Induced E.M.F.

Induced EMF

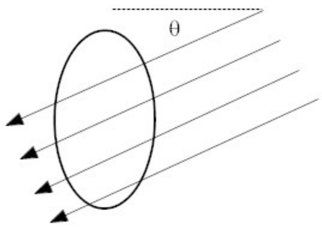
- Faraday showed that moving a wire in a magnetic field induces a current in that wire.
- As work is done in moving the charge from one end to the other, an electric potential exists: induced emf (voltage)

- The induced emf (and current) only occurs when the displacement is at right angles to the magnetic field.
- The induced emf (and current) immediately stops when the velocity is zero.

- The strength of the emf produced depends on:
  - The speed of the movement
  - The strength of the magnetic flux density
  - Number of turns in the coil (number of wires)
  - The area of the coil

Magnetic Flux

- The number of magnetic field lines passing through an area.



- Faraday realized that the magnitude of the induced emf was not proportional to the rate of change of the magnetic field
- The magnitude of the induced emf is related to the rate of change of magnetic flux (or flux linkage for more than one wire)

Faraday related the emf to magnetic flux, which is an area.

$$\Phi = BA\cos\theta$$

Units: weber, Wb

Magnetic flux — Magnetic field — Area

Magnetic flux is a measure of the number of lines of magnetic force passing through an area.

Faraday's Law

- The magnitude of the induced emf in a circuit is directly proportional to the rate of change of magnetic flux or flux-linkage.

$$\varepsilon \propto N\frac{\Delta\Phi}{\Delta t}$$

Heinrich Lenz

- In 1834, Russian physicist Lenz applied the Law of Conservation of Energy to determine the direction of the induced emf for all types of conductors.

Lenz's Law

- The direction of the induced emf is such that the current it causes to flow opposes the change producing it.
- In other words, the resulting emf is in the opposite direction of the motion.

- Combining Faraday's law and Lenz's law then gives us equation for induced emf.

$$\varepsilon = -\frac{\Delta\Phi}{\Delta t}$$

$$\boxed{\varepsilon = -N\frac{\Delta\Phi}{\Delta t}}$$

Example 1

- The magnetic flux through a coil of wire containing 5 loops, changes from -25 Wb to 15 Wb in 0.12 s. What is the induced emf in the coil?

$$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$$

$$= -(5)\frac{(15\,Wb - -25\,Wb)}{0.12\ s} \quad = -1667\ \text{V}$$