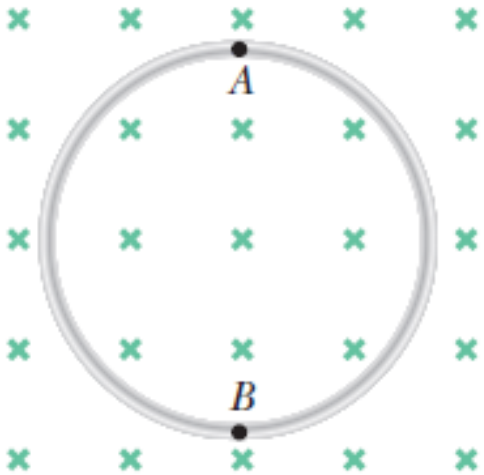
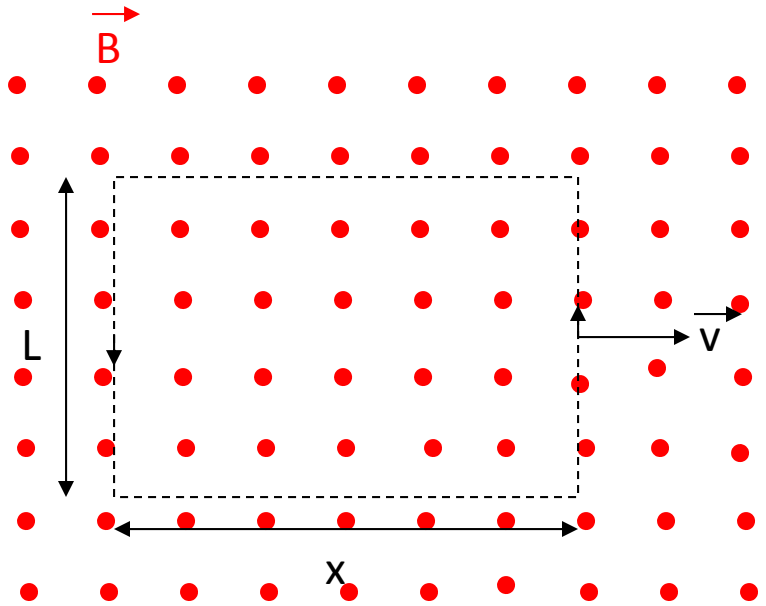
Class 32 More Faraday's Law

Faraday's Law for changing A: Example I



The flexible loop in the figure has a radius and is in a magnetic field of magnitude B. The loop is grasped at points *A* and *B* and stretched until its area is nearly zero. If it takes Δt to close the loop, what is the magnitude of the average induced emf in it during this time interval?

Faraday's Law for changing A: Example II



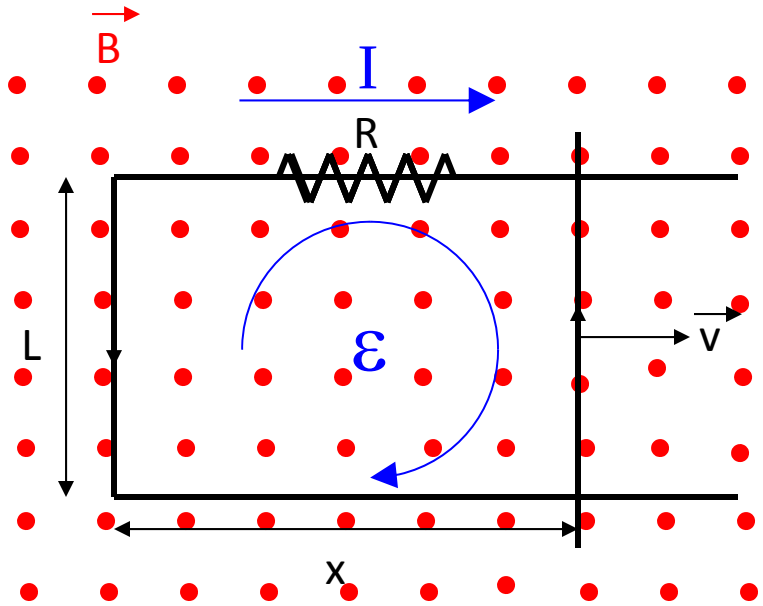
$$\varepsilon_{\text{loop}} = -\frac{d}{dt}\Phi_B$$

$$\Phi_B = BLx$$

$$\Rightarrow \quad \frac{d}{dt}\Phi_B = BL\frac{dx}{dt} = BLv$$

$$\therefore \ \varepsilon_{\text{loop}} = -BLv$$

Faraday's Law for changing A: Realization of Example II



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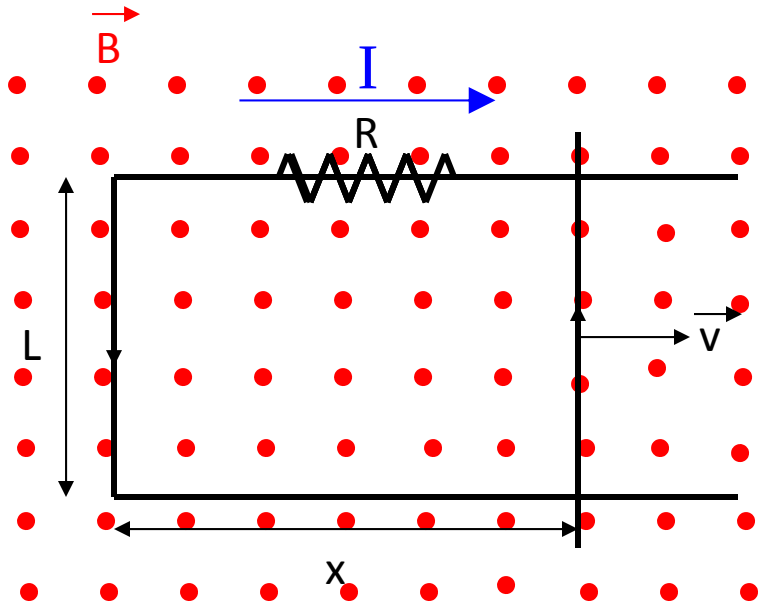
Ohm's Law: $\varepsilon_{\text{loop}} = IR$

$$\Rightarrow \ I = \frac{\varepsilon_{\text{loop}}}{R} = -\frac{BLv}{R}$$

Faraday's Law for changing A: A note for Example II



You need an external force to maintain a constant velocity, because of the magnetic field.

You can calculate this force either by

(i) Newton's Law of motion:

$$\vec{F} = -\vec{F}_B$$

(ii) Conservation of energy:

$$I^2R = Fv$$

Lenz's Law

Direction of the induced emf (clockwise or counter clockwise) is determined by the Lenz's Law:

1. Make a sketch of the situation for use in visualizing and recording directions.
2. Identify the direction of the magnetic field B.
3. Ask yourself, *with respect to the external magnetic field B*, whether the flux is increasing or decreasing.

Lenz's Law →

4. The induced magnetic field B opposes the change in flux, i.e. The induced magnetic field is in opposite direction to the external field if the flux is increasing and it will be in the same direction as the external field if the flux is decreasing.

Biot-Savart →

5. Now determine the direction of the induced current I that is responsible for the induced magnetic field B.
6. The direction (or polarity) of the induced emf will now drive a current in this direction and can be represented as current emerging from the positive terminal of the emf and returning to its negative terminal.