

magnetic flux

$$\Phi = B \perp A$$

- B = magnetic field strength (T)
- A = area perpendicular to the magnetic field (m^2)
- Φ = magnetic flux (Wb)

Faraday's Law

$$\epsilon = -N(\Delta\Phi/\Delta t)$$

$$\epsilon = EMF(V), N = \text{number of turns in coil}$$

- $(\Delta\Phi/\Delta t)$ is the derivative of Φ with respect to time.
- ϵ graph should be negative when Φ -t graph has +ve gradient
- ϵ graph should be positive when Φ -t graph has -ve gradient

Lenz's Law

An induced current will flow in a direction such that the magnetic field created by the current will oppose the change in flux that induced the current.

Right Hand coil rule:

- thumb: direction of induced magnetic field
- fingers: direction of induced current

how to find induced current

Problem solving process

To determine the direction of an induced current:

- 1 Identify whether the magnetic flux is **increasing or decreasing**.
- 2 Identify the **direction of the original magnetic field** ('up', 'right', 'into the page' etc.).
- 3 Identify the **direction of the induced magnetic field**:
 - If the flux is **increasing** (found in step 1) then the magnetic field is in the **opposite direction** to the original field (found in step 2).
 - If the flux is **decreasing** (found in step 1) then the magnetic field is in the **same direction** as the original field (found in step 2).
- 4 Apply the right-hand coil rule, with thumb pointing in the direction of the induced magnetic field identified in step 3, to determine the **direction of the induced current**.

generators and alternators

$$f = 1/T$$

f = frequency (Hz), T = period of revolution(s) - time taken to complete a full cycle

*max ϵ when coil is parallel to magnetic field, ie. greatest rate of change

*DC current can only be produced in presence of a split ring commutator

Alternator (AC): sinusoidal

DC generator: modulus of AC

$$\cdot \Phi(t) = a \cos(2\pi ft)$$

$$\cdot \epsilon = \Phi'(t) = -2\pi f a \sin(2\pi ft)$$

electricity recap

$$V = I \cdot R - V(V), I(A), R(\Omega)$$

$$P_{\text{supply}} = V \cdot I - \text{also: power rating}$$

$$P_{\text{dissipated}} = I^2 \cdot R = V^2/R$$

Power (W) is the rate of change of energy with respect to time

$$P = \Delta E/\Delta t - \text{gradient of E-t graph}$$

series circuit:

- current (I) is the same through the whole circuit
- flow: from positive to negative terminal
- total resistance (RT) is the sum of individual resistances: $R_1 + R_2 + \dots$
- total voltage supplied to a circuit must be equal to the total voltage used around the circuit (sum of voltage drops): $V_{\text{supply}} = V_1 + V_2 + \dots$

Transformers, comparing AC and DC

$$V_{\text{RMS}} = V_{\text{peak}}/\sqrt{2}, I_{\text{RMS}} = I_{\text{peak}}/\sqrt{2}$$

$$P_{\text{avg}} = V_{\text{RMS}} \cdot I_{\text{RMS}} = I_{\text{RMS}}^2 \cdot R = V_{\text{RMS}}^2/R - \text{avg power delivered by sinusoidal signal}$$

Transformers:

$$P_{\text{in}} = P_{\text{out}}$$

$$V_1/V_2 = N_1/N_2$$

$$I_1/I_2 = N_2/N_1$$

when $V_1 > V_2$: Step-down transformer

when $V_1 < V_2$: Step-up transformer

*transformers will not work for converting a DC voltage

Transmission of power (Power systems)

Power loss:

$$P_{\text{loss}} = I_{\text{line}}^2 \cdot R_{\text{line}}$$

Voltage drop:

$$V_{\text{drop}} = I_{\text{line}} \cdot R_{\text{line}}$$

$$I_{\text{load}}/I_{\text{line}} = N_1/N_2$$

- almost all wires have some resistance
- as electricity passes through the wires, it causes them to heat up, resulting in power loss, and a decrease in the voltage that is available at the load.

High voltage transmission

- we can reduce power loss by lowering the current in the line
- we can keep the same supply power by increasing the supply voltage
- this is done using transformers.



By **cadmiumium**

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