6.7 The rectangular conducting loop shown in Fig. P6.7 rotates at 3,000 revolutions per minute in a uniform magnetic flux density given by

$$\mathbf{B} = \hat{\mathbf{y}}\,50 \qquad \text{(mT)}.$$

Determine the current induced in the loop if its internal resistance is 0.5 Ω.

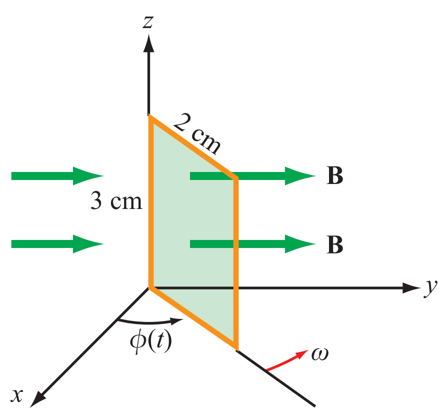

Figure P6.7 Rotating loop in a magnetic field (Problem 6.7).

Solution:

$$\Phi = \int_S \mathbf{B}\cdot d\mathbf{S} = \hat{\mathbf{y}}\,50\times 10^{-3}\cdot\hat{\mathbf{y}}(2\times 3\times 10^{-4})\cos\phi(t) = 3\times 10^{-5}\cos\phi(t),$$

$$\phi(t) = \omega t = \frac{2\pi\times 3\times 10^3}{60}\,t = 100\pi t \qquad \text{(rad/s)},$$

$$\Phi = 3\times 10^{-5}\cos(100\pi t) \qquad \text{(Wb)},$$

$$V_{\text{emf}} = -\frac{d\Phi}{dt} = 3\times 10^{-5}\times 100\pi\sin(100\pi t) = 9.4\times 10^{-3}\sin(100\pi t) \qquad \text{(V)},$$

$$I_{\text{ind}} = \frac{V_{\text{emf}}}{0.5} = 18.85\sin(100\pi t) \qquad \text{(mA)}.$$

The direction of the current is CW (if looking at it along $-\hat{\mathbf{x}}$-direction) when the loop is in the first quadrant ($0 \le \phi \le \pi/2$). The current reverses direction in the second quadrant, and reverses again every quadrant.