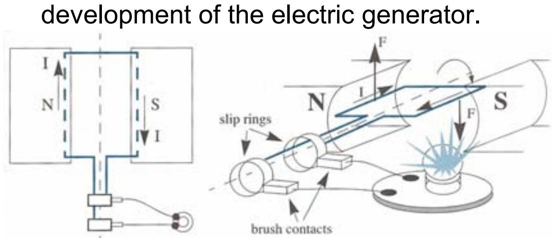
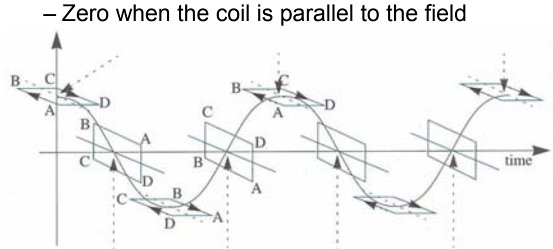
Alternating Current

Alternating Current

- The most important application of the laws of electromagnetic induction was the development of the electric generator.



- The magnitude of the emf and current varies with time
  - Maximum when coil is perpendicular to the field
  - Zero when the coil is parallel to the field



We can calculate the emf…

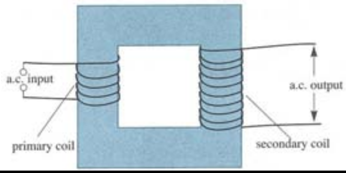
$$\Phi = BA\cos\theta$$

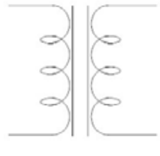
$$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$$

Transformers

- A transformer is a practical application of electromagnetic induction that can be used for increasing or decreasing AC voltages.

- Transformers consist of:
  - Two coils of wire known as the primary and secondary coils
  - Each coil has a laminated soft iron core to reduce eddy currents (increases efficiency)
  - Enclosed on top and bottom with soft iron bars that increase the strength of the magnetic field





- When a current flows in the primary coil, a magnetic field is produced.
- It grows and “cuts” the secondary coil inducing a current.
- The size of the voltage input/output depends on the number of turns of wire in each coil:

$$\frac{I_s}{I_p} = \frac{V_p}{V_s} = \frac{N_p}{N_s}$$

- If a transformer is 100% efficient, the power produced in the secondary coil should equal the power input of the primary coil.

$$I_p V_p = I_s V_s$$

- In practice, the efficiency is closer to 98% due to eddy currents.

Example

- A transformer has 50 turns in its primary coil and 1000 turns in its secondary coil. If the input voltage is 110 V, what is the output voltage?

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$V_s = \frac{V_p N_s}{N_p} = \frac{(110\text{ V})(1000)}{(50)} = 2200\text{ V}$$

Power Transmission

- Electric power is usually transmitted over high voltage (high tension) power lines.
- Copper wire has a resistance and over long runs some energy will be lost to the surroundings as heat.
- A low current (high voltage) minimizes this loss.

Example

- An average of 120 kW is delivered to a suburb 10 km away. The transmission lines have a total resistance of 0.40 Ω. Calculate the power loss if the transmission voltage is:
  - 240 V
  - 24 000 V

240 V

$$P = IV$$

$$I = \frac{P}{V} = \frac{120\text{x}10^3\ \text{W}}{240\ \text{V}} = 500\ \text{A}$$

Power loss:

$$P = I^2 R = (500\ \text{A})^2 (0.40\ \Omega) = 100\ \text{kW}$$

24 000 V

$$P = IV$$

$$I = \frac{P}{V} = \frac{120\text{x}10^3\ \text{W}}{24\,000\ \text{V}} = 5\ \text{A}$$

Power loss:

$$P = I^2 R = (5\ \text{A})^2 (0.40\ \Omega) = 10\ \text{W}$$