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E21 Electromagnetic induction

P21.01 Generating electricity

motor - device for transforming electrical energy into kinetic energy

generator - device for transforming mechanical energy into electrical energy

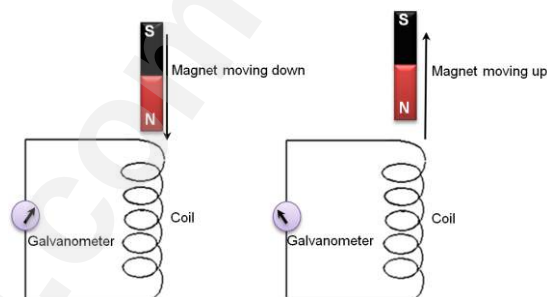
- spinning motor → current has been **induced**

General feature of electric motor

- magnetic field
- coil of wire
- movement

1. The principles of electromagnetic induction

- coil of wire & magnet are needed to induce a voltage
- move magnet or wire while another is stationary
- complete circuit → induced e.m.f will make induced current
- up and down motion - make the current flow

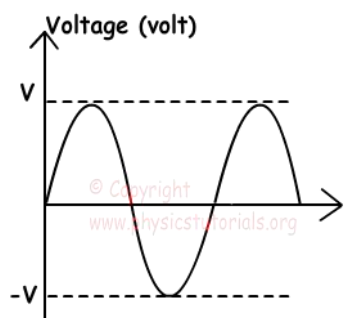


2. increasing the induced e.m.f

- use a stronger magnet
- move the wire or coil quickly relative to the magnet
- use a coil with more turns of wire

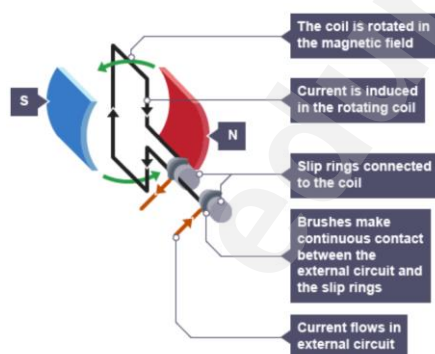
3. Generating a.c.

generator produces **alternating current(a.c)**



- always flows back and forth
- each time magnet is moved → magnetic field lines are cut by wire
- this cutting induces the current
 - all stationary → no cutting field → no e.m.f induced
 - too distant → field lines too far to be cut → e.m.f smaller
 - move magnet quickly → lines are cut more → e.m.f higher
 - coil not wire → more lines are cut → e.m.f higher

4. An a.c generator



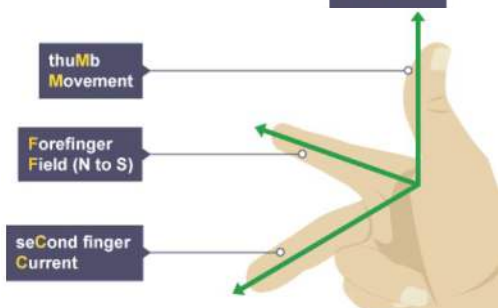
- axle is made to turn so that the coil can spin in magnetic field
- current is induced

- use **slip ring** - each ring is connected to the each end of coil

Increase voltage

- turn the coil more rapidly
- use the coil with more turns
- use a coil with a bigger area
- use stronger magnets

Frequency(Hz) 계산 - how many times the coil spins per second



→ **left hand for motors, right hand for generators**

P21.02 Power lines and transformers

power lines - power station ~ house which carry million volts

- decrease the volts steadily to 230V using transformers

1. Why use high voltages?

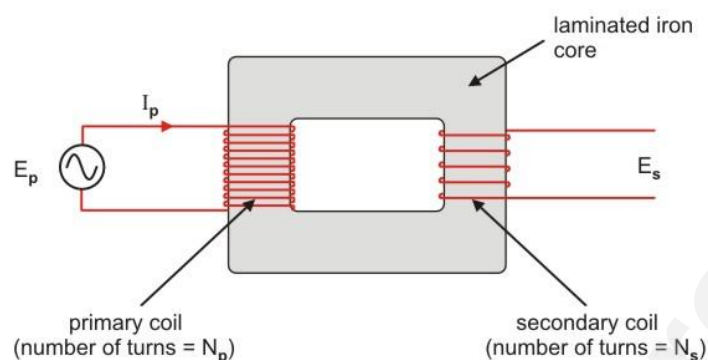
high voltages - current is relatively low - waste less energy

- some energy is lost because of the cable's resistance when a current flows
 - high voltage - fewer coulombs flowing - each coulomb carries more energy in it
 - by heat energy
 -
- small current - waste less energy
- $\text{current} \propto \text{waste energy}^2$

2. Transformers

transformer - device used to increase or decrease the voltage of an electricity supply

- designed for 100% efficiency
- only change the size → keep d.c / no change at all



Structure

primary coil - connected to incoming voltage

secondary coil - provide voltage to external circuit

iron core - link two coils

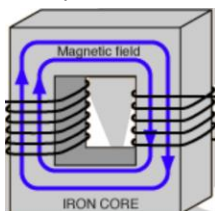
step-up transformer - increase the voltage, more turns on the secondary than on the primary

step-down transformer - reduce the voltage, less turns on the secondary than on the primary

$$\frac{\text{Output voltage}}{\text{Input voltage}} = \frac{\text{Turns on output coil}}{\text{Turns on input coil}}$$
$$\frac{V_P}{V_S} = \frac{N_P}{N_S}$$

3. how transformers work

✧ only work with a.c.



4. Calculating current and power

$$P = IV$$

power in to primary coil = power out of secondary coil

$$I_p \times V_p = I_s \times V_s$$