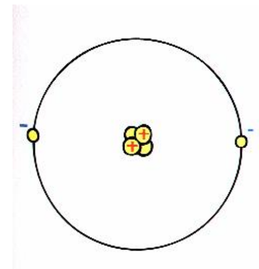
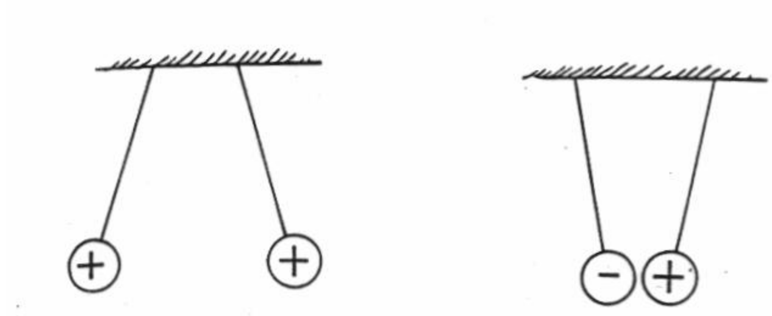
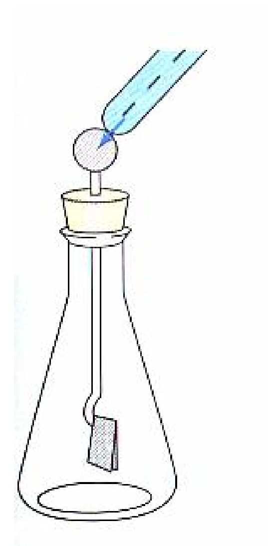
ELECTRICAL CHARGES



- ***Static electricity*** is the ***accumulation of electric charges*** on an object.
- Electric ***charges*** are caused by an ***imbalance*** between ***positive*** (protons) and ***negative*** (electrons) particles in matter.
- ***Like*** charges ***repel*** each other, while ***unlike*** charges ***attract***.





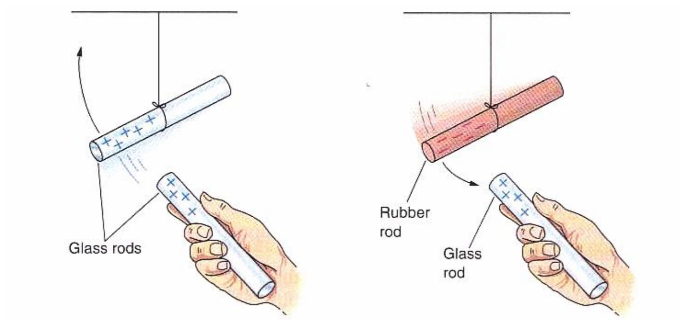
- Presence of electrical charges can be detected by the use of an ***electroscope***.

Neutral objects can be charged in two ways:

- Charging of neutral objects through ***contact*** is called ***conduction***.
- Charging of neutral objects ***without*** direct ***contact*** is called ***induction***.
- ***Conductors*** are substances that ***allow*** electrons to ***move easily*** through them. ***Metals*** are examples of good conductors.
- ***Insulators*** are substances that ***don't allow*** electrons to ***move easily*** through them. ***Plastics, wood and glass*** are good insulators.

ELECTRIC FORCES

- ***Repulsions*** and ***attractions*** caused by electrical charges are ***forces***.



- The magnitude of the electric forces is described by ***Coulomb's Law***:

$$F=k\frac{q_1q_2}{r^2}$$

where,

F= force of attraction or repulsion
q_1 and q_2 = electric charges
r = distance between the charges
k= the Coulomb's constant

<u>Examples:</u>
Two positive charges are a distant of 2 cm from one another. If they are moved to a distant of 1 cm, the force between them

A) increases 2 times
B) decreases 2 times
C) increases 4 times
D) decreases 4 times

CURRENT / VOLTAGE / RESISTANCE

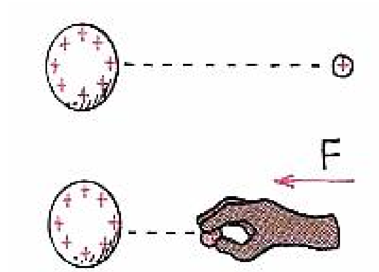
Current:

- ***Motion*** of electric ***charges*** causes electric ***current.***
- ***Rate of flow*** of electric charges is measured as ***electric current.***

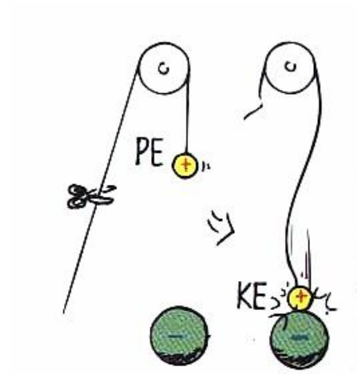
$$\textbf{current} = \frac{\textbf{charge}}{\textbf{time}} = \frac{\textbf{q}}{\textbf{t}}$$

- Electric current is measured as ***amperes***.

Voltage:



- When two charges are brought together or separated from each other, ***work*** must be done to overcome the ***forces between them***.
- The work thus done increases the ***electric potential energy*** of the charges.
- When the charge is released, the electrical ***PE is converted to KE***.
- The ***electrical potential difference*** is what is measured as ***voltage (V)***.

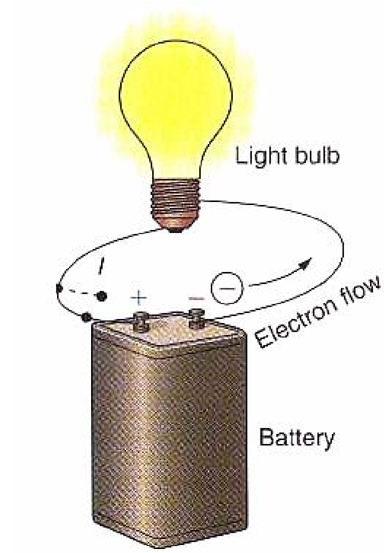


Resistance

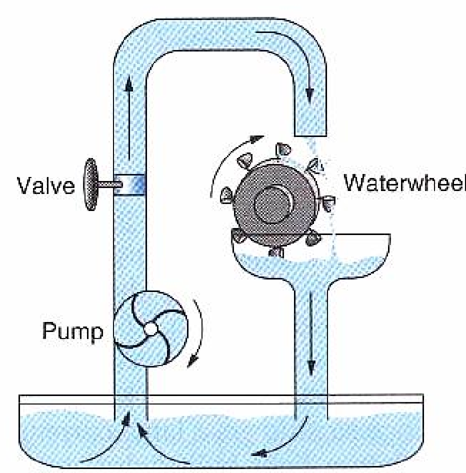
- When current flows through a conducting material, it meets some opposition to its flow due to collisions within the material.
- This property is called ***resistance (R)*** and is measured in ***ohms (Ω).***

ELECTRIC CIRCUIT & WATER ANALOGY

- In the electric circuit, the battery provides the voltage, current flows through the wire and the bulb provides the resistance to flow of electrons.



- In the water circuit, the pump is analogous to the battery, the pipe represents the wire carrying water flow, and the water wheel provides resistance to flow of water.



OHM'S LAW

- The relationship between ***voltage, current*** and ***resistance*** in a circuit is called Ohm's Law and is described as follows:

Voltage = Current x Resistance

(volts) = (amperes) x (ohms)

$$V = I R$$

Examples:

1. A toaster with a resistance of 50 Ω is connected to a 120 V source. What current flows through the toaster?

   V=

   R=

   I=

2. A 12-V car battery operates a lamp with a current 0.08 amperes. What is the resistance of the lamp?

   V=

   R=

   I=

ELECTRICAL POWER

- ***Electrical Power (P)*** is the work done by the current against the resistance of the circuit, and can be calculated as follows:

$$P = V\ I$$

- The ***unit*** of power is ***watts (W).***

Examples:

1. A color television connected to a 120-V source draws 3.5 A of current. What is the power rating of this TV?

   V=

   I=

   P =

2. A 60-W light bulb is connected to a 120-V power source. Find the current and the resistance of the bulb.

   V=

   P =

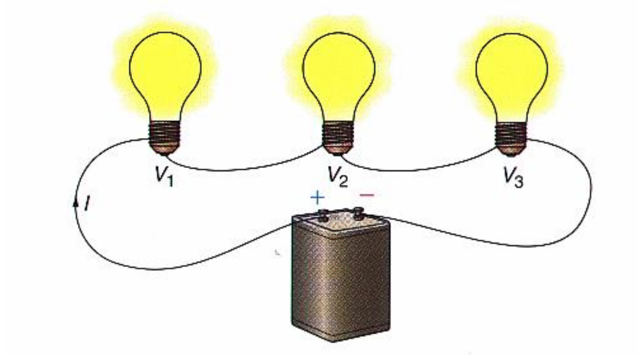
   I =

   R=

ELECTRICAL CIRCUITS

- Any ***closed path*** along which electrons can ***flow*** is a ***circuit***.
- Two types of circuits are possible: ***series*** & ***parallel***.

Series Circuit



- Electric ***current*** has only ***one path of flow*** through this circuit.

- The ***total resistance*** of the circuit is the ***sum*** of all the ***individual resistances***.

$$R_{tot} = R_1 + R_2 + R_3 + \ldots.$$

- The ***current*** through each bulb is the ***same***.

$$I = I_1 = I_2 = I_3$$

- The ***sum of the voltages*** across each bulb equals the source voltage.

$$V_{tot} = V_1 + V_2 + V_3$$

Examples:
Three lamps with resistances of 15Ω each are connected to a 72-V power source. What is the current and power through the circuit?

$R_1 = R_2 = R_3 =$

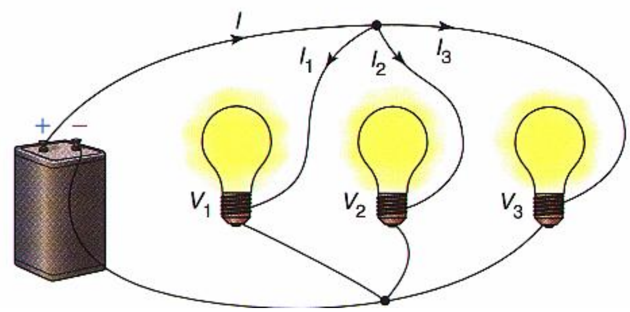
V =

I =

P =

ELECRICAL CIRCUITS

Parallel Circuit



- Electric ***current*** has ***more than one path of flow*** through this circuit.
- The ***total resistance*** of the circuit is ***less than the smallest*** resistance in the circuit.

$$R_T = \frac{R_1 R_2}{R_1 + R_2}$$

- The ***total current*** in the circuit is equal to the ***sum of the currents*** in its parallel branches.

$$I_{tot} = I_1 + I_2 + I_3$$

- In this circuit, the ***voltage*** across each branch is the ***same***.

$$V_{tot} = V_1 = V_2 = V_3$$

Example:

1. Two lamps with resistances of 6Ω and 3Ω respectively are wired in parallel. Calculate the total resistance of this circuit.

$$R_T = \frac{R_1 R_2}{R_1 + R_2} = \_\_\_\_\_\_\_\_\_\_\_\_$$

2. When three 15Ω lamps are connected in parallel to a 72-V power source, the current through each lamp is 4.8 amperes. What is the total resistance in this circuit?

I_{Total}=

V =

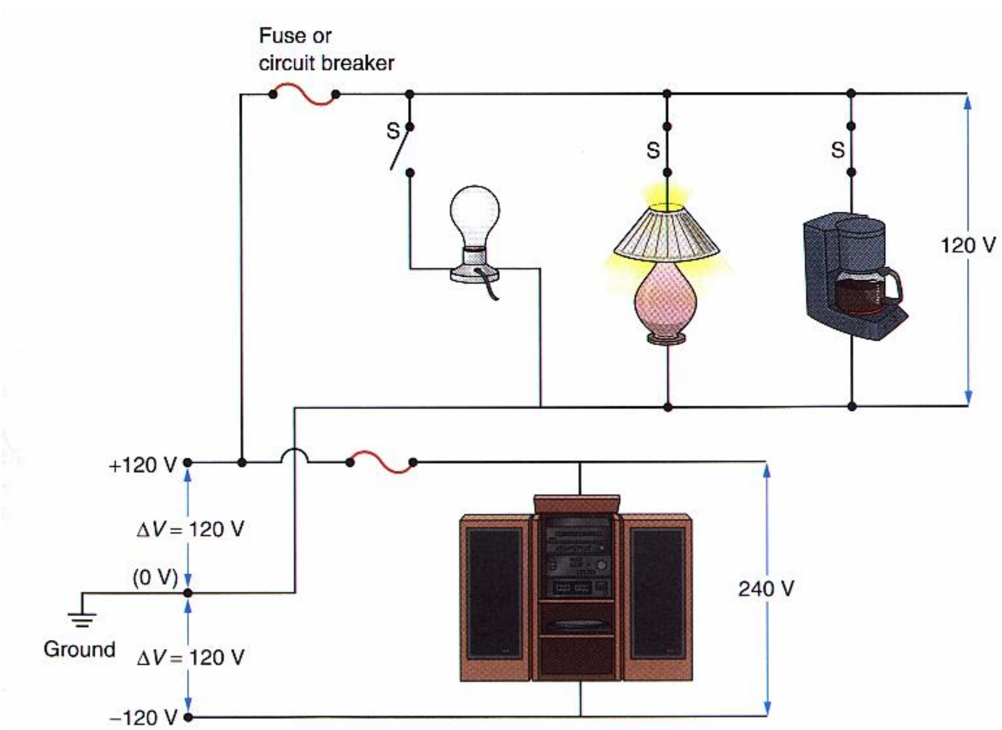
R =

COMPARING CIRCUITS

- There are several differences in operation between the series and the parallel circuits.

Series Circuit	Parallel Circuit
➢ If ***one*** lamp ***fails***, all ***others stop working***.	➢ If ***one*** lamp ***fails***, the ***others continue to work***.
➢ As ***more lamps*** are added to the circuit, total ***resistance increases***, and total ***current decreases***.	➢ As ***more lamps*** are added to the circuit, total ***resistance decreases***, and total ***current increases***.
➢ As a result the lamps get ***dimmer*** as more is added to the circuit.	➢ As a result the circuit can get ***overheated*** as more lamps are added to it.

- Household circuits are wired in parallel so each appliance can work independently of others.



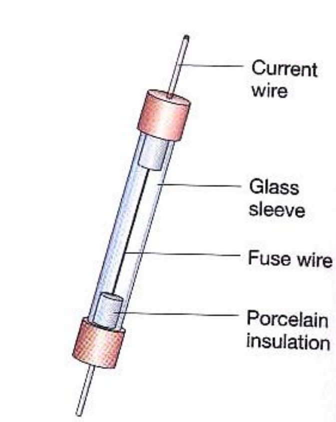
ELECTRICAL SAFETY

- The damaging effects of ***electric shock*** on a human body are caused by a ***current*** and ***not by voltage***. The resistance of a human body ranges from 500,000 Ω (dry skin) to about 100 Ω (fully soaked body in salt water).

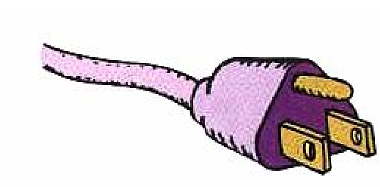
- For a body to receive shock, there must be a ***difference in electric potential*** between one part of the body and another.

- That is why a bird can sit on a high voltage wire without any problem, but it had better not reach over and grab a neighboring wire!

- To avoid hazard from an ***overheating*** circuit, a ***fuse*** is placed in the circuit. The low melting point of the ***fuse wire*** causes it to ***melt and break*** the circuit if the current becomes excessive.



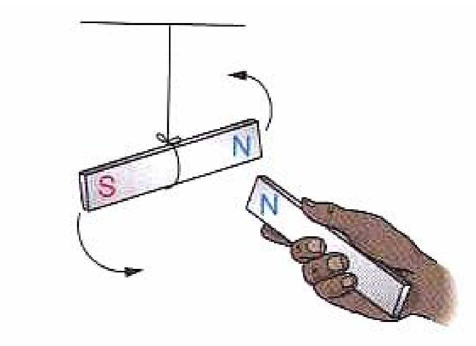
- A dedicated ***ground wire*** in electrical appliances through a third prong causes the ***circuit to be opened*** and ***electric potential*** of the casing to become ***zero***, ***avoiding a shock hazard***.

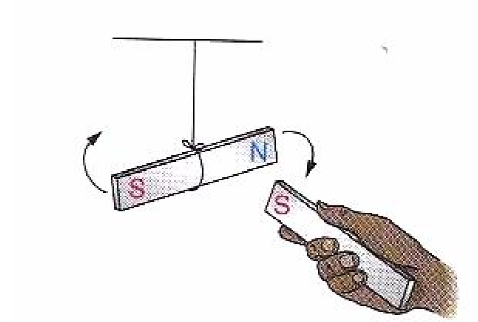


MAGNETIC FORCES & FIELDS

- ***Magnetic forces*** are ***similar*** to ***electric forces***, for they can attract and repel without touching (***action at a distance***).

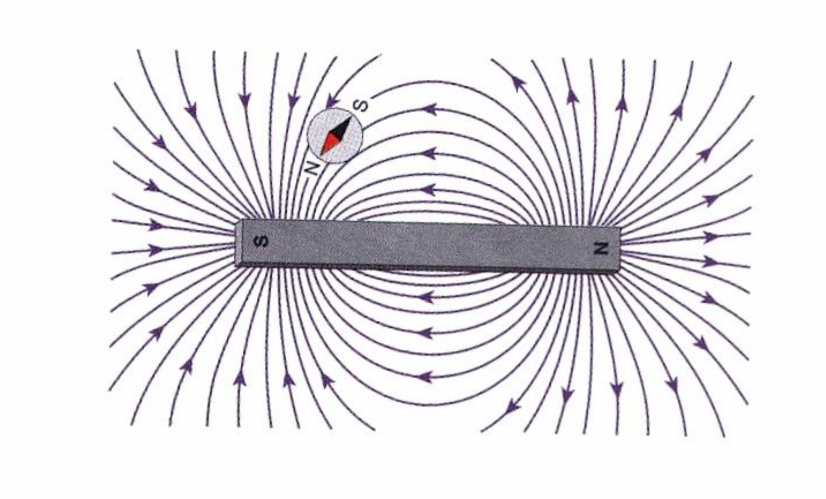
- Similar to electric charges, ***like magnetic poles repel***, while ***opposite poles attract***.





- Magnetic ***poles cannot be isolated*** while ***electric charges can***.

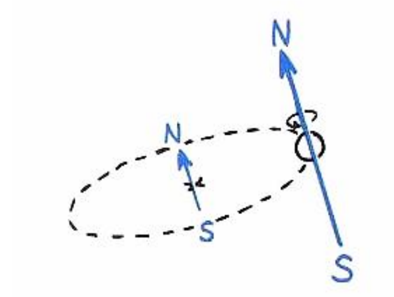
- ***Magnetic field*** is the ***area*** around a magnet where the ***magnetic forces act***, and are concentrated near the poles of a magnet.



MAGNETIC DOMAINS

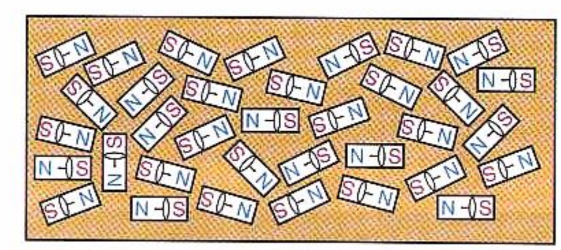
- ***Magnetic fields*** are caused by ***"distortions"*** in a ***moving electric field***.

- These ***distortions*** are caused by the ***"spinning" and revolving motion of electrons*** in an atom. Each ***atom*** is therefore a ***tiny magnet***.



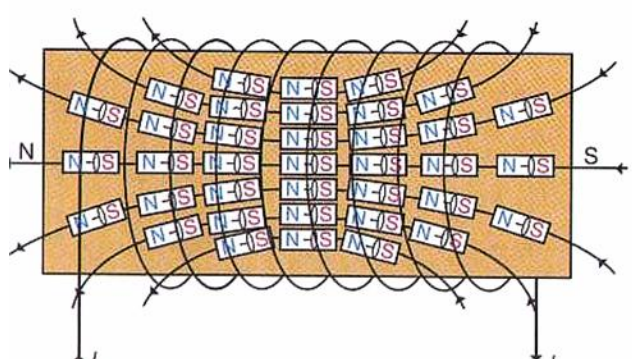
- A large ***cluster of atoms aligned*** together give rise to a ***magnetic domain***.

- An ***unmagnetized*** material has ***unaligned domains***.



(a) Unmagnetized material

- When the domains are ***induced into alignment***, ***magnetic properties appear***.



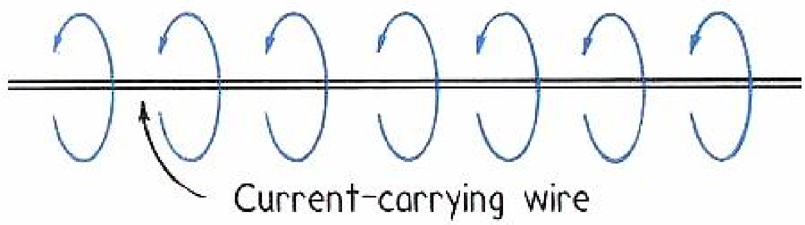
(b) Magnetized material

- Domains can be induced into alignment by ***rubbing against a strong magnet*** or by running ***current through a wire*** wrapped around a metal.

ELECTROMAGNETISM

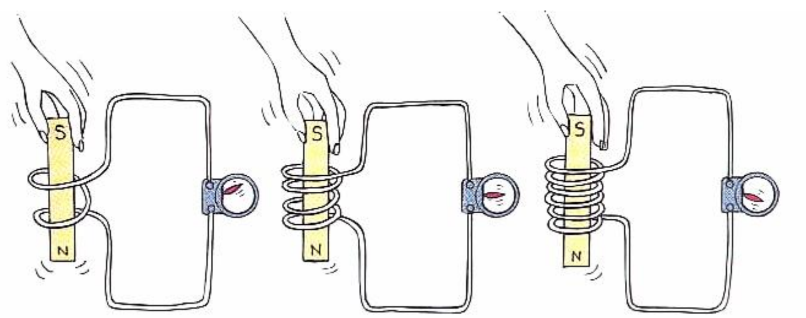
- The interaction of ***electric and magnetic*** effects is called ***electromagnetism***.

- An ***electric current*** produces a ***magnetic field perpendicular*** to the direction of its movement.



- In early 1800, ***Michael Faraday*** discovered that an ***electric current*** could be produced from a ***changing magnetic field***.

- ***Electromagnetic induction*** is the process of creating a current by movement of a magnet through a coil of wire.

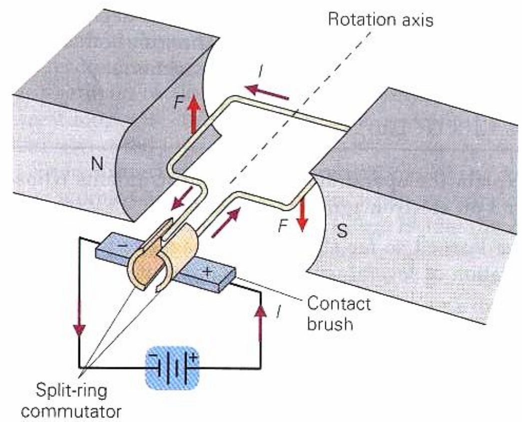


- The ***amount of current*** produced depends on the ***number of loops***, the ***rate of movement*** of the magnet and the ***strength of the magnet***.

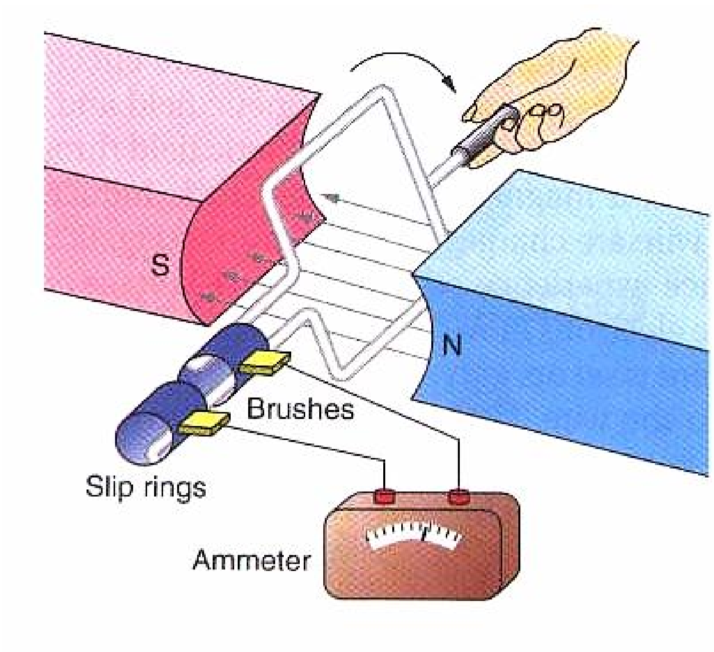
- Many devices such as a telephone & doorbell use this principle to operate.

APPLICATIONS OF ELECTROMAGNETISM

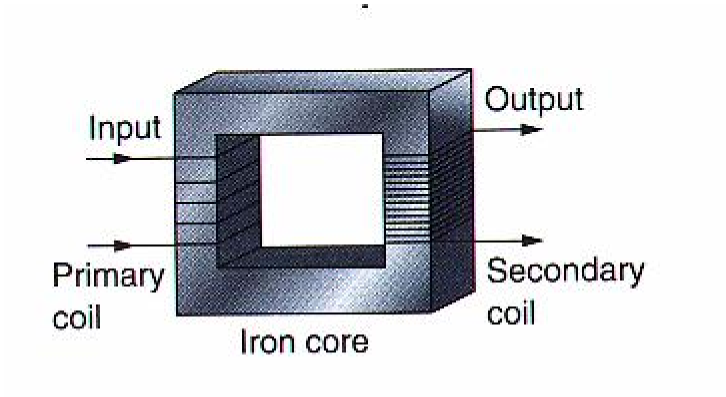
- A simple ***motor*** is an ***electromagnet*** that converts ***electrical energy to mechanical energy***.



- A ***generator*** converts ***mechanical energy to electrical energy***, and uses the principle of ***electromagnetic induction***.



TRANSFORMERS



- A transformer is used to increase or decrease voltage in a circuit using Faraday's Law.
- A ***transformer*** consists of two coils of insulated wire wrapped around an iron core.
- ***Current*** in the primary coil ***creates a magnetic field***, which is concentrated by the iron core, and passed through the secondary coil.
- The ***magnetic field*** in the secondary coil ***produces a current*** output.
- The ***voltage change*** in the transformer is based on ***Faraday's Law***, and is given by

$$\frac{V_1}{N_1} = \frac{V_2}{N_2} \qquad \text{or} \qquad V_2 = \left(\frac{N_2}{N_1}\right) V_1$$

where,

V_1=input voltage
N_1=number of turns in the primary coil
V_2=output voltage
N_2=number of turns in the secondary coil

- A transformer that has ***more turns*** in the ***secondary coil*** compared to the primary coil is a ***step-up*** transformer.
- A transformer that has ***more turns*** in the ***primary coil*** compared to the secondary coil is a ***step-down*** transformer.

TRANSFORMERS

- The power output in the primary and secondary coils of a transformer remain the same, therefore

$$P_1 = P_2$$

$$V_1 I_1 = V_2 I_2$$

Examples:

1. A transformer has 500 windings in its primary coil and 25 in its secondary coil. If the input voltage is 4400 V, find the output voltage.

$N_1 =$

$N_2 =$

$V_1 =$

$V_2 =$

2. A transformer has 300 turns in its secondary and 50 turns in its primary coil. The input voltage is 12 V. If 3.0 A flows in the primary coil, find the voltage and current in the secondary coil?

$N_1 =$

$N_2 =$

$V_1 =$

$I_1 =$

$V_2 =$

$I_2 =$