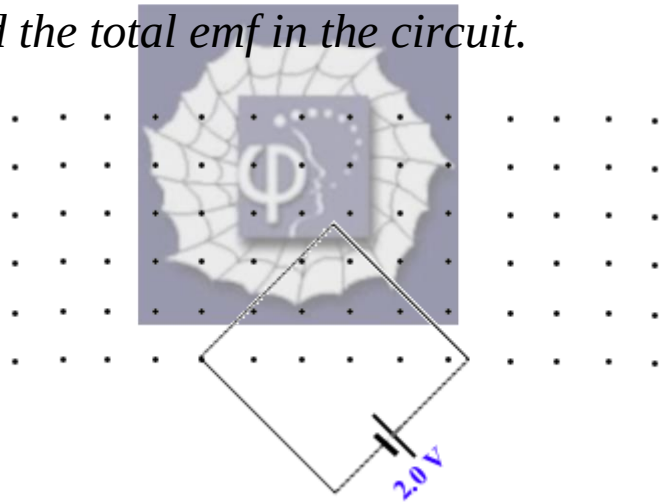
486.

Problem 36.14 (RHK)

A square loop with 2.3-m *sides is perpendicular to a uniform magnetic field, with half the area of the loop in the field, as shown in the figure. The loop contains a* 2.0-V *battery with negligible internal resistance. If the magnitude of the field varies according to* $B = 0.042 - 0.87t$, *with* B *in tesla and* t *in seconds, we have to find the total emf in the circuit.*



Solution:

Magnetic field varies according to

$B = 0.042 - 0.87t$, with B in tesla and t in seconds and is perpendicular to the plane of the figure and is coming out of it.

$\therefore \quad \dfrac{dB}{dt} = -0.87 \text{ T s}^{-1}.$

As the rate of change of the magnetic field with time is negative, the flux enclosed by the square loop, as shown in the figure, will decrease with time. Hence, by the Lenz' law an additional current will flow in the counter-clockwise direction so as to compensate the decrease in the flux enclosed. Hence, induced emf will get generated in the loop which will add to the 2.0 V emf of the battery, as both emfs result in flow of current in the counter-clockwise direction in the loop. By the Faraday's law of induction the induced emf will be

$$\begin{aligned} \mathrm{E} &= -\frac{d\Phi}{dt} = -\left(\text{area of the loop in the field}\right) \times \frac{dB}{dt} \\ &= -\frac{1}{2} \times 2.3^2 \times \left(-0.87\right)\ \mathrm{V} \\ &= 2.3\ \mathrm{V}. \end{aligned}$$

Hence, the total emf in the circuit will be $4.3\ \mathrm{V}$.