Example 4 Joule-Lenz Law

$$Q = .24R\int_0^T I_0^2 \sin^2\left(\frac{2\pi t}{T} - \phi\right) dt$$

$$= .24R I_0^2 \int_0^T \sin^2\left(\frac{2\pi t}{T} - \phi\right) dt$$

$$= .24R I_0^2 \int_0^T \frac{1 - \cos\left(\frac{4\pi t}{T} - 2\phi\right)}{2} dt$$

$$= .24R I_0^2 \left[\frac{1}{2}T - \frac{1}{2}\int_0^T \cos\left(\frac{4\pi t}{T} - 2\phi\right) dt\right]$$

$$= .24R I_0^2 \left[\frac{1}{2}T - \frac{1}{2}\frac{\sin\left(\frac{4\pi t}{T} - 2\phi\right)}{4\pi/T}\Bigg|_0^T\right]$$

$$= .24R I_0^2 \left[\frac{1}{2}T - \frac{1}{8\pi}T\left(\sin(4\pi - 2\phi) - \sin(-2\phi)\right)\right]$$

$$= \frac{.24R I_0^2 T}{2}$$