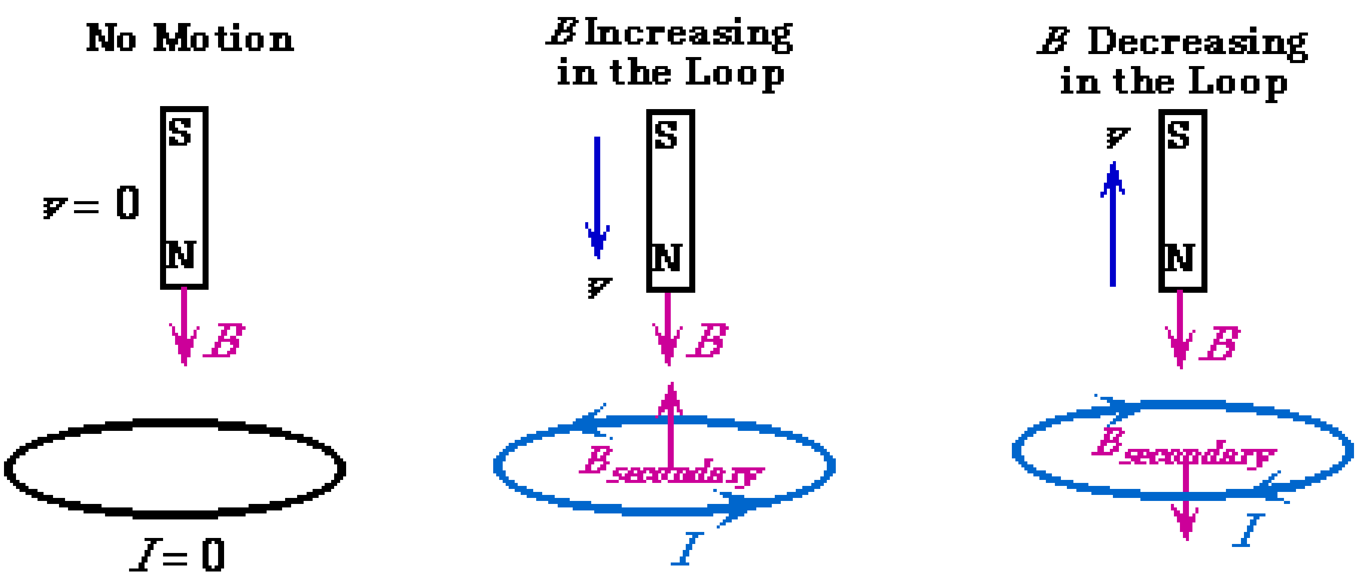
Chapter 29: Electromagnetic Induction

- Induction
- Faraday’s Law
- Maxwell’s Equations

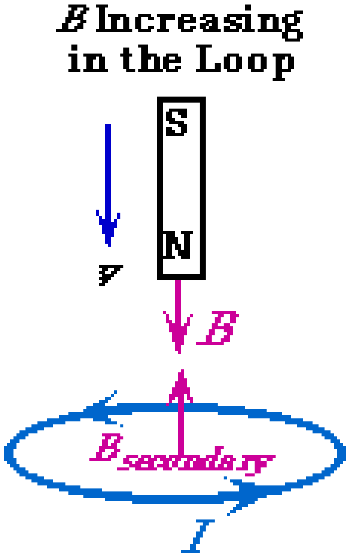
Induction: Lenz's Law



Lenz's Law: emf will be produced when the magnetic flux is changing as function of time.

The direction of the induced emf is as if the system is trying to maintain the original magnetic status; or equivalently, the direction of any magnetic induction effect is such as to oppose the cause of the effect.

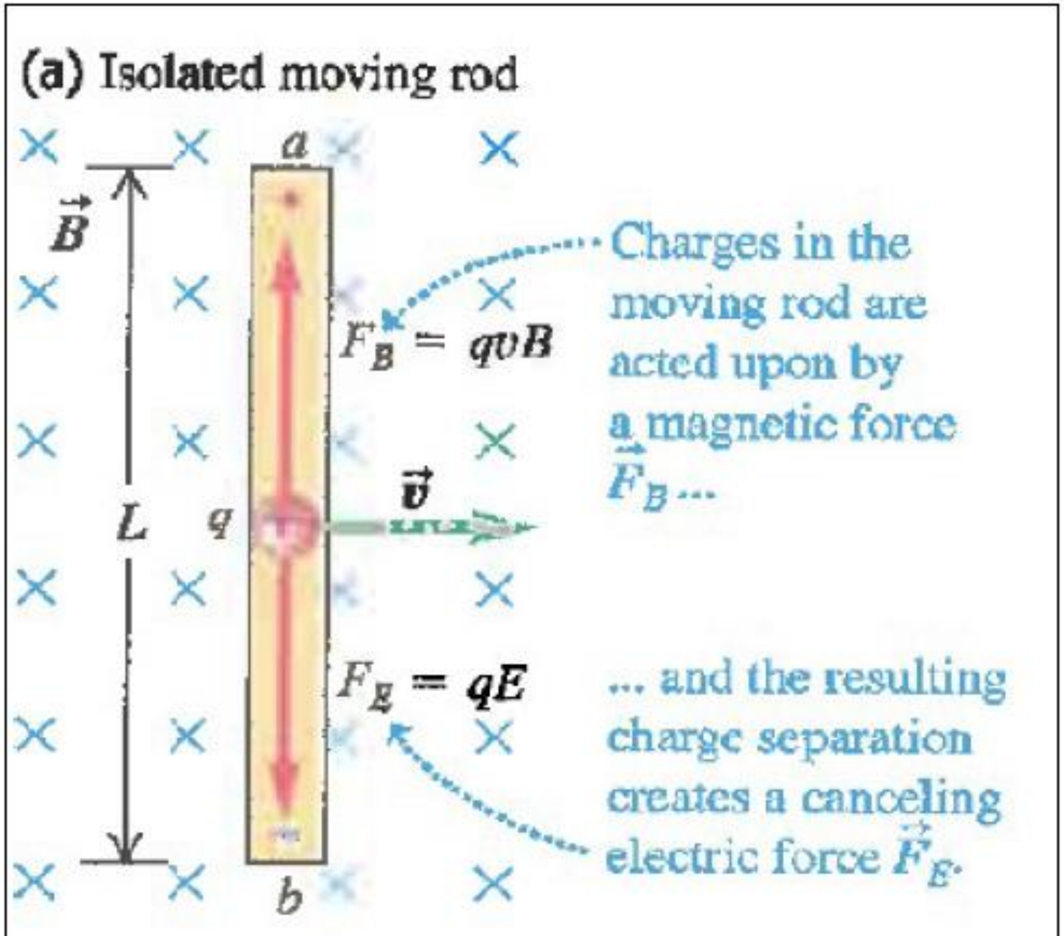
Faraday's Law



$$\varepsilon = -\frac{d\Phi_B}{dt}$$

(Faraday's Law of induction)

Emf in a conducting rod moving across a magnetic field



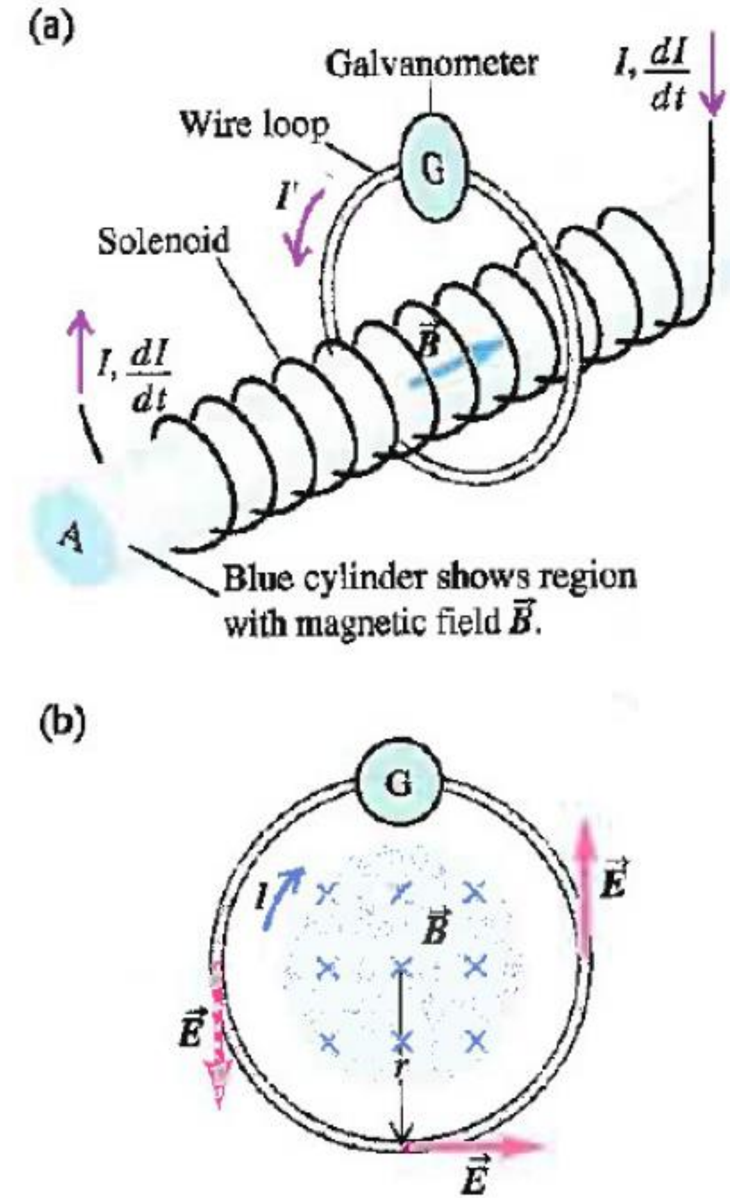
$\varepsilon = vBL$

This is closely related to Hall Effect

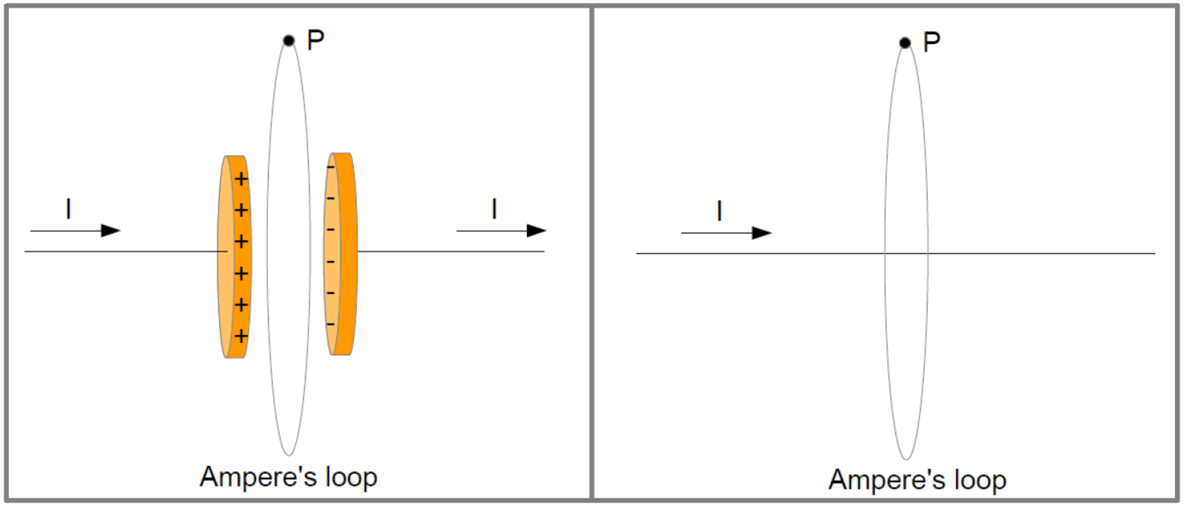
Faraday's Law

$$\varepsilon = -\frac{d\Phi_B}{dt} = \oint_C \vec{E} \cdot d\vec{l}$$

In any loop, the electric field in the path of the loop is related to the magnetic flux change enclosed in the loop



Revisit Ampere's Law



$$I=\frac{dq}{dt}=\frac{d\left(CV\right)}{dt}=\frac{d\left(\epsilon_0\frac{A}{D}\cdot ED\right)}{dt}=\frac{d\left(\epsilon_0 AE\right)}{dt}=\frac{d\left(\epsilon_0\Phi_E\right)}{dt}=\epsilon_0\frac{d\,\Phi_E}{dt}$$

(Equivalent to the current term)

$$\oint_C \vec{B}\cdot d\vec{l}=\mu_0\left(I_{encl}+\varepsilon_0\frac{d\Phi_E}{dt}\right)$$

Maxwell’s Equation

$$\oint \vec{E}\cdot d\vec{A}=\frac{Q_{encl}}{\epsilon_0} \qquad \text{(Gauss's Law for } \vec{E}\text{)}$$

$$\oint \vec{B}\cdot d\vec{A}=0 \qquad \text{(Gauss's Law for } \vec{B}\text{)}$$

$$\oint \vec{B}\cdot d\vec{l}=\mu_0\left(I_{encl}+\epsilon_0\frac{d\Phi_E}{dt}\right) \qquad \text{(Ampere's Law)}$$

$$\oint \vec{E}\cdot d\vec{l}=-\frac{d\Phi_B}{dt} \qquad \text{(Faraday's Law)}$$