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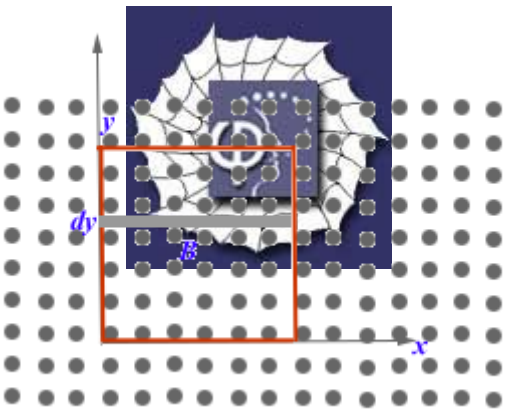
Problem 36.17 (RHK)

A square circuit of side lengths 2.0 cm *has been shown in the figure. A magnetic field points out of the page; its magnitude is given by* $B = 4t^2 y$, *where B is in tesla, t is in seconds, and y is in meters. We have to determine the emf around the square at* $t = 2.5$ s *and give its direction.*



Solution:

A square loop has sides of length 2.0 cm. A magnetic field points out of the page. Its magnitude is being given by $B = 4t^2 y$, where B is in tesla and t is in seconds, and y is in meters. We have to determine the emf around the square at $t = 2.5$ s and also have to find its direction.

The flux due to the magnetic filed $B = 4t^2 y$ can be calculated by integration. We have

$$\Phi = \int_0^{2.0\times10^{-2}} 4t^2 y \times 2.0\times10^{-2} dy \text{ T m}^2 = 8\times10^{-2} t^2 \left[\frac{y^2}{2} \right]_0^{2.0\times10^{-2}} \text{ T m}^2.$$

Or

$$\Phi = 16\times10^{-6} t^2 \text{ T m}^2.$$

And

$$\frac{d\Phi}{dt} = 32\times10^{-6} t \text{ T m}^2 \text{ s}^{-1}.$$

By the Faraday's law, the emf in the circuit at $t = 2.5$ s will be given by

$$\mathcal{E} = \frac{d\Phi(t = 2.5 \text{ s})}{dt} = 32\times10^{-6} \times 2.5 \text{ V} = 80 \ \mu\text{V}.$$

By the Lenz' law we note that the direction of induced current will be clockwise.