moment of $\mathbf{F}_B$ about A is

$$\mathbf{M}_B = \mathbf{r}_B \times \mathbf{F}_B = 2.5\langle \cos 20^\circ, \sin 20^\circ, 0\rangle \times 30\langle \sin 5^\circ, \cos 5^\circ, 0\rangle \text{ ft}\cdot\text{lb} = \begin{vmatrix} \hat{\mathbf{x}} & \hat{\mathbf{y}} & \hat{\mathbf{z}} \\ 2.5\cos 20^\circ & 2.5\sin 20^\circ & 0 \\ 30\sin 5^\circ & 30\cos 5^\circ & 0 \end{vmatrix} \text{ ft}\cdot\text{lb}$$

$$\approx (68.0 \text{ ft}\cdot\text{lb})\hat{\mathbf{z}},$$

and the moment of $\mathbf{F}_C$ about A is

$$\mathbf{M}_C = \mathbf{r}_C \times \mathbf{F}_C = 3.25\langle \cos 20^\circ, \sin 20^\circ, 0\rangle \times 45\langle -\sin 50^\circ, \cos 50^\circ, 0\rangle \text{ ft}\cdot\text{lb} = \begin{vmatrix} \hat{\mathbf{x}} & \hat{\mathbf{y}} & \hat{\mathbf{z}} \\ 3.25\cos 20^\circ & 3.25\sin 20^\circ & 0 \\ -45\sin 50^\circ & 45\cos 50^\circ & 0 \end{vmatrix} \text{ ft}\cdot\text{lb}$$

$$\approx (127 \text{ ft}\cdot\text{lb})\hat{\mathbf{z}}.$$

Therefore, the resultant moment about A is

$$\mathbf{M}_A = \mathbf{M}_B + \mathbf{M}_C \approx (195 \text{ ft}\cdot\text{lb})\hat{\mathbf{z}}.$$