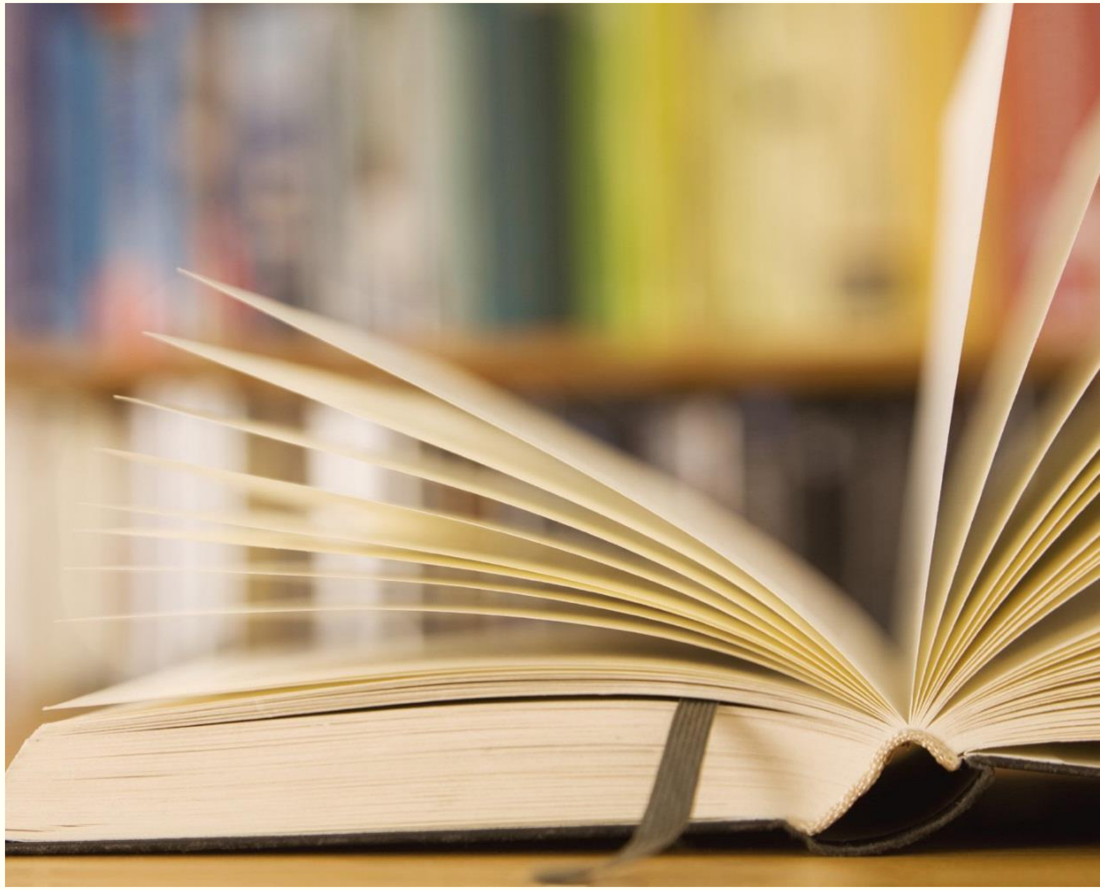
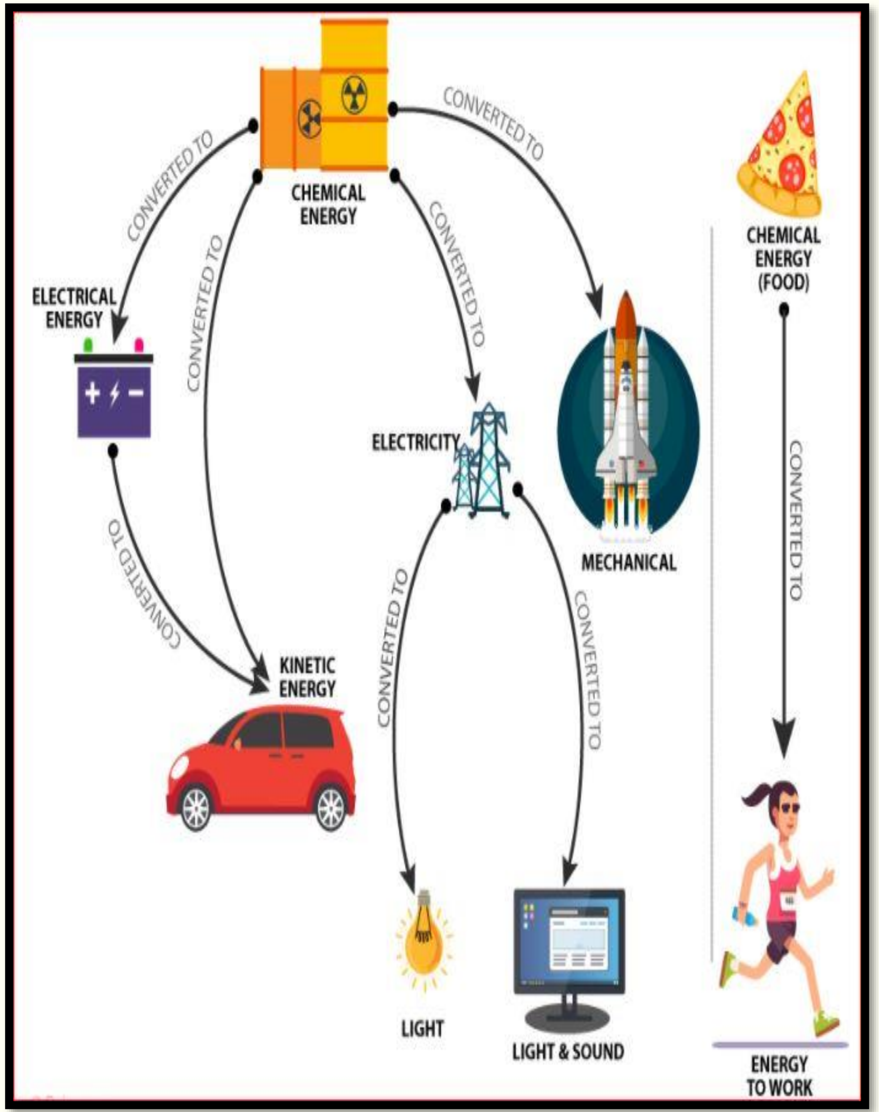
# CHAPTER-4
# ELECTRIC AND MAGNETIC CIRCUIT

PREPARED BY:- PURVESH A VALAND

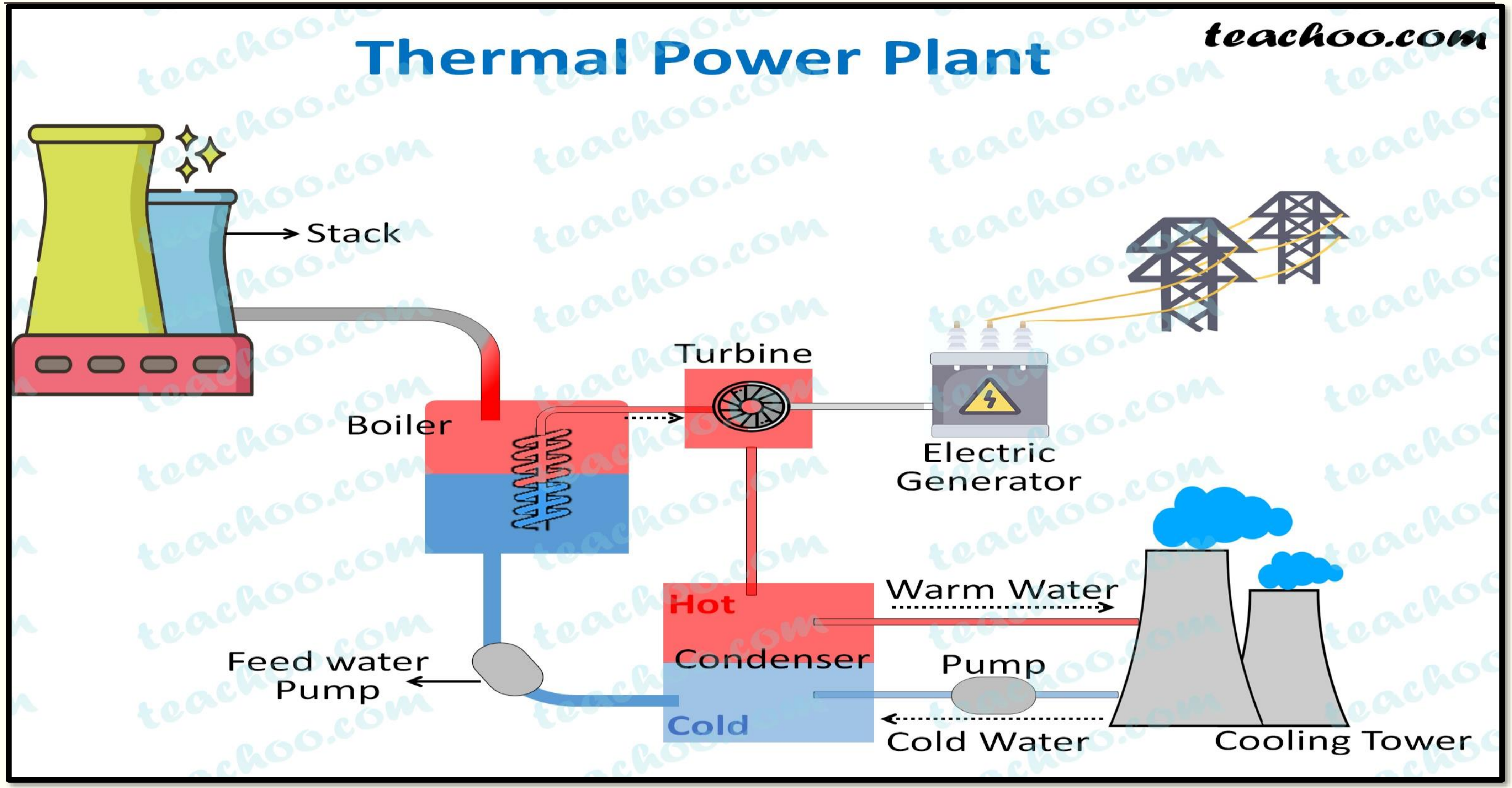


# LAW OF ENERGY CONVERSION & GENERATION OF ELECTRICAL ENERGY

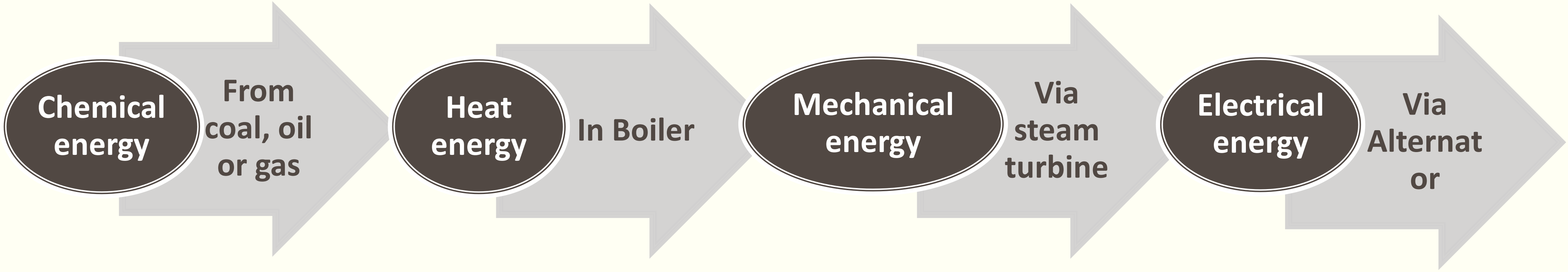
- The law of conservation of energy states that ***energy can neither be created nor be destroyed. Although, it may be transformed from one form to another.***
- Energy conversion also termed as the **energy transformation**, is the process of changing one form of energy into another. Energy conversion occurs everywhere and every minute of the day. There are numerous forms of energy like thermal energy, electrical energy, nuclear energy, electromagnetic energy, mechanical energy, chemical energy, sound energy etc.
- Whether the energy is transferred or transformed, the total amount of energy doesn't change and this is known as the **Law of Conservation of Energy.**



# LAW OF ENERGY CONVERSION & GENERATION OF ELECTRICAL ENERGY

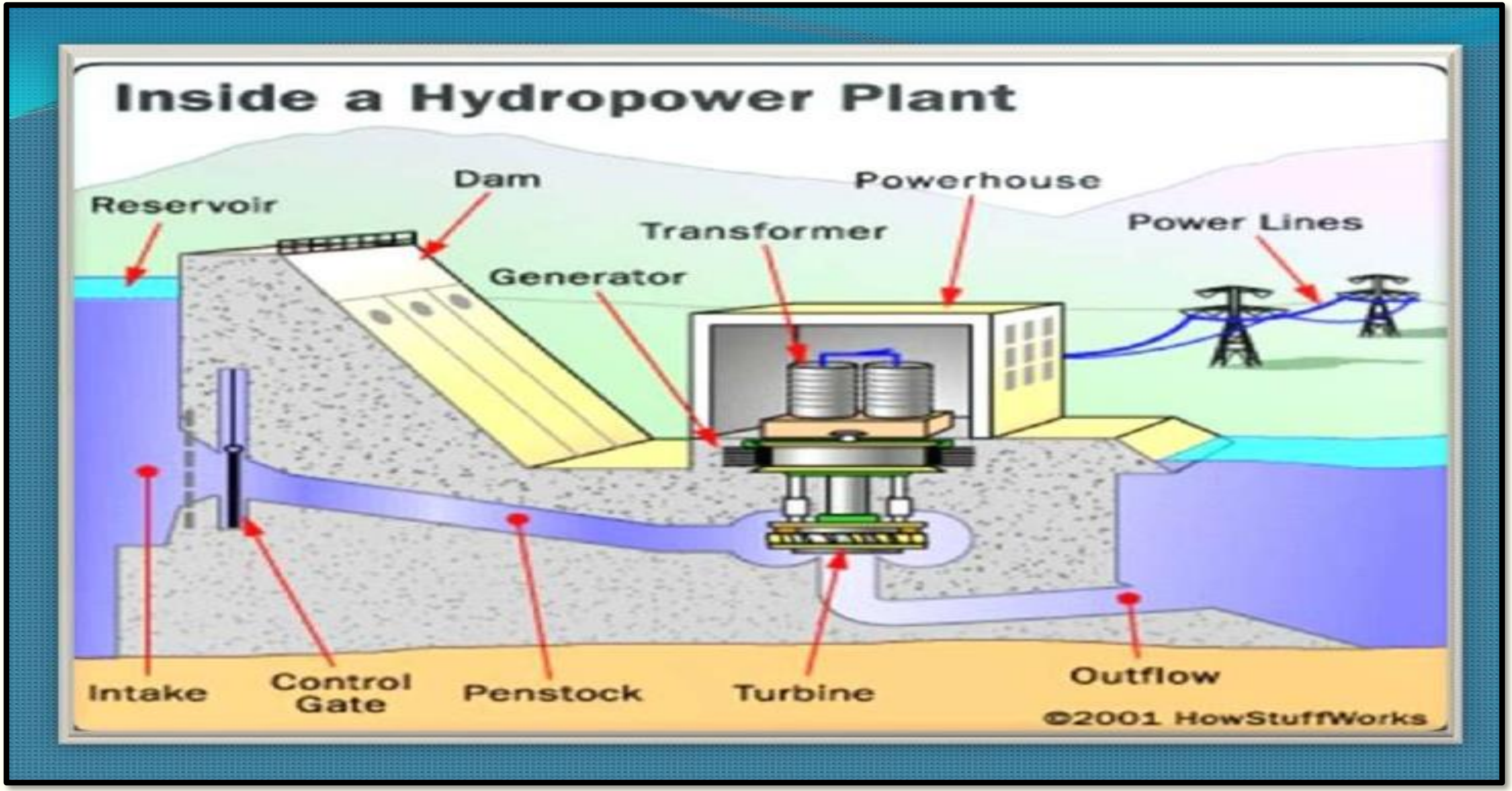


# LAW OF ENERGY CONVERSION & GENERATION OF ELECTRICAL ENERGY

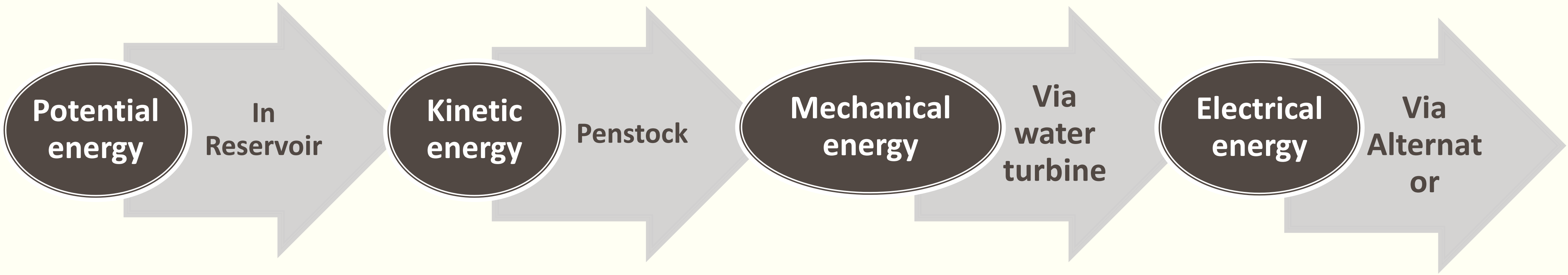



**Energy Conversion in Thermal Power Station**

# LAW OF ENERGY CONVERSION & GENERATION OF ELECTRICAL ENERGY



# LAW OF ENERGY CONVERSION & GENERATION OF ELECTRICAL ENERGY




**Energy Conversion in Hydro Power Station**

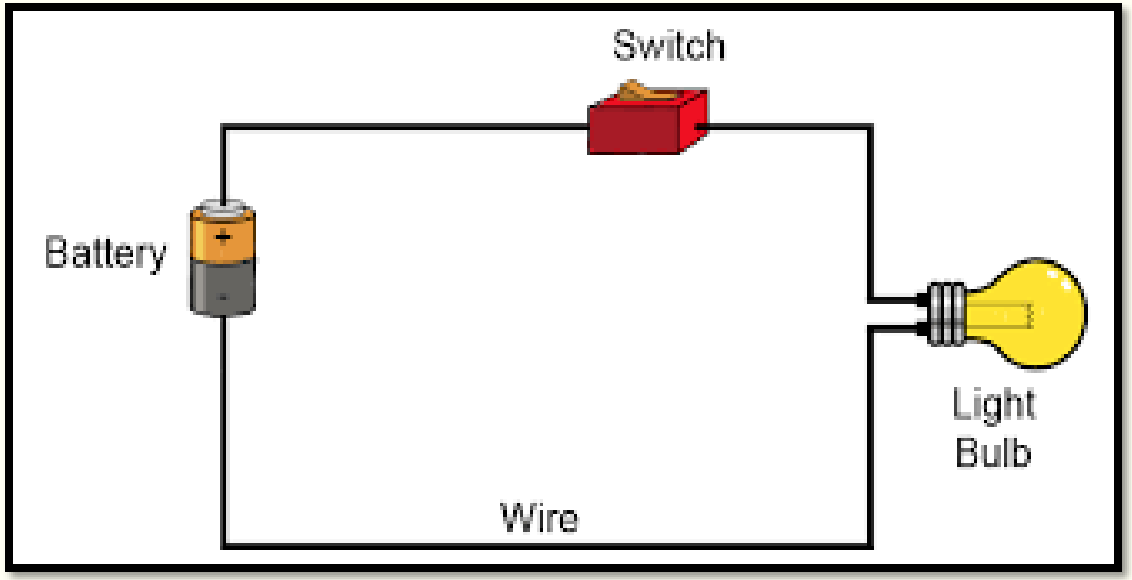
# SOURCES OF ELECTRICITY

- Basically there are two types **1.** sources which produce direct current and **2.** sources which produce alternating current.

- **Battery and D.C generator** is the two main sources which generate direct current and **Alternator (A.C generator)** is the main source for the generation of Alternating Current.

- **<u>Battery:-</u> chemical energy is converted in to electrical energy** with the help of battery. Battery is the form of direct current in which there are two terminal marked as **positive terminal** and **negative terminal**. Direct current flows from positive terminal to negative terminal if we connect load.

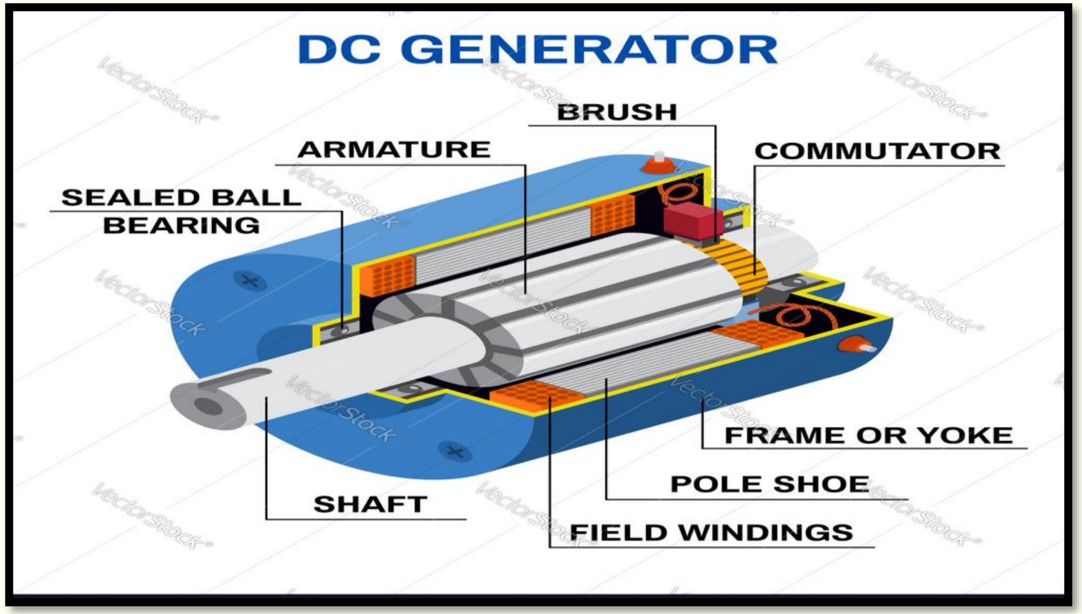
- A simple electric circuit is shown if figure.



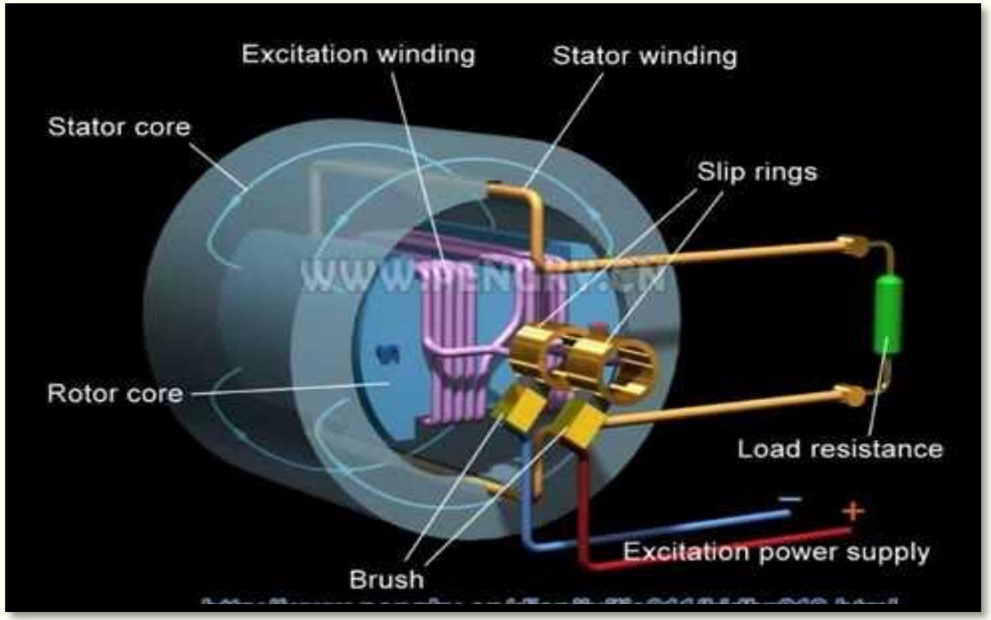
# SOURCES OF ELECTRICITY

- **<u>D.C GENERATOR:-</u>** This is rotating electrical machine which **converts mechanical energy in to the electrical energy.** Main parts of D.C generator is **armature, field winding, pole and commutator**. D.C generator generates energy in the form of direct current.

- **<u>ALTERNATOR:-</u>** Like d.c generator this is also rotating electrical machine which converts mechanical energy in to electrical energy. Alternator generates energy in the form of alternating current. There are two main parts of the alternator such as **field and armature.**




D.C GENERATOR

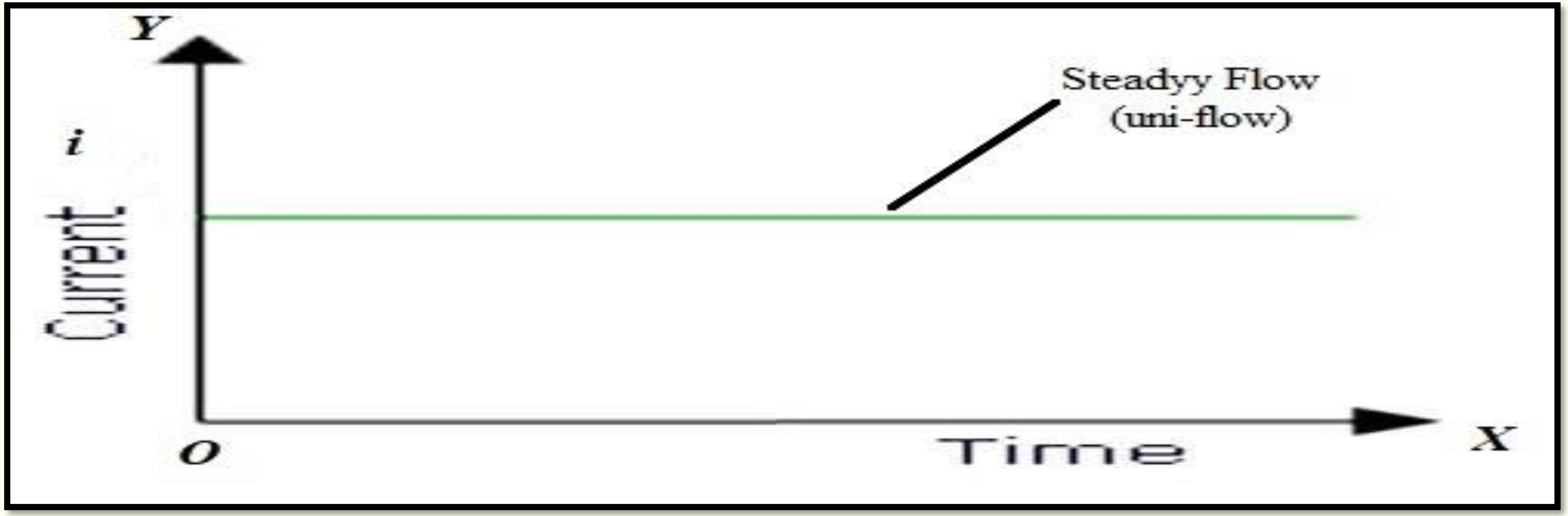



ALTERNATOR (A.C GENERATOR)

# DIRECT CURRENT AND ALTERNATING CURRENT

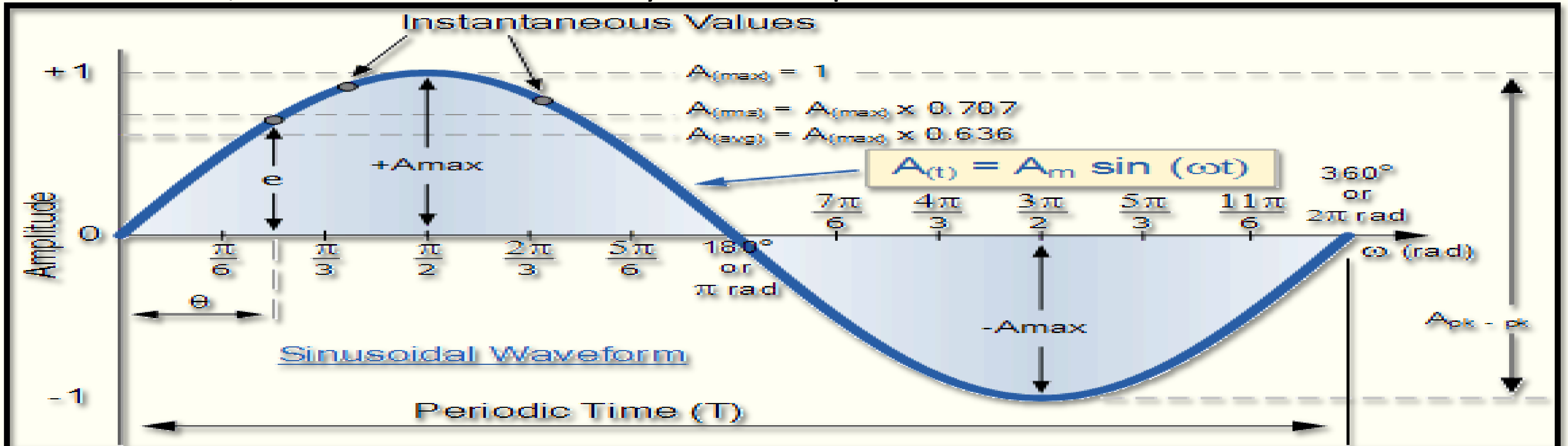
- **<u>DIRECT CURRENT:-</u>** In direct current there is no change in the direction of electric current. In figure below there is no change in the magnitude of the current.

- Direct current (DC) is an electric current that is **uni-directional**, so the flow of charge is always in the same direction. As opposed to alternating current, the direction and amperage of direct currents do not change. It is used in many household electronics and in all devices that use batteries.



# DIRECT CURRENT AND ALTERNATING CURRENT

- **<u>ALTERNATING CURRENT:-</u> Alternating current** (AC) is an electric **current** which periodically reverses direction, in contrast to direct **current** (DC) which flows only in one direction.
- In alternating current, the magnitude and the direction of current are changing continuously. Graph of electric current varying sinusoidally is shown in figure.
- From the graph it is seen that the value of current increases in direction from zero, becomes maximum, then decreases to zero and increases in reverse direction, becomes maximum in that direction, and becomes zero. The cycle then repeats.



# DIFFERENET TERMS REGAEDING ELECTRIC CURRENT

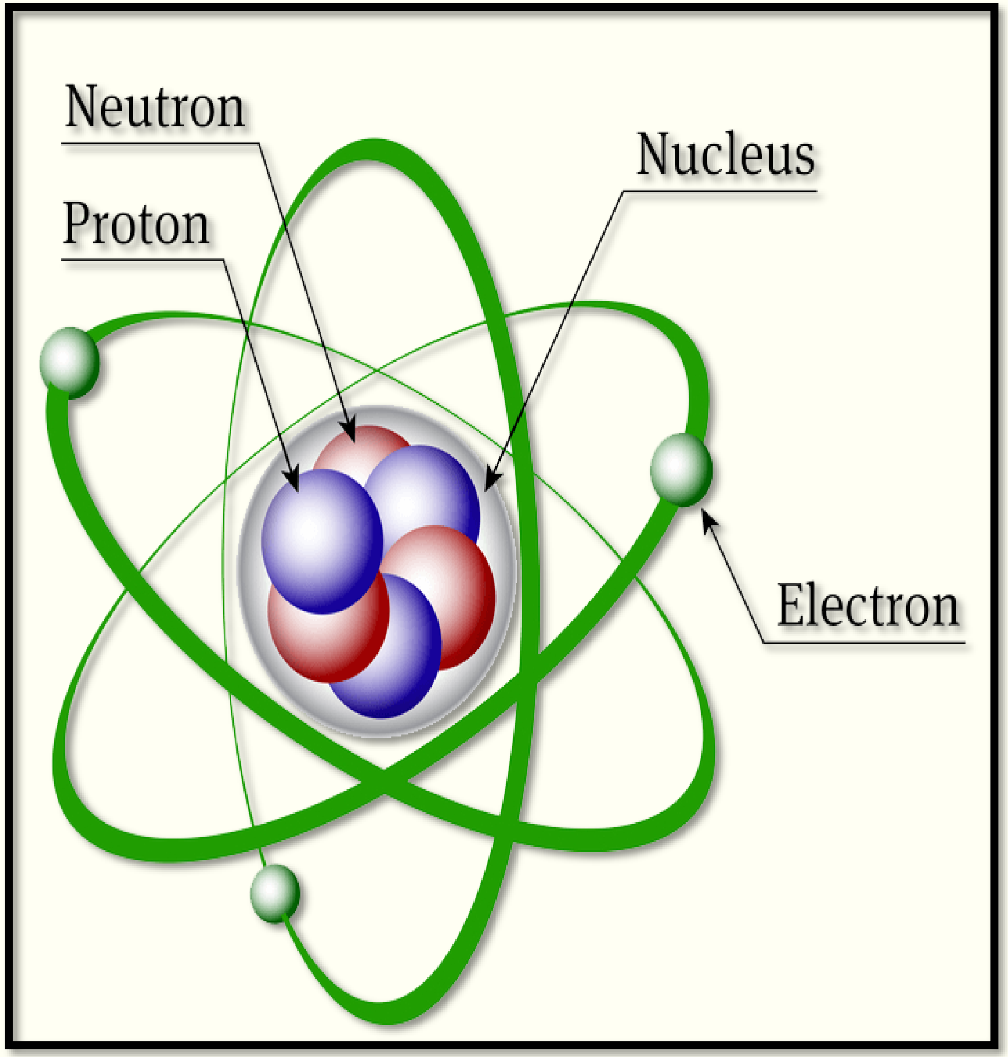
- **ELECTRIC CURRENT:-** For electric current we need to understood the concept of **atomic structure.**

- If there are less than 4 electrons in the outer orbit of the atomic structure they are known as free electrons, this free electrons are having tendency to move from one atom to another atom when they experience any external force. **Free electrons are electrically charged. This movement of free electrons are termed as electric current.**

- It is represented by **the letter I** , and **unit is ampere.**

- $Q = I * t$ ……… (1)

- **Where Q= charge in coulomb, I = current in amp and t = time in second.**

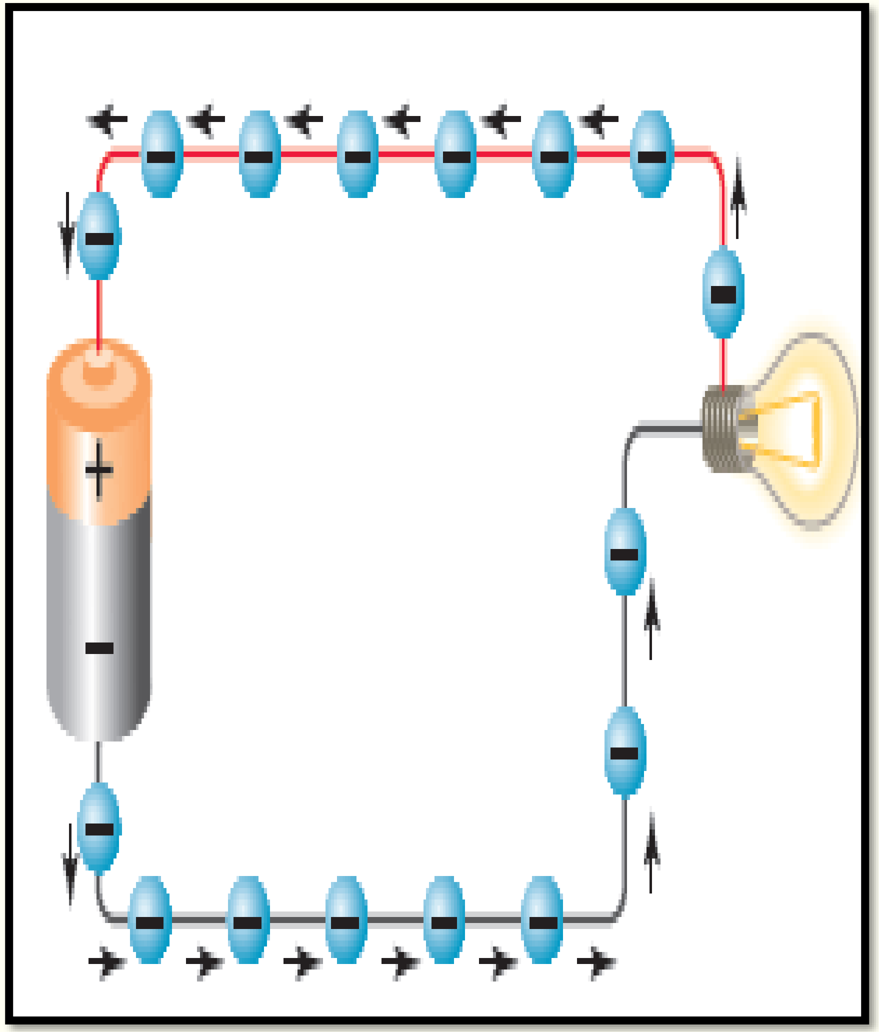


# DIFFERENET TERMS REGAEDING ELECTRIC CURRENT

- **E.M.F:-** Flow of electric charge is essential to make current to flow through a conductor. So it is necessary to do work. And to do work, energy is required. This energy is supplied by battery. This is called electro motive force.

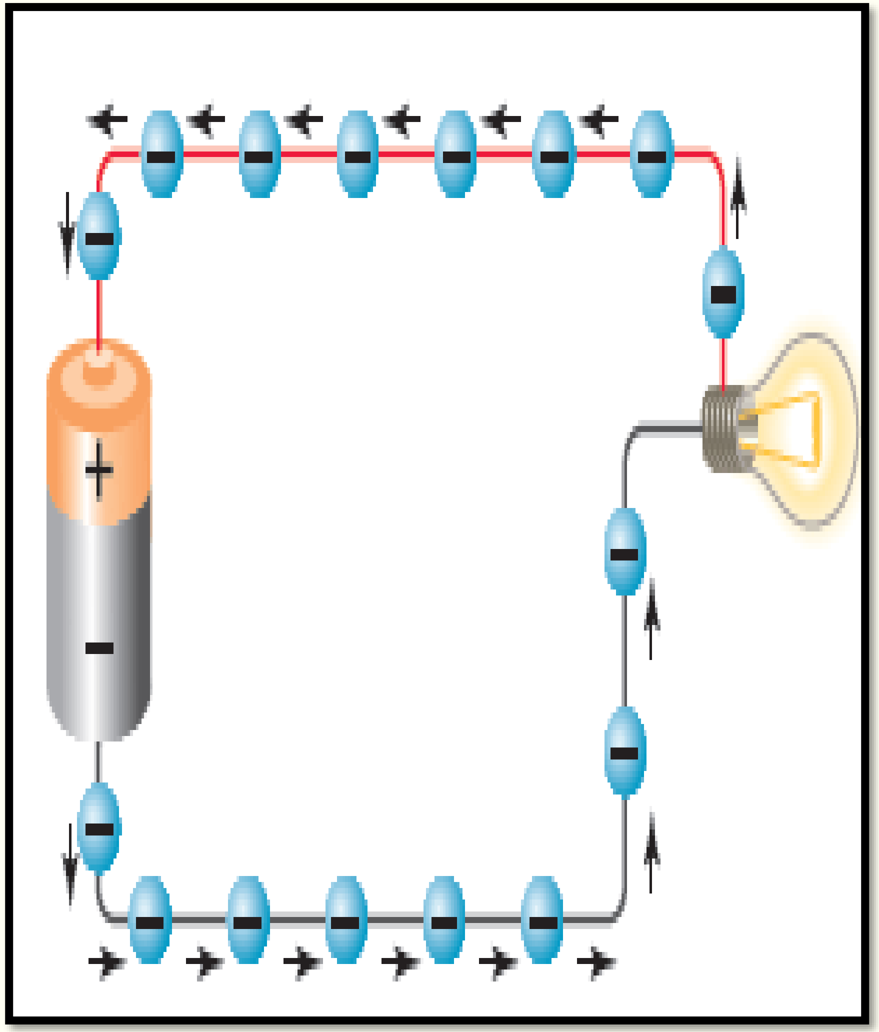
- **The force required to move the electrons from one point to another point is called electro motive force.**

- Its **unit is volt** and represented by a **letter E**.

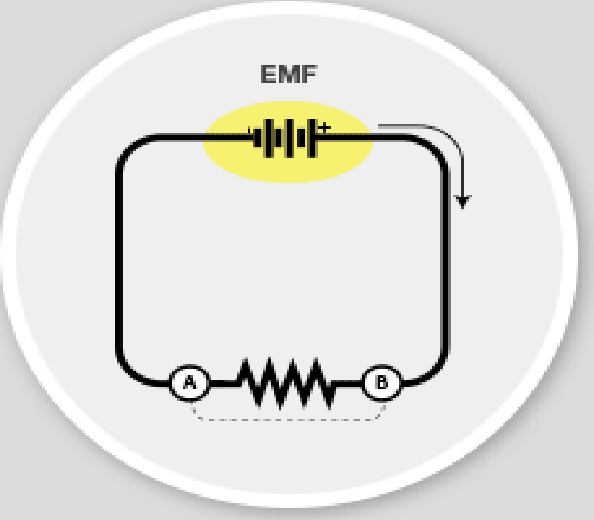


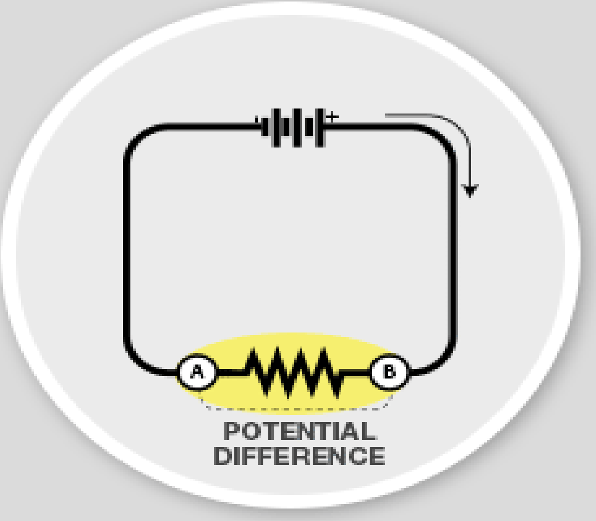
# DIFFERENET TERMS REGAEDING ELECTRIC CURRENT

- **POTENTIAL DIFFERENCE:-** voltage or potential difference between two points can be defined as follows:
- Work required to be done (or energy needed) to move unite positive charge from one point to another in the circuit is called voltage or the potential difference.
- **Voltage = work or energy/charge.**
- **Voltage = W/Q…..(2)**
- It is represented **by letter V and unit is volt.**



# DIFFERENCE BETWEEN EMF AND POTENTIAL DIFFERENCE




## EMF

THE ELECTROMOTIVE FORCE IS THE TYPE OF ENERGY WHICH FORCES A UNIT POSITIVE CHARGE TO MOVE FROM THE POSITIVE TO THE NEGATIVE TERMINAL OF THE SOURCE. IT SEPARATES THE TWO CHARGES FROM EACH OTHER.

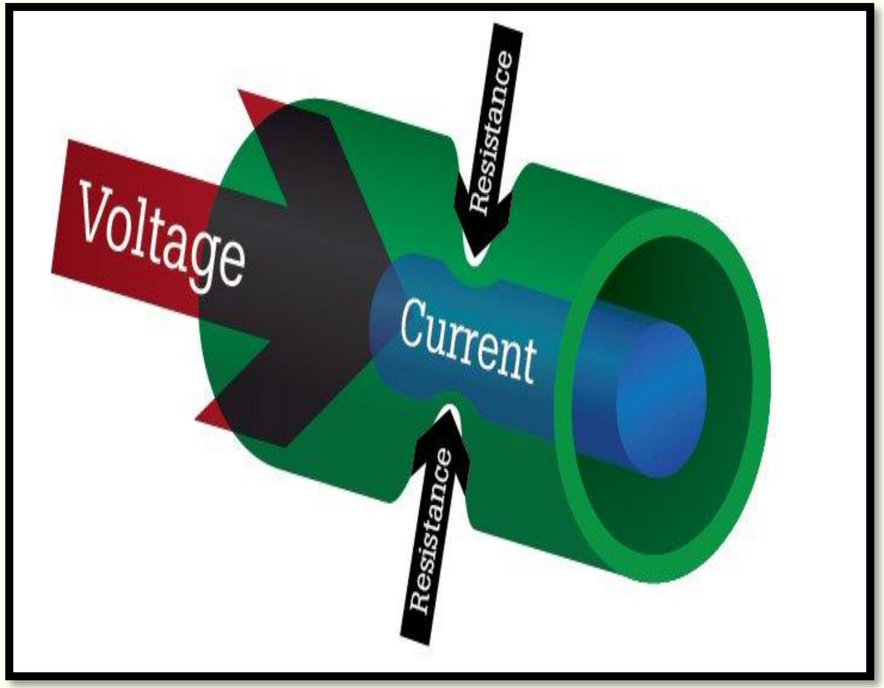
## VOLTAGE

VOLTAGE IS THE DIFFERENCE IN ELECTRIC POTENTIAL BETWEEN TWO POINTS. THE VOLTAGE BETWEEN TWO POINTS IS EQUAL TO THE WORK DONE PER UNIT OF CHARGE AGAINST A STATIC ELECTRIC FIELD TO MOVE A TEST CHARGE BETWEEN TWO POINTS.

SOURCE:- BYJU’S

# DIFFERENET TERMS REGAEDING ELECTRIC CURRENT

- **RESISTANCE:-** The property of material which oppose the flow of electrons is **known as resistance of the circuit.**
- It is denoted by **letter R.**
- It's unit is **ohm (Ω).**
- **R= V/I….(3).**
- Resistance id depends upon below mentioned factors .
  - **Length of material.**
  - **Cross sectional area.**
  - **Temperature.**
  - **Type of Material.**

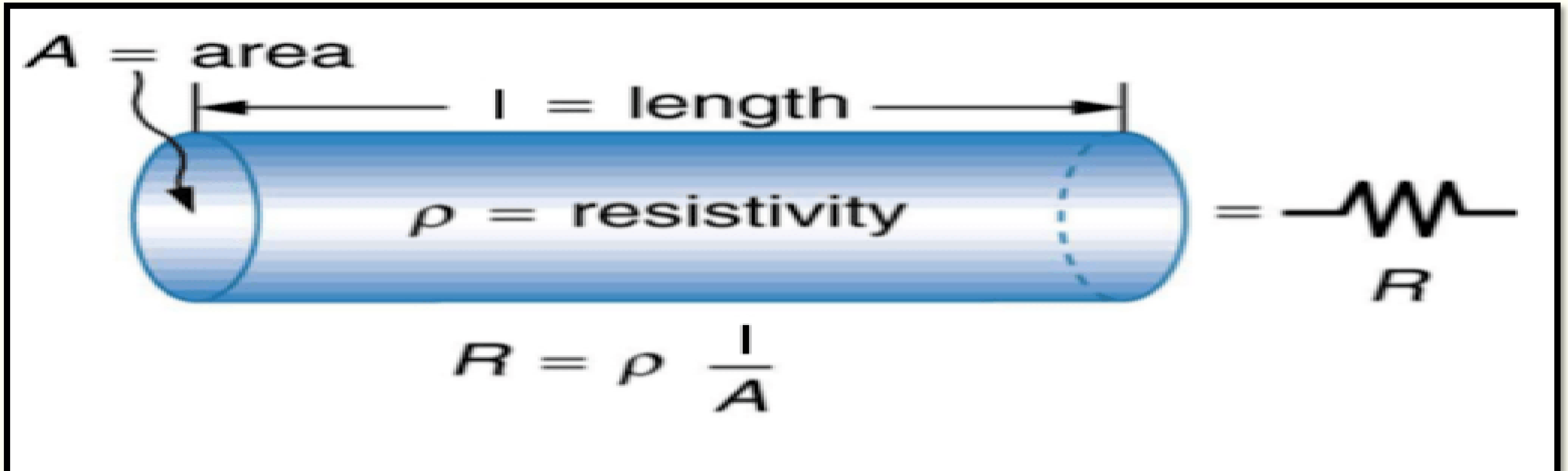
# FACTORS AFFECTING RESISTANCE

1. **Length of material :-** Resistance of material increases as length increases.

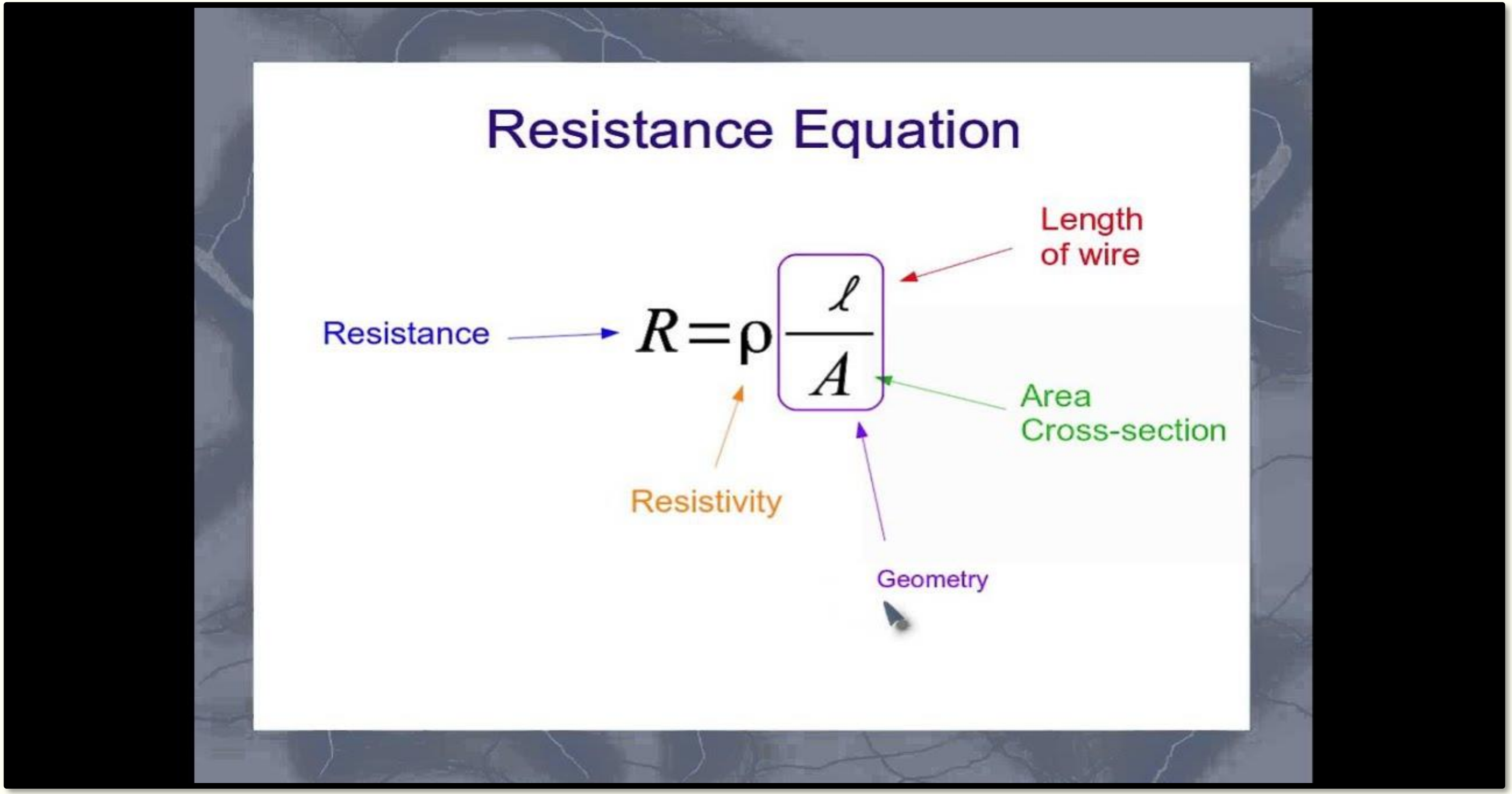
2. **Cross-sectional area :-** Resistance is inversely proportional to the cross-sectional area. When area increases resistance decreases and when area decreases, resistance increases.

3. **Temperature :-** As temperature increase resistance also increases.

4. **Material :-** Resistance varies according to the types of material **e.g. conductor, semi-conductor and insulator.**

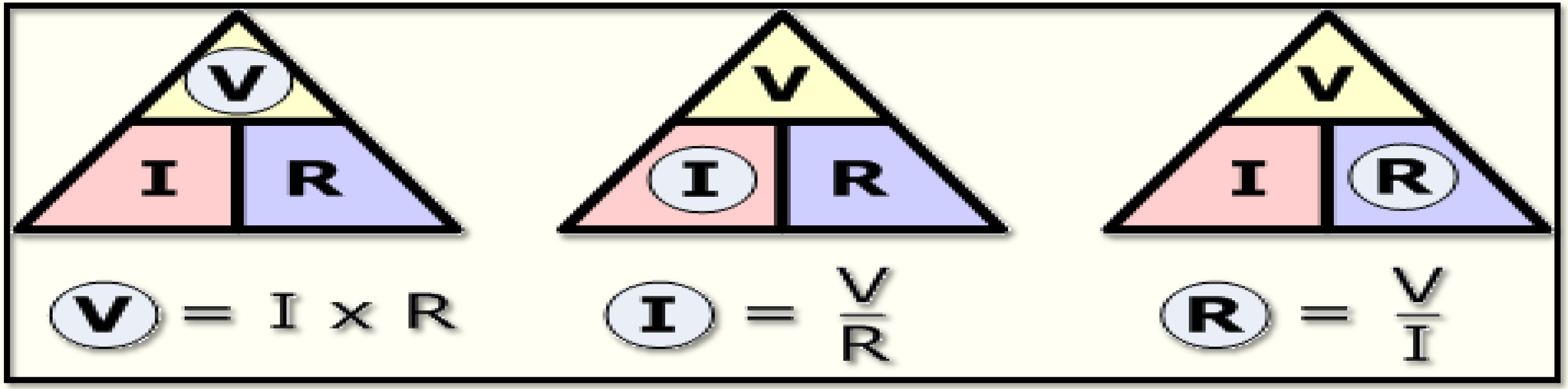


# FACTORS AFFECTING RESISTANCE

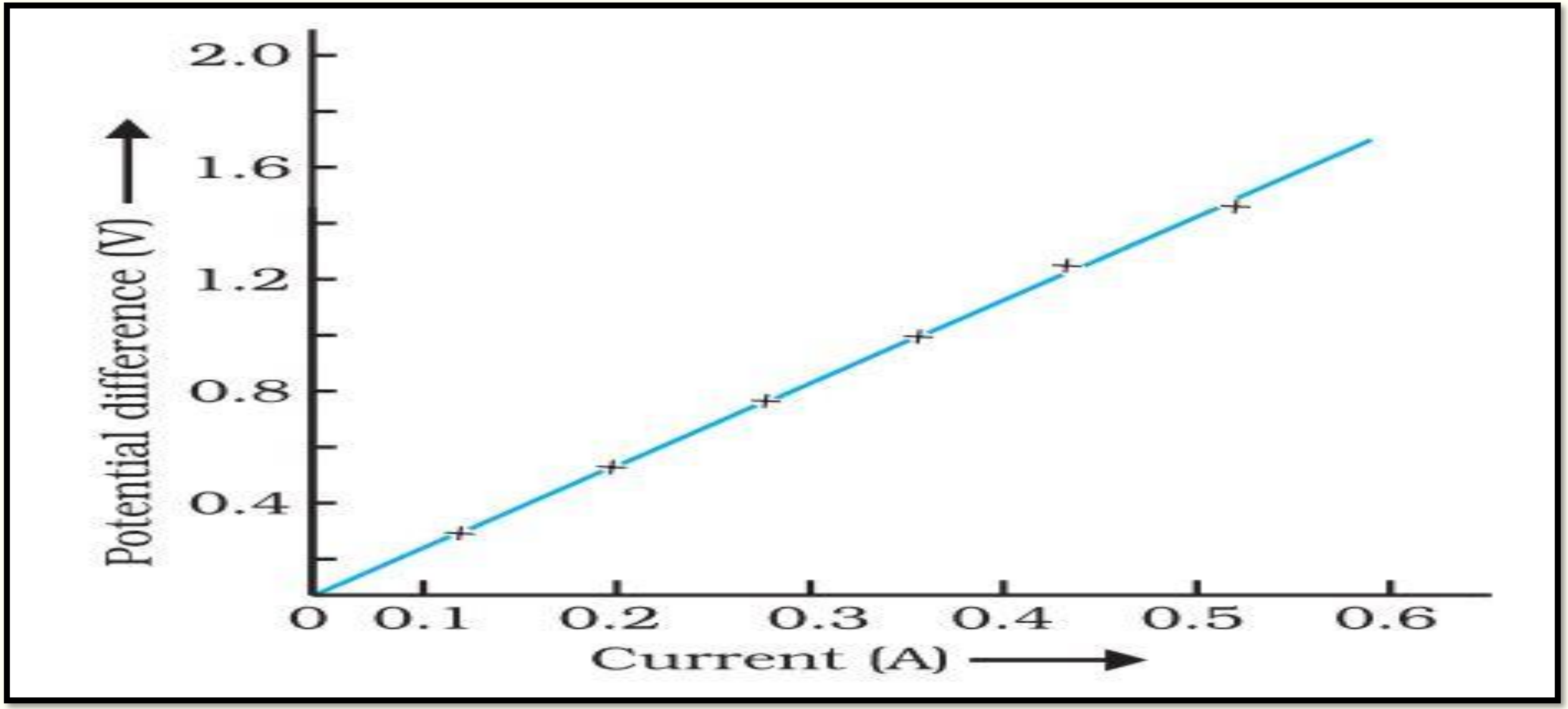


# OHM'S LAW

- **STATEMENT:-** when temperature remains constant, voltage v applied across the conductor and current i passing through it remains constant.
- So, ratio **V/I = constant.** (constant is replaced with resistance R)
- So, **V/I = R.** (where V = voltage , I = current and R= resistance).
- If in above equation if the value of voltage V= 1 Volt , current I = 1 Amp., the resistance R = 1ohm. So with the help of ohm's law we can find the value of current , voltage or resistance.



# OHM’S LAW



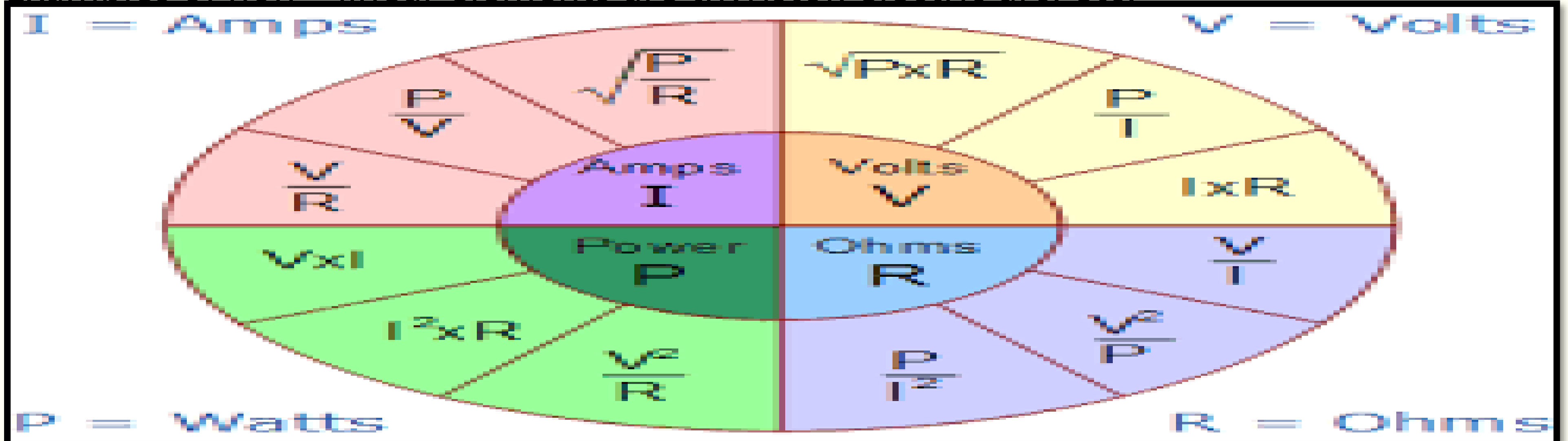

VARIATION OF VOLTAGE V WITH RESPECT TO CURRENT I

# OHM’S LAW

- **<u>LIMITATIONS OF OHM’S LAW</u>**

- This law cannot be applied to unilateral networks. A unilateral network has unilateral elements like diode, transistors etc., which do not have same voltage current relation for both directions of current.

- Ohm’s law is also not applicable for non – linear elements. Non-linear elements are those which do not have current exactly proportional to the applied voltage, that means the resistance value of those elements changes for different values of voltage and current. Examples of non – linear elements are thyristor, electric arc, etc.



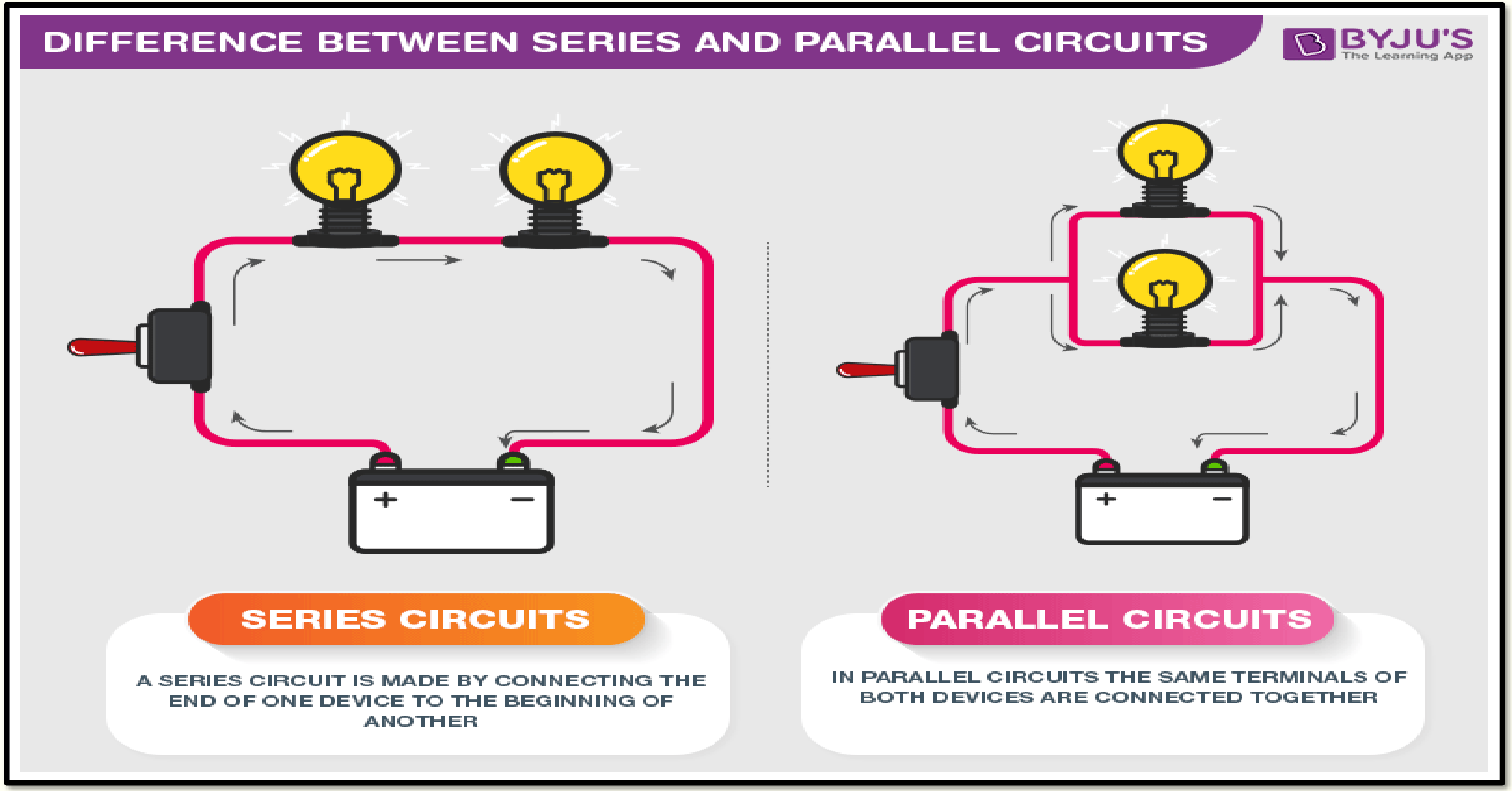
# WORK, POWER AND ENERGY

- **WORK:-** When force of 1 Newton moves the body through a distance of 1 meter in the direction of force, 1 joule work is done.
- **Work= force * distance.**
- 1 N * 1 m = 1 Nm = 1 Joule.
- Nm is a mechanical unit of work.
- **Electrical work = W = V I t joule.--------------------- (1)**
- If V= 1 volt , I = 1 ampere and t = 1 second then work is 1 joule.
- **POWER:-** rate of doing work is power.
- **Power = work / time.------------------------------------(2)**
- **Unit is watt.**

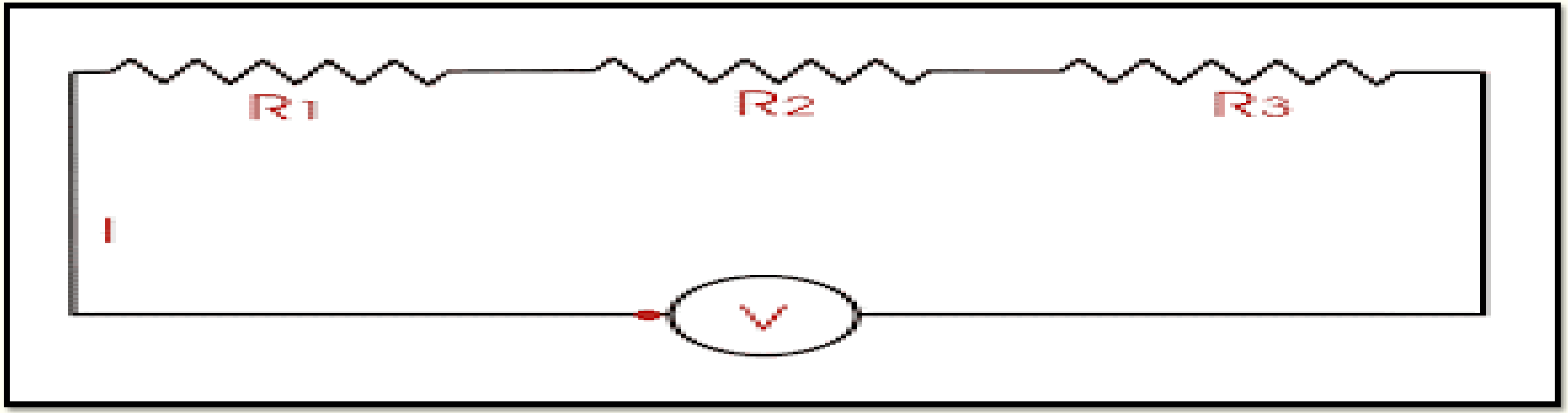
# WORK, POWER AND ENERGY

- **ENERGY:-**
- Energy = power * time.
- **Energy = p*t.---------------------------------(3)**
- **Unit is watt-second.**

# SERIES AND PARALLEL CONNECTION OF RESISTANCE

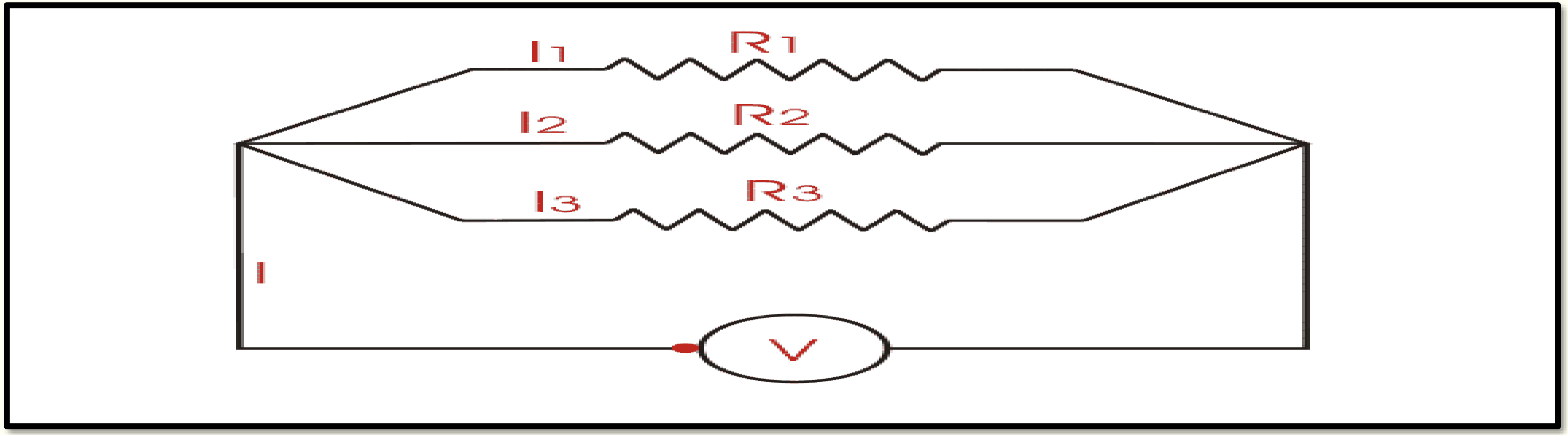


# RESISTANCE IN SERIES




- CURRENT **I = SAME**
- VOLTAGE V = DIVIDED BETWEEN RESISTORS
- SO, TOTAL VOLTAGE **V=V1+V2+V3…………………(1)**
- **According to ohm's law  V=IR.**
- **IR=IR1+IR2+IR3…………………………………………(2)**
- Take current I common From both side
- **R=R1+R2+R3………………………………………………(3)**

# RESISTANCE IN PARALLEL




- In Parallel connection voltage V is same throughout the circuit.
- Current I is divided between resistors.

**So in parallel connection,**

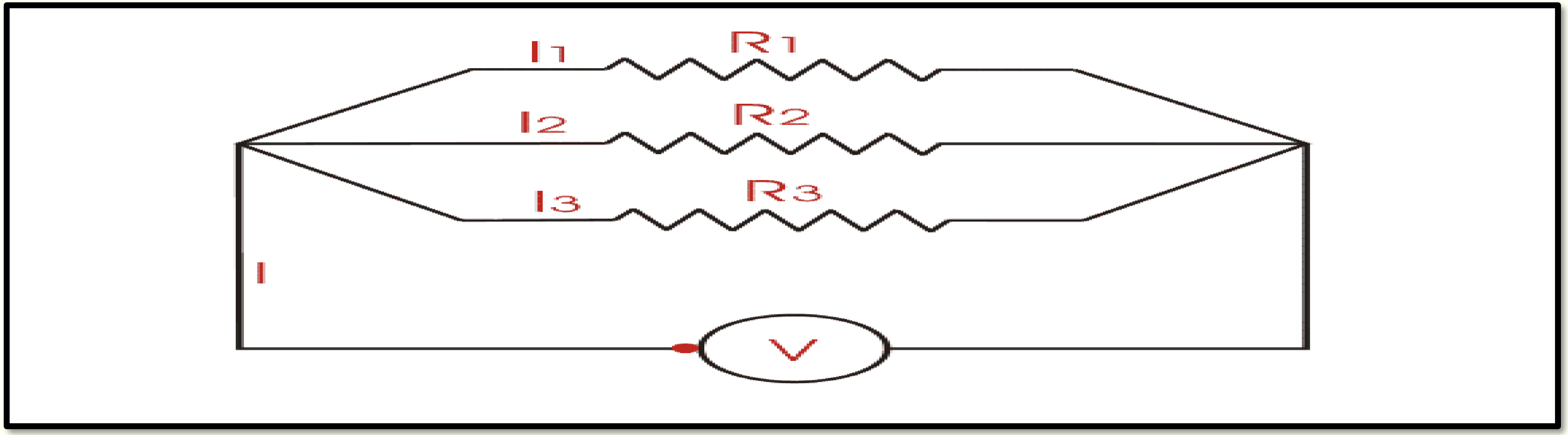
- **CURRENT I = DIVIDED**
- **AND VOLTAGE V = SAME IN THE CIRCUIT**

**SO , I=I1+I2+I3……………………………….(1)**

**According to ohm's law**

**I=V/R.**

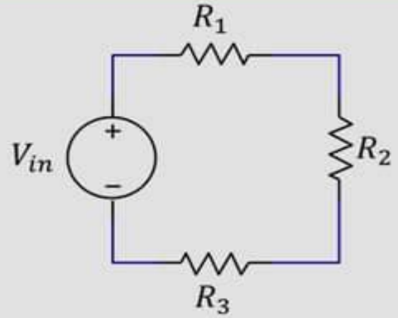
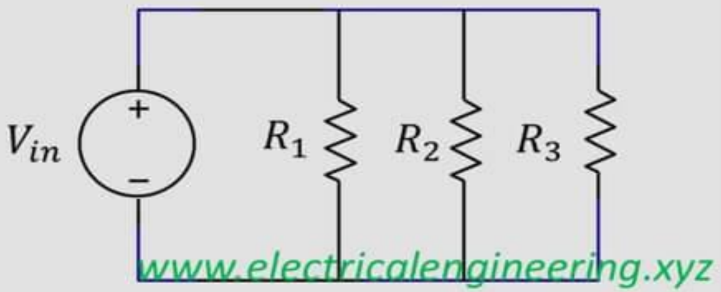
# RESISTANCE IN PARALLEL




- SO, V/R=V/R1+V/R2+V/R3 ……………………………………(2)
- Take voltage V common from both side we get,

- 1/R=1/R1+1/R2+1/R3 ………………………………………..(3)

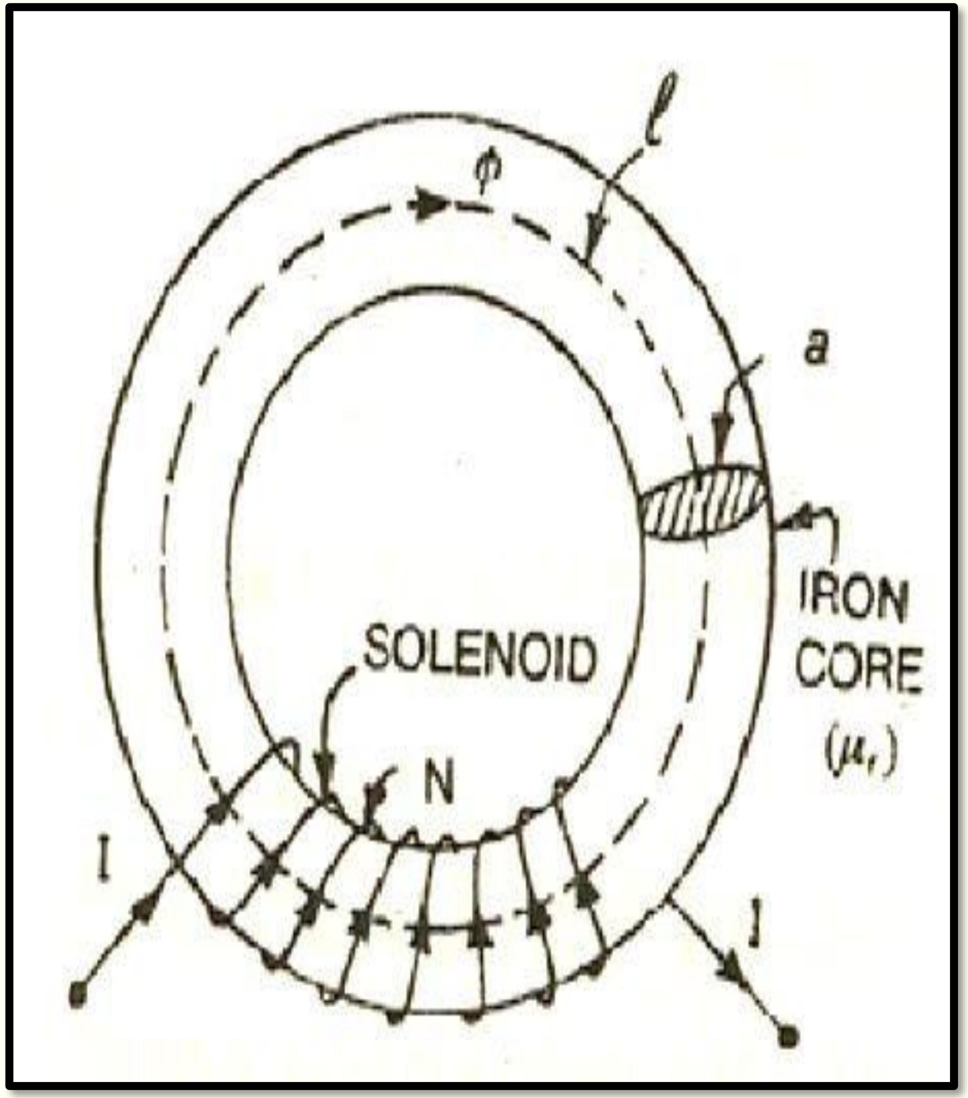
# COMPARISSION BETWWEEN SERIES AND PARALLEL CIRCUIT

| | Series | Parallel |
|---|---|---|
| How it looks |   |   |
| Voltage | $V_{in} = V_1 + V_2 + V_3$ | $V_{in} = V_1 = V_2 = V_3$ |
| Current | $I_{series} = I_1 = I_2 = I_3$ | $I_{in} = I_1 + I_2 + I_3$ |
| Resistance | $R_{eq} = R_1 + R_2 + R_3$ | $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ |
| Features | If one components burns current becomes inactive | If one component burns current stops only through that branch rest part works fine |

# TERMS RELATED TO MAGNETIC CIRCUIT

1. **Magnetic circuit:-** in fig an iron ring of **mean length l meter** and **cross sectional area of A meter square** is shown. The ring wound with a coil of **N number of turns.** The coil **carries current of I ampere**. **So magnetic flux** is produced in the ring.

2. **Magnetic flux (ϕ) :-** Magnetic Flux is defined as the number of magnetic field lines passing through a given closed surface. It gives the measurement of the total magnetic field that passes through a given surface area. Here, the area under consideration can be of any size and under any orientation with respect to the direction of the magnetic field.



# TERMS RELATED TO MAGNETIC CIRCUIT

3. **MMF (magneto motive force) :-** just as electromotive force (emf) is necessary to pass current in electric circuit. **Magneto motive force (mmf) is necessary to establish flux in the magnetic circuit. Magneto motive force is the multiplication of current flowing through the coil and the number of turns of the coil.**

   **mmf = I*N.**

   unit of magneto motive force is **ampere turn** and its symbol is **Fm.**

4. **Magnetic field strength or magnetic field intensity:-** it is the magneto motive force per meter length of the magnetic path. It is **denoted by letter H** and its unit is **ampere turn meter.**

   **H = mmf / length.**
   **H = IN / l.**

   **l** is the length of the magnetic flux path.

# TERMS RELATED TO MAGNETIC CIRCUIT

5. **Reluctance:-** **it is the property of the material to oppose the establishment of magnetic flux through it.** It is similar to resistance in electric circuit. Just as **R= E/I,** we have,

   **Reluctance = mmf / flux.**

   **S = IN / Φ.**

   its unit is **AT / Wb.**

6. **Permeability:- The property of material to allow the magnetic flux to be produced through it is called permeability.**
   permeability of air or vacuum is taken as reference or base. it is **denoted by μ0** its value is **4π × 10-7**.

   permeability of any material is **denoted by μ**. It is called the **absolute permeability**.
   When the permeability of material is compared with that of the air or vacuum it is called **the relative permeability and it is denoted by μr.**

# TERMS RELATED TO MAGNETIC CIRCUIT

7. **Relative Permeability:-** **when the permeability of material is compared with that of air or vacuum it is called the relative permeability and it is denoted by letter μr.**

   **Relative permeability = absolute permeability / permeability of air or vacuum.**

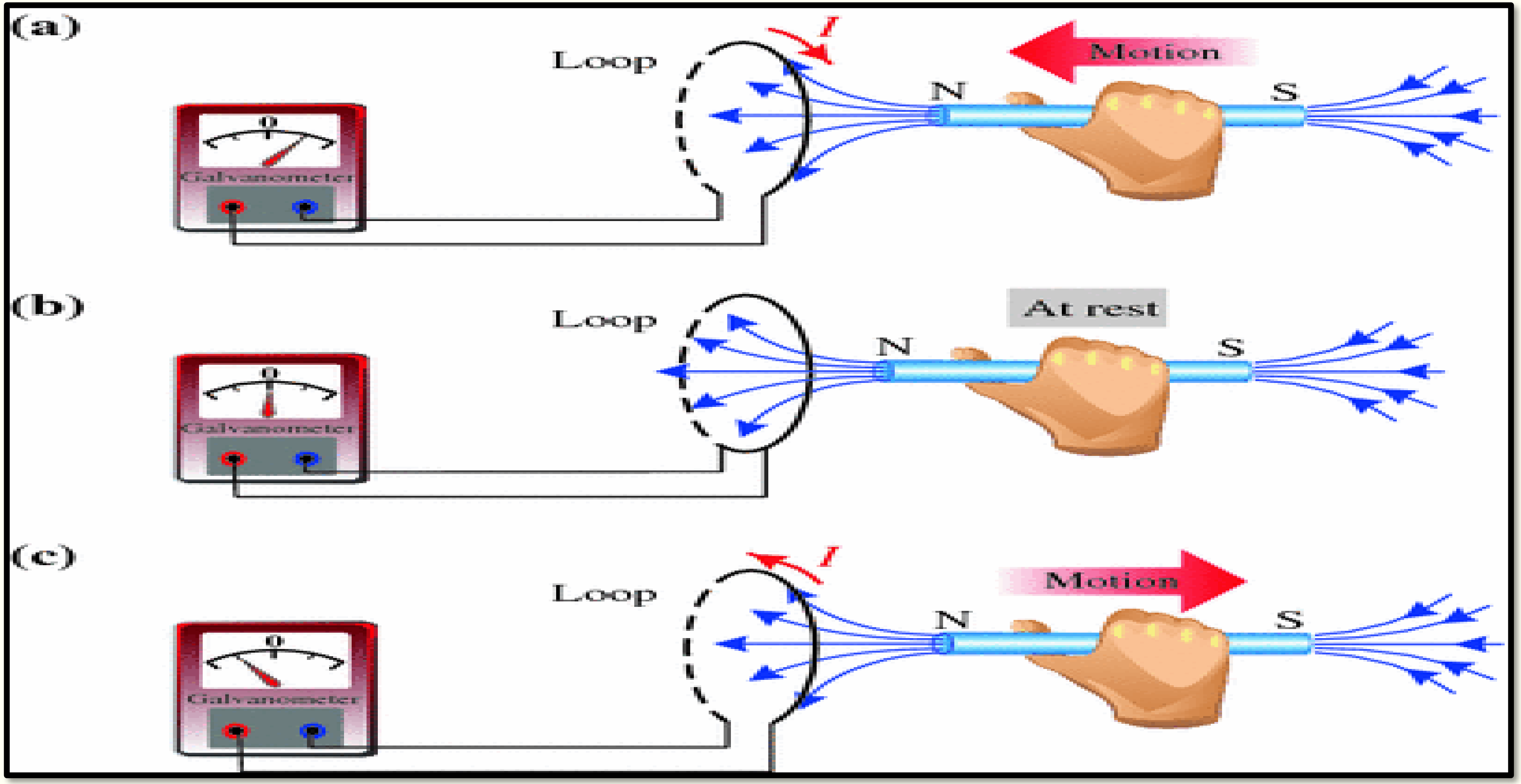
   $$\mu_r = \mu / \mu_o.$$
   $$\mu = \mu_r * \mu_o.$$

8. **Permeance :- it is inverse of reluctance.**
   Permeance = 1 / Reluctance.

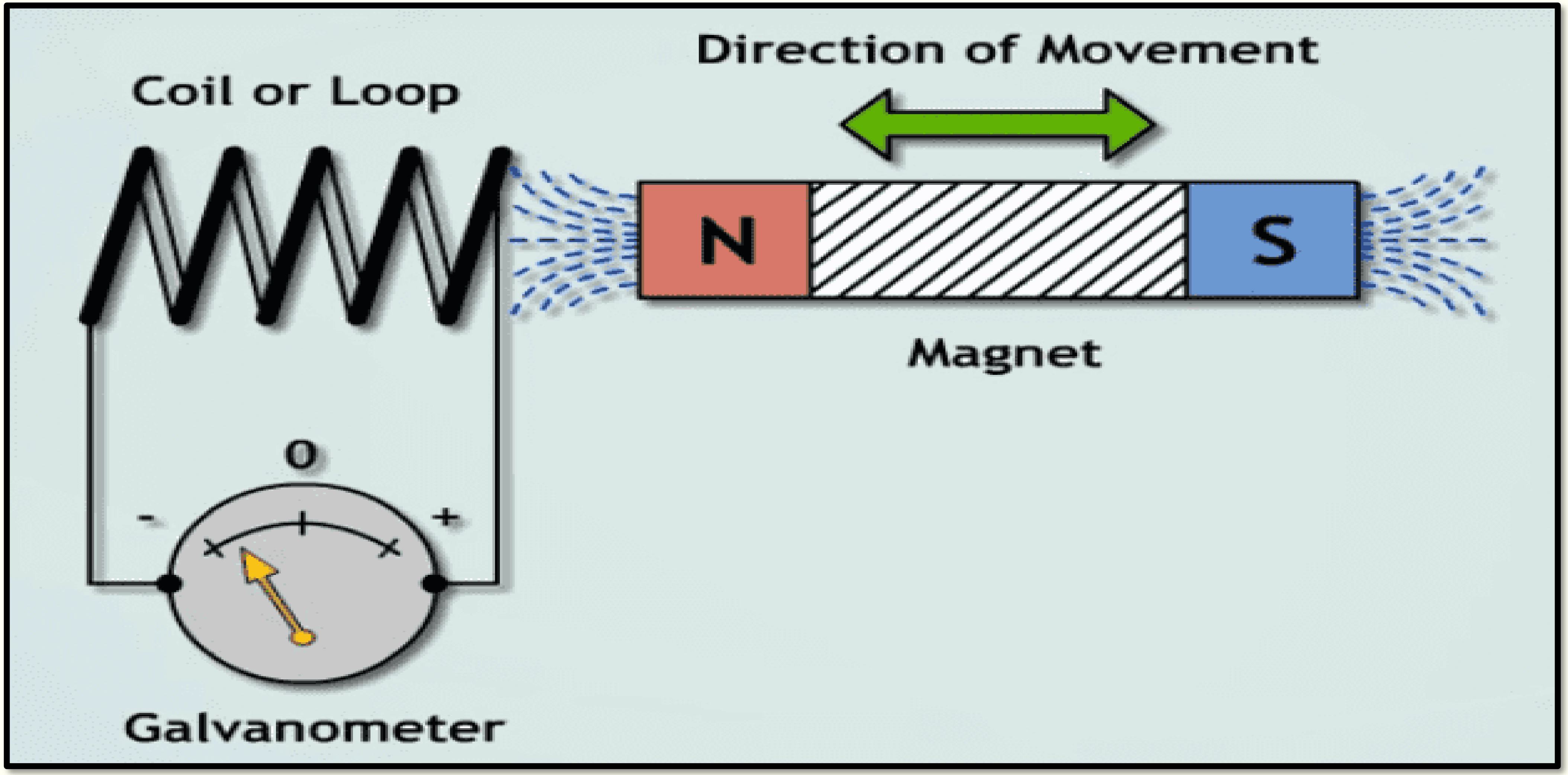
   it is **denoted by Δ.**

   $$\Delta = 1 / S.$$

# FARDAY’S LAW OF ELECTROMAGNETIC INDUCTION



# CONTI…



Direction of Movement
Coil or Loop
N
S
Magnet
0
-
+
Galvanometer

# CONTI…

**<u>1ST LAW:-</u>** whenever a current carrying conductor cuts the magnetic field emf Is induced in the conductor.

**<u>2$^{ND}$ LAW:-</u>** e.m.f induced = rate of change of flux.

- Primary flux linkage = $N\phi 1$
- Secondary flux linkage= $N\phi 2$
- E.m.f induced = $N\phi 2 - N\phi 1 / t$ (time)

  = $N(\phi 2 - \phi 1) / t$ (time)

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