5.4 The rectangular loop shown in Fig. P5.4 consists of 20 closely wrapped turns and is hinged along the z-axis. The plane of the loop makes an angle of 30° with the y-axis, and the current in the windings is 0.5 A. What is the magnitude of the torque exerted on the loop in the presence of a uniform field $\mathbf{B} = \hat{\mathbf{y}}\,2.4$ T? When viewed from above, is the expected direction of rotation clockwise or counterclockwise?

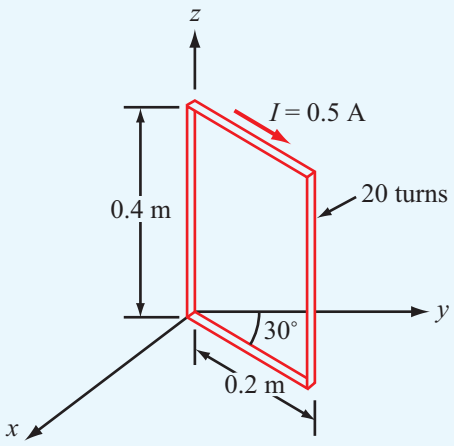

Figure P5.4 Hinged rectangular loop of Problem 5.4.

Solution: The magnetic torque on a loop is given by $\vec{T} = \vec{m} \times \vec{B}$ (Eq. (5.20)), where $\vec{m} = \hat{\mathbf{n}}NIA$ (Eq. (5.19)). For this problem, it is given that $I = 0.5$ A, $N = 20$ turns, and $A = 0.2\text{ m} \times 0.4\text{ m} = 0.08\text{ m}^2$. From the figure, $\hat{\mathbf{n}} = -\hat{\mathbf{x}}\cos 30° + \hat{\mathbf{y}}\sin 30°$. Therefore, $\vec{m} = \hat{\mathbf{n}}0.8\ (\text{A}\cdot\text{m}^2)$ and $\vec{T} = \hat{\mathbf{n}}0.8\ (\text{A}\cdot\text{m}^2) \times \hat{\mathbf{y}}2.4\text{ T} = -\hat{\mathbf{z}}1.66\ (\text{N}\cdot\text{m})$. As the torque is negative, the direction of rotation is clockwise, looking from above.