Problem 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?

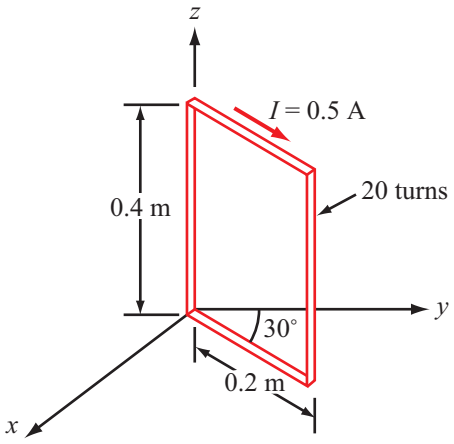

Figure P5.4: Hinged rectangular loop of Problem 5.4.

Solution: The magnetic torque on a loop is given by $\mathbf{T} = \mathbf{m} \times \mathbf{B}$ (Eq. (5.20)), where $\mathbf{m} = \hat{\mathbf{n}}NIA$ (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, $\mathbf{m} = \hat{\mathbf{n}}0.8 \text{ (A} \cdot \text{m}^2\text{)}$ and $\mathbf{T} = \hat{\mathbf{n}}0.8 \text{ (A} \cdot \text{m}^2\text{)} \times \hat{\mathbf{y}}2.4 \text{ T} = -\hat{\mathbf{z}}1.66 \text{ (N·m)}$. As the torque is negative, the direction of rotation is clockwise, looking from above.