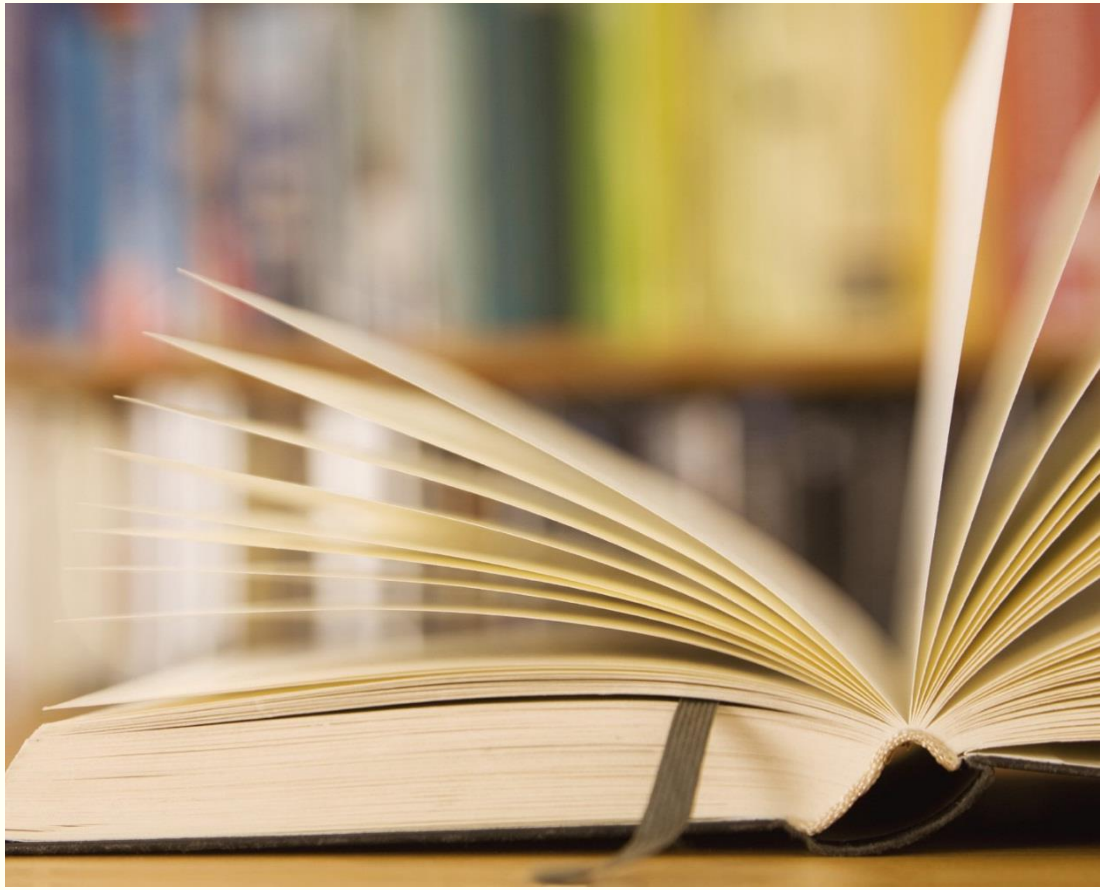
CHAPTER-4
ELECTRIC CIRCUIT



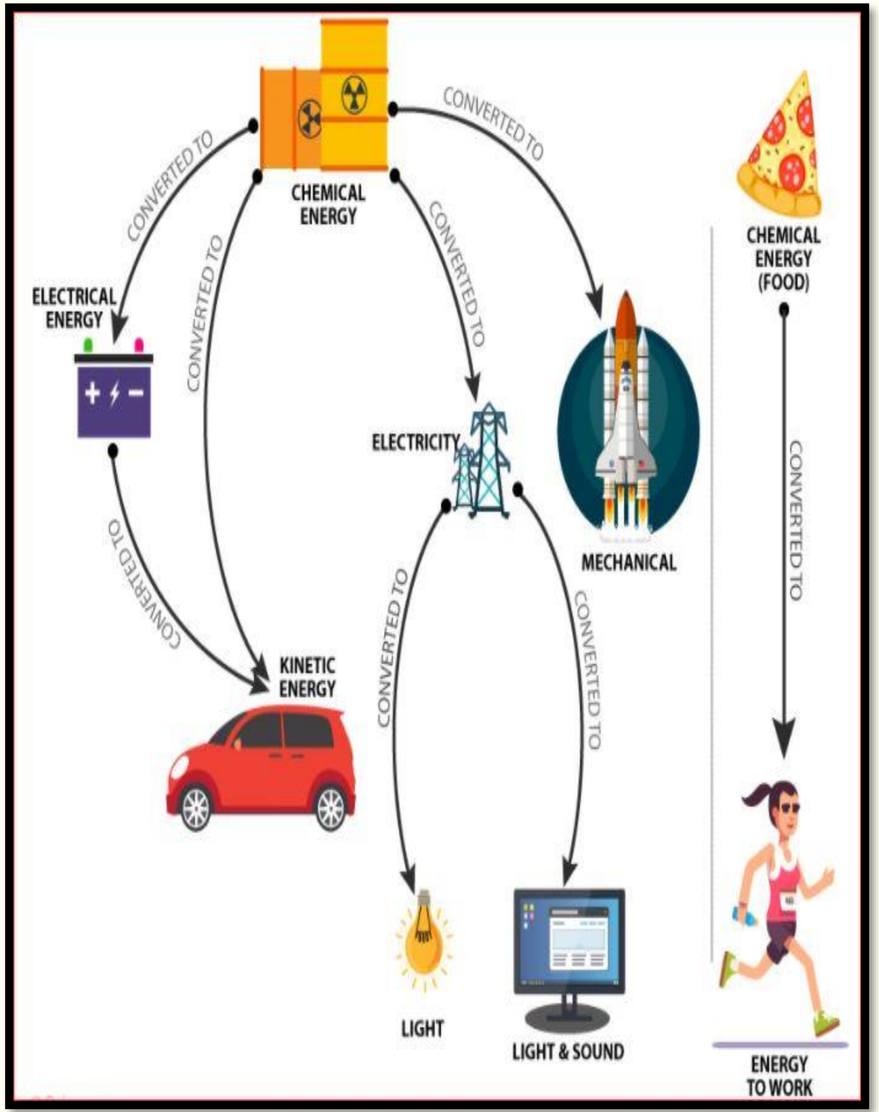
PREPARED BY:- PURVESH A VALAND

LAW OF ENERGY CONVERSION & GENERATION OF ELECTRICAL ENERGY

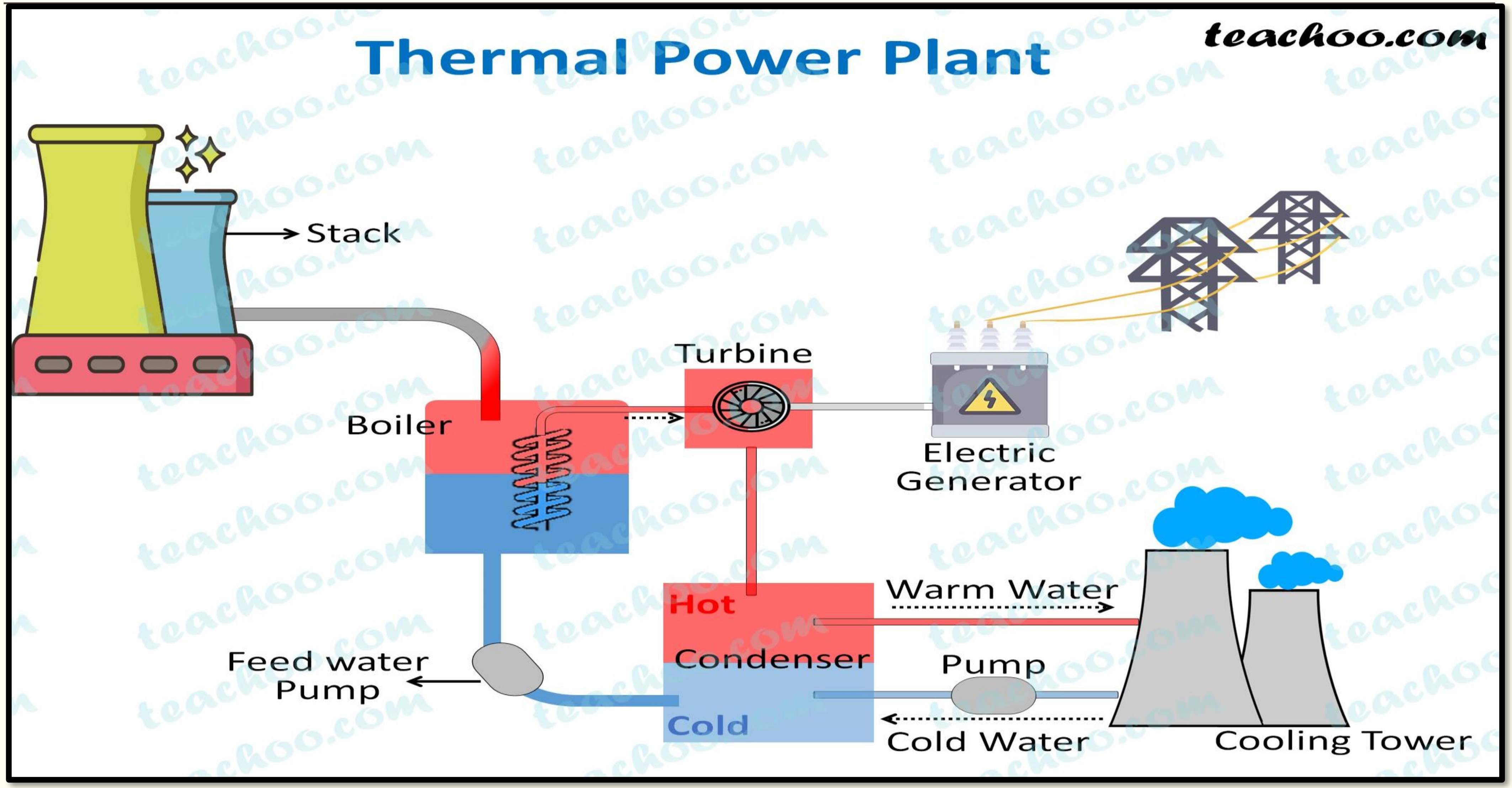
- The law of conservation of energy states that ***energy can neither be created nor be destroyed. Although, it may be transformed from one form to another.***

- 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



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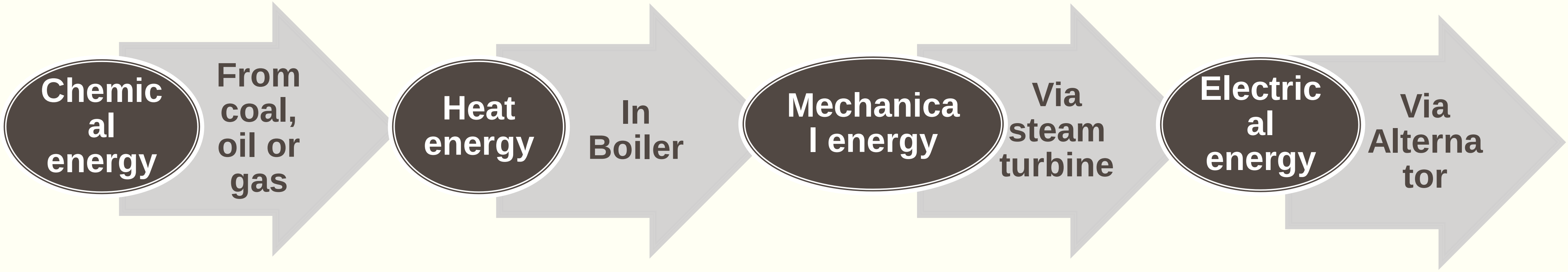
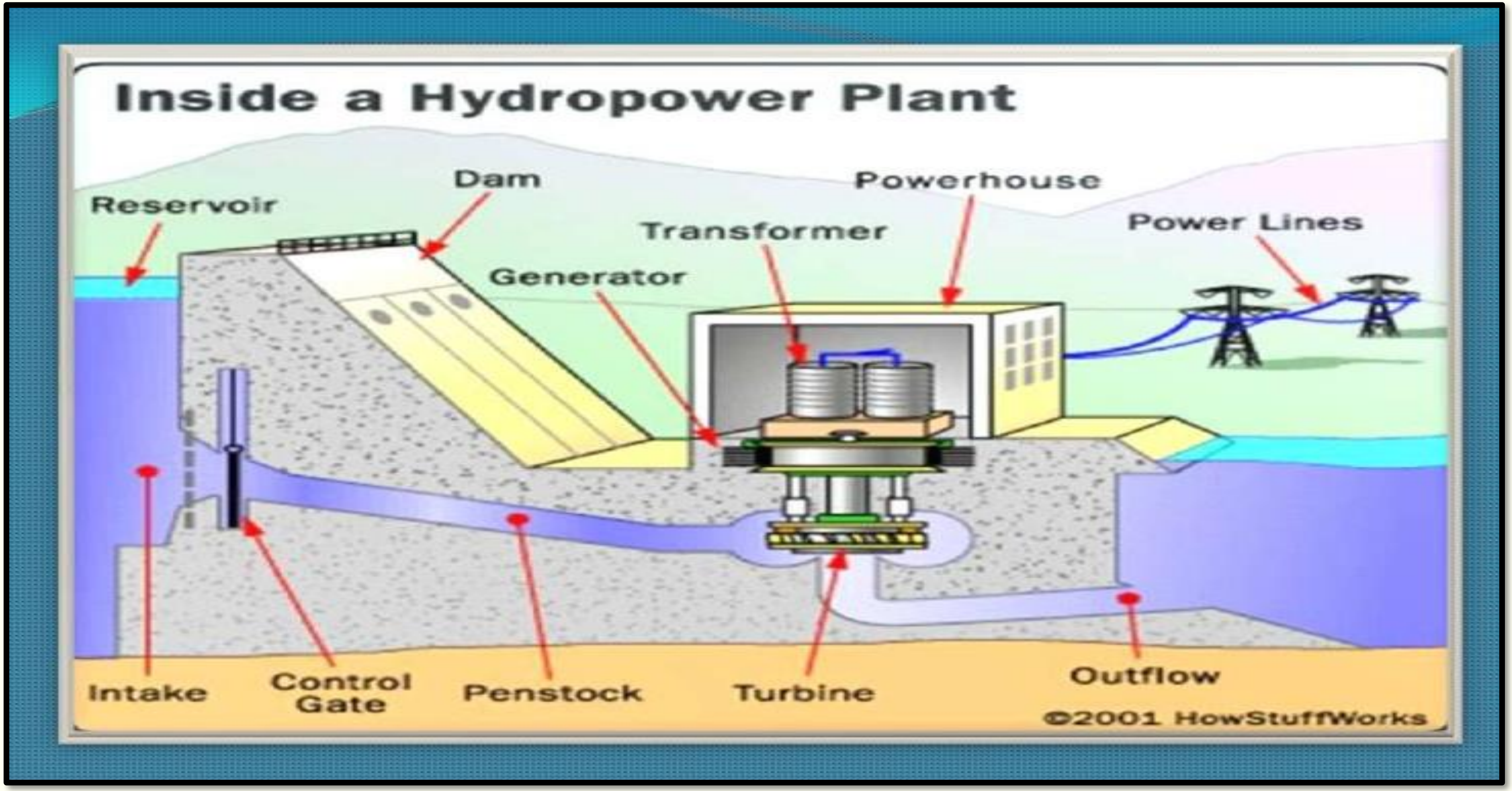
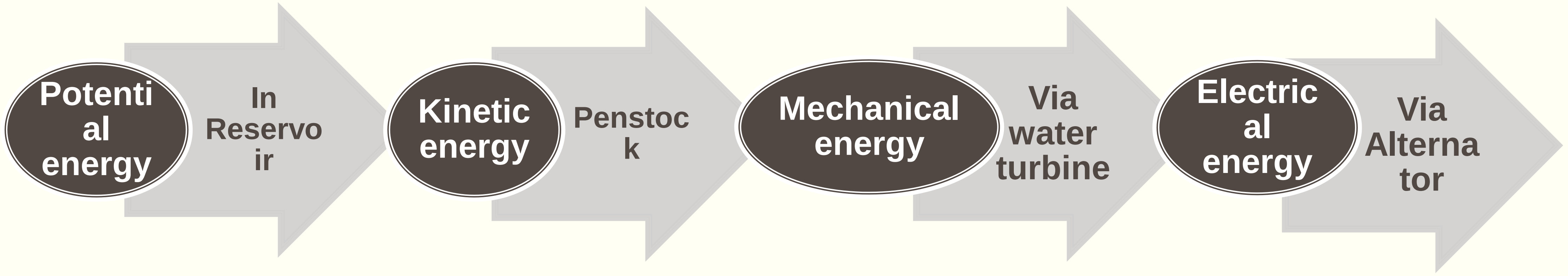


Energy Conversion in Thermal Power Station

LAW OF ENERGY CONVERSION & GENERATION OF ELECTRICAL ENERGY



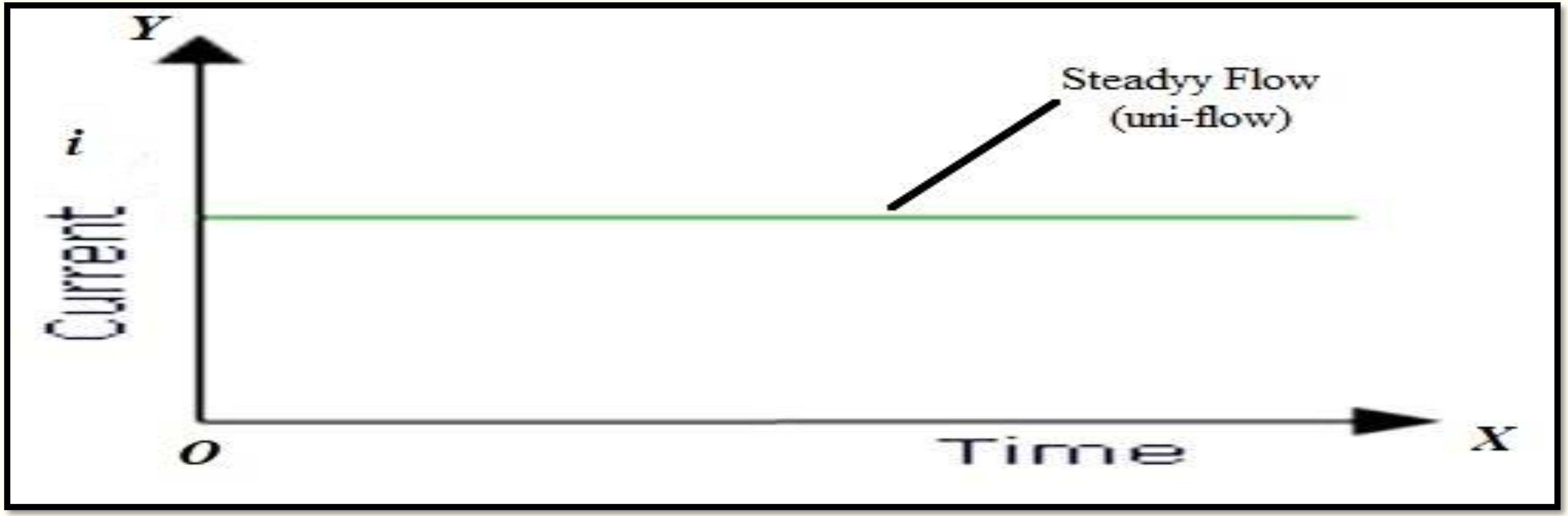
LAW OF ENERGY CONVERSION & GENERATION OF ELECTRICAL ENERGY



Energy Conversion in Hydro Power Station

DIRECT CURRENT AND ALTERNATING CURRENT

- **DIRECT CURRENT:-** 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.

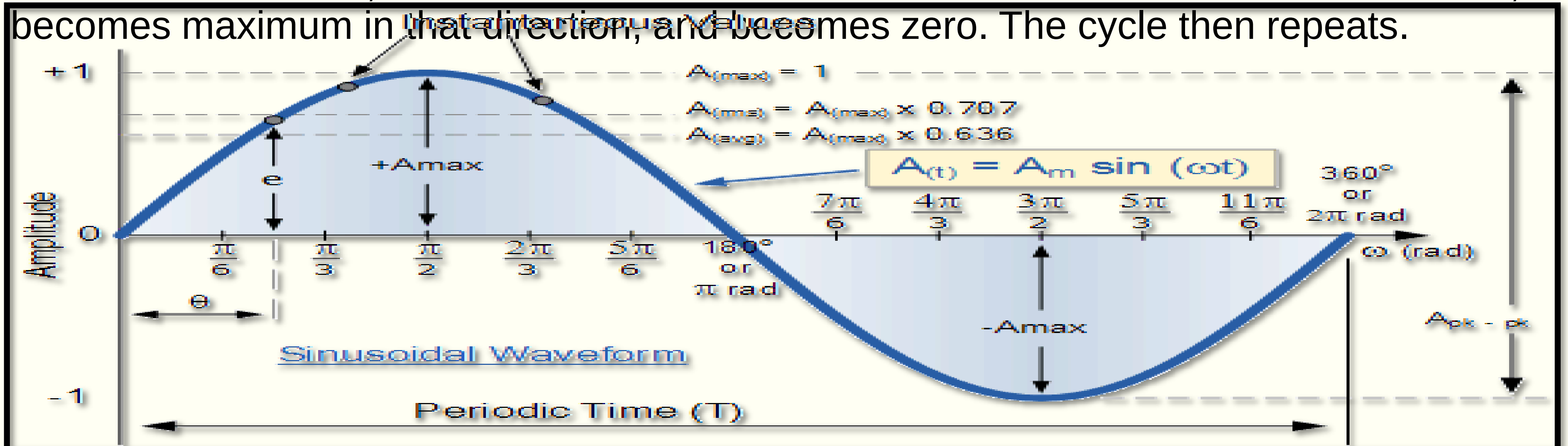


DIRECT CURRENT AND ALTERNATING CURRENT

- **ALTERNATING CURRENT:-** **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.



COMPARISSION BETWEEN A.C & D.C

Comparison Basis	AC	DC
Energy Transmission Capacity	Travels over long distance with minimal Energy loss	Large amount of energy is lost when sent over long distances
Generation Basics	Rotating a Magnet along a wire.	Steady Magnetism along a wire
Frequency	Usually 50Hz or 60Hz depending on Country	Frequency is Zero
Direction	Reverses direction periodically when flowing through a circuit	It steady constant flow in one direction.
Current	Its Magnitude Vary with time	Constant Magnitude
Source	All forms of AC Generators and Mains	Cells, batteries, Conversion from AC
Passive Parameters	Impedance (RC, RLC, etc)	Resistance Only
Power Factor	Lies between 0&1	Always 1
Waveform	Sinusoidal, Trapezoidal, Triangular and Square	Straight line, sometimes Pulsating.

WHAT ARE THE DIFFERENCE BETWEEN SINGLE PHASE POWER AND THREE PHASE POWER

- In a single-phase connection, the flow of electricity is **through a single conductor**. A three-phase connection, on the other hand, consists of **three separate conductors that are needed for transmitting electricity.**

- In a single-phase power supply system, the **voltage may reach up to 230 Volts.** But on a three-phase connection, it can carry a **voltage of up to 415 Volts.**

- For smooth flow of electricity on a single-phase connection, it requires two separate wires. **One represents the neutral wire and another one represents a single phase.** These are required to complete the circuit. In a three-phase connection, the system requires **one neutral wire and three-phase wires to complete the circuit.**

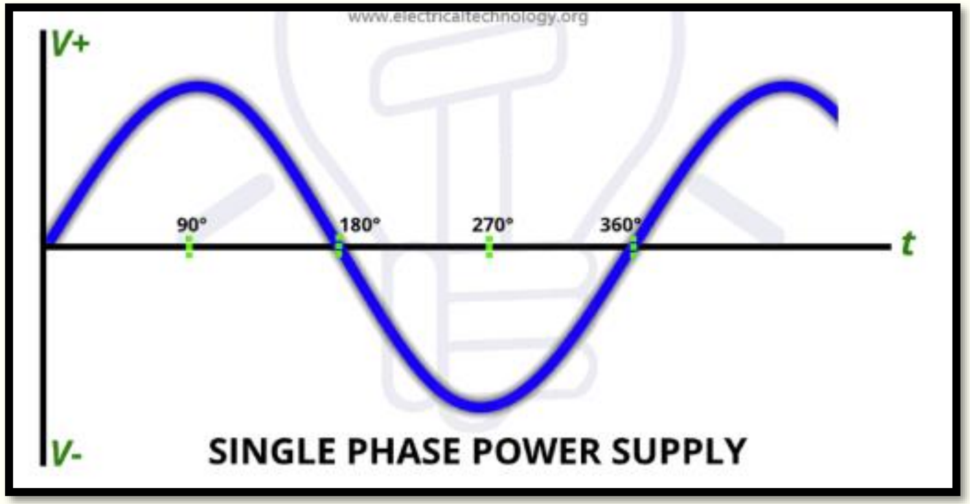
- **Maximum power gets transmitted on a three-phase connection compared to a single phase power supply.**

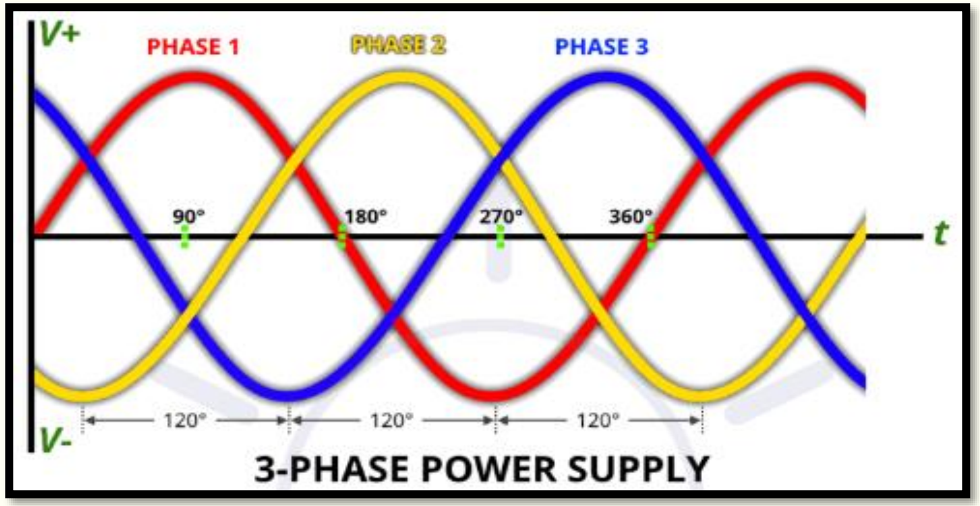
- A single-phase connection consists of two wires that make a simple network. But the network is complicated on a three-phase connection because there are four different wires.

WHAT ARE THE DIFFERENCE BETWEEN SINGLE PHASE POWER AND THREE PHASE POWER

- Because a **single-phase connection has one phase wire, if anything happens to the network, the complete power supply gets interrupted.** However, in a three-phase power supply, if anything happens to a single phase the other phases still work. As such, there is no power interruption.

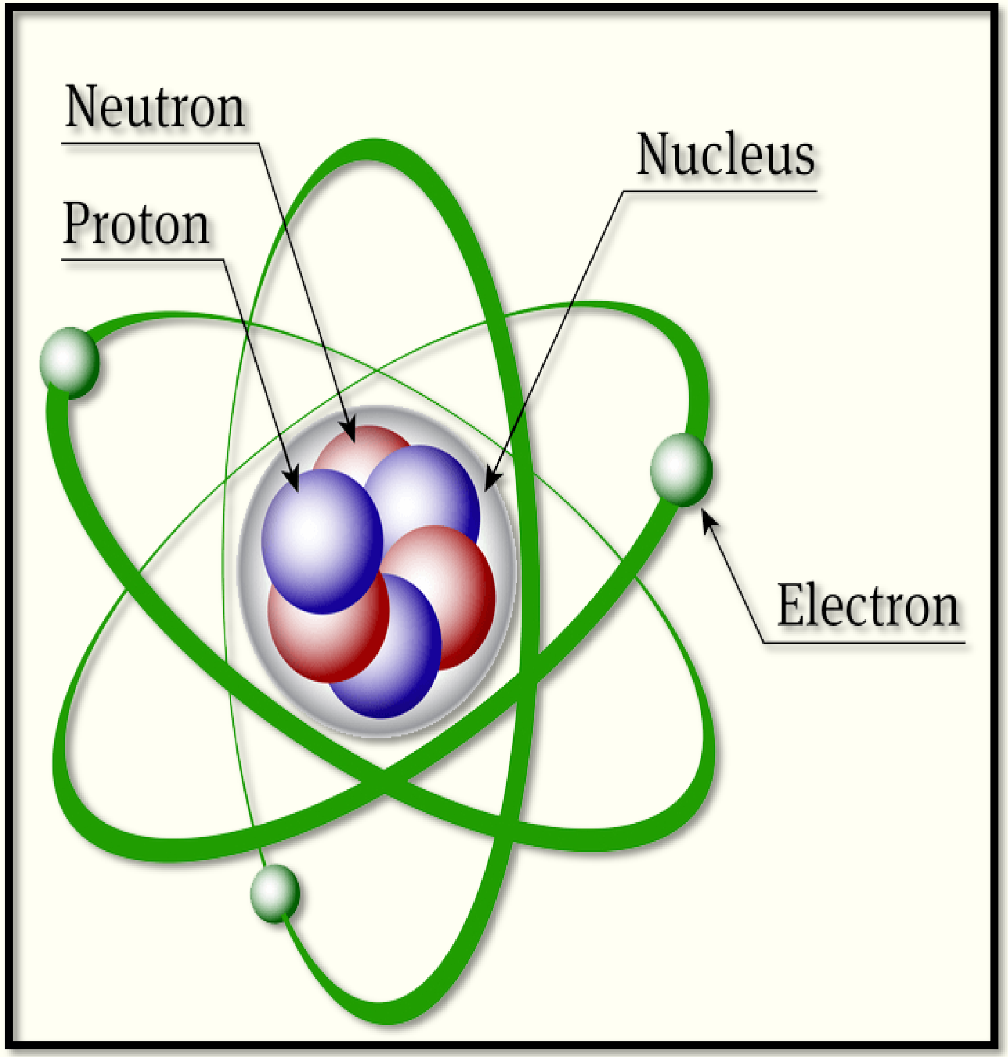
- Regarding efficiency, a single-phase connection is less compared to a three-phase connection. This is because a three-phase supply needs less conductor compared to a single-phase power supply for the same circuit.





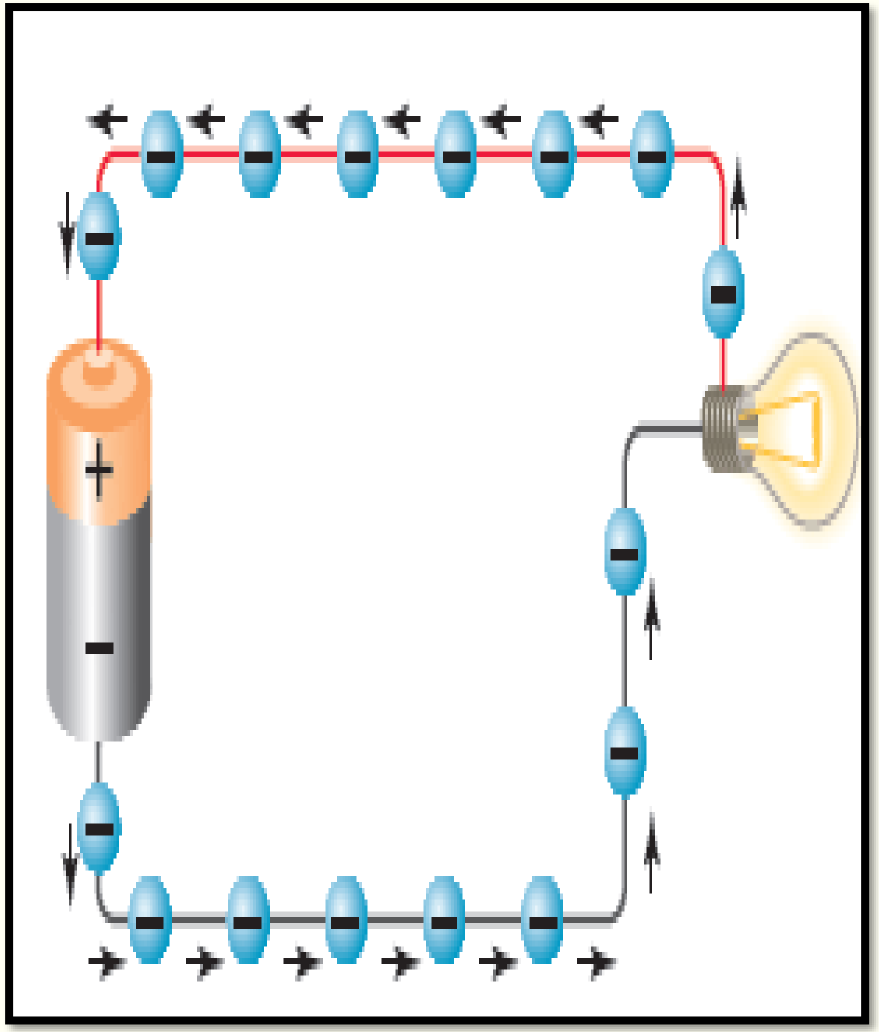
DIFFERENET TERMS REGAEDING ELECTRIC CURRENT

- **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**



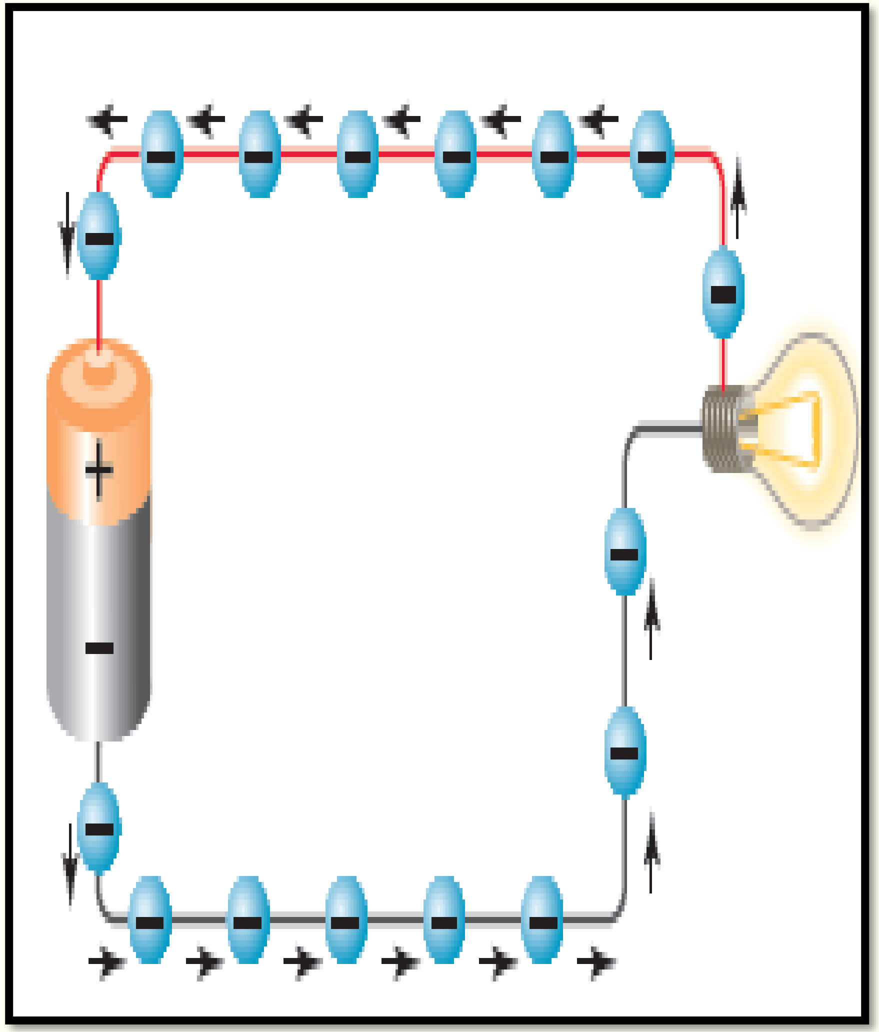
DIFFERENET TERMS REGAEDING ELECTRIC CURRENT

- **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**.

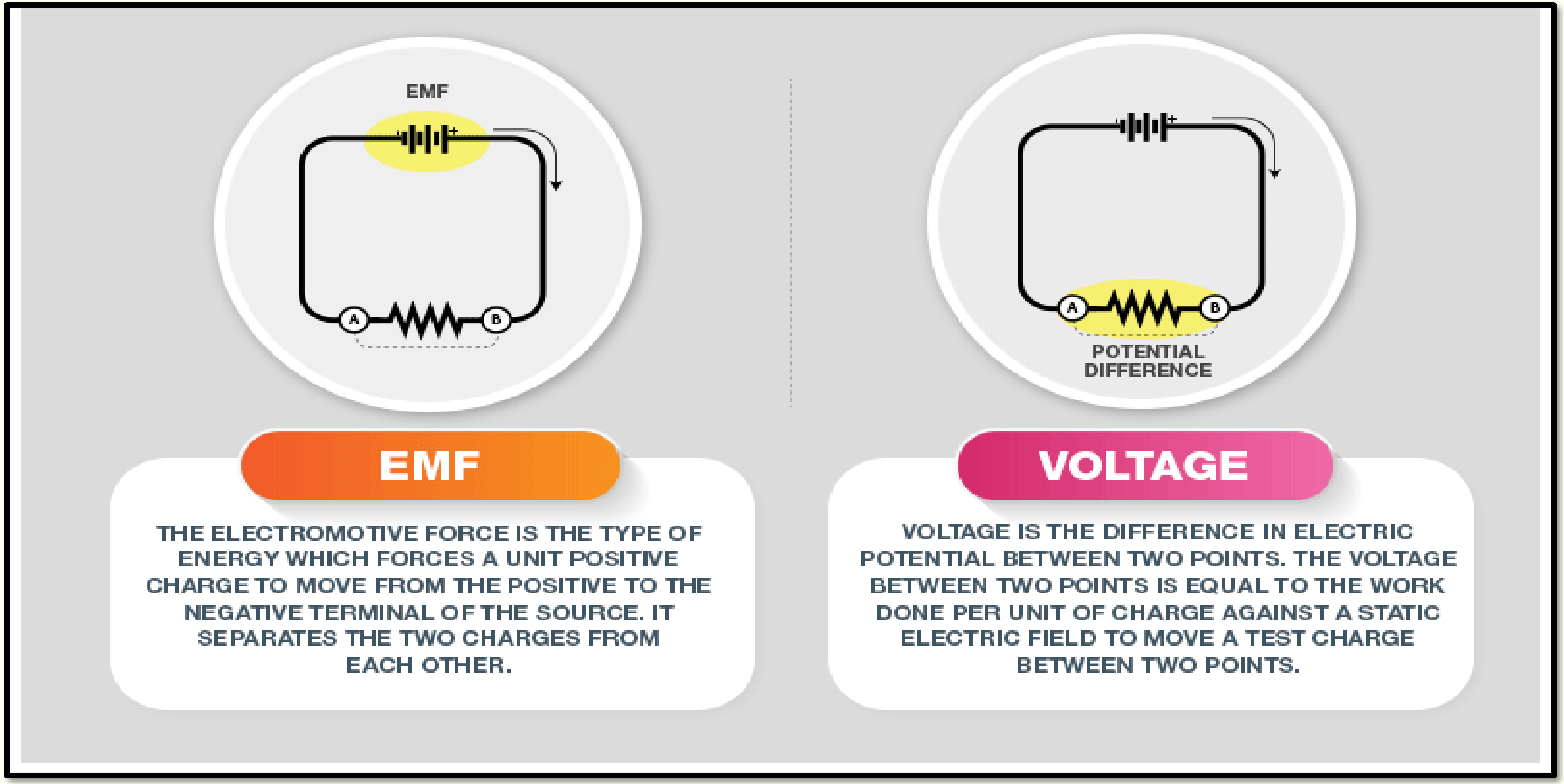


DIFFERENET TERMS REGAEDING ELECTRIC CURRENT

- **<u>POTENTIAL DIFFERENCE:-</u>** 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.**



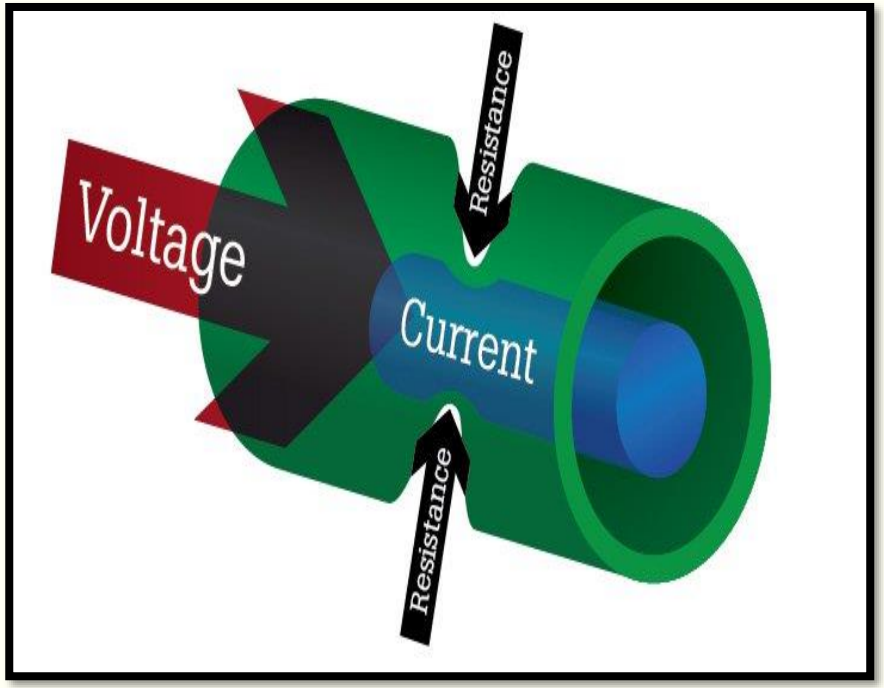
DIFFERENCE BETWEEN EMF AND POTENTIAL DIFFERENCE



SOURCE:- BYJU'S

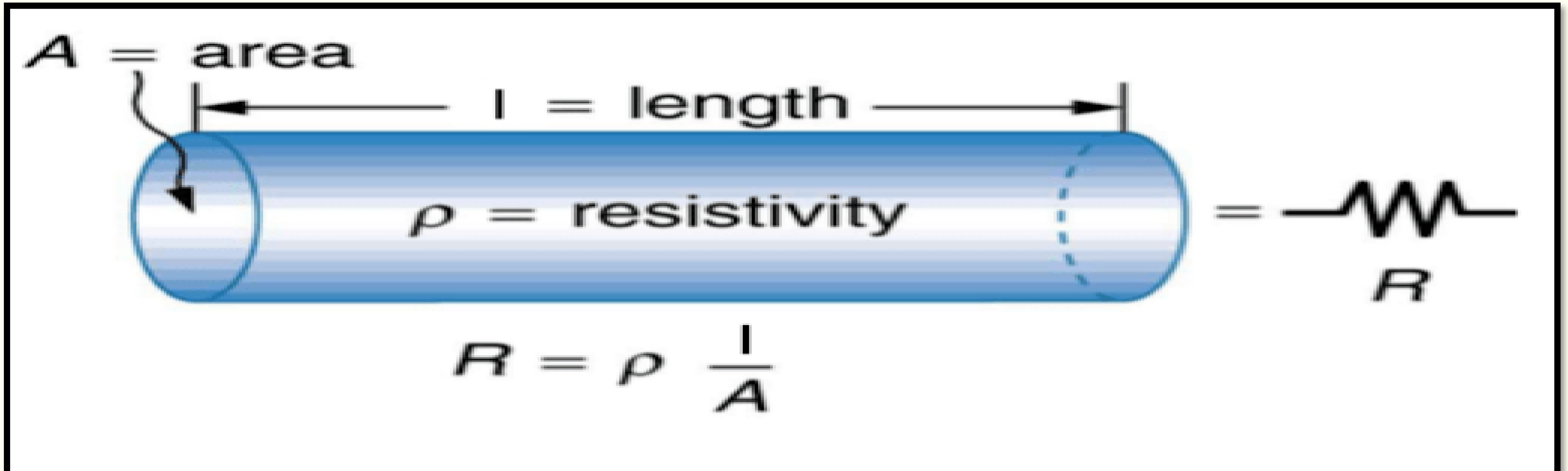
DIFFERENET TERMS REGAEDING ELECTRIC CURRENT

- **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.**

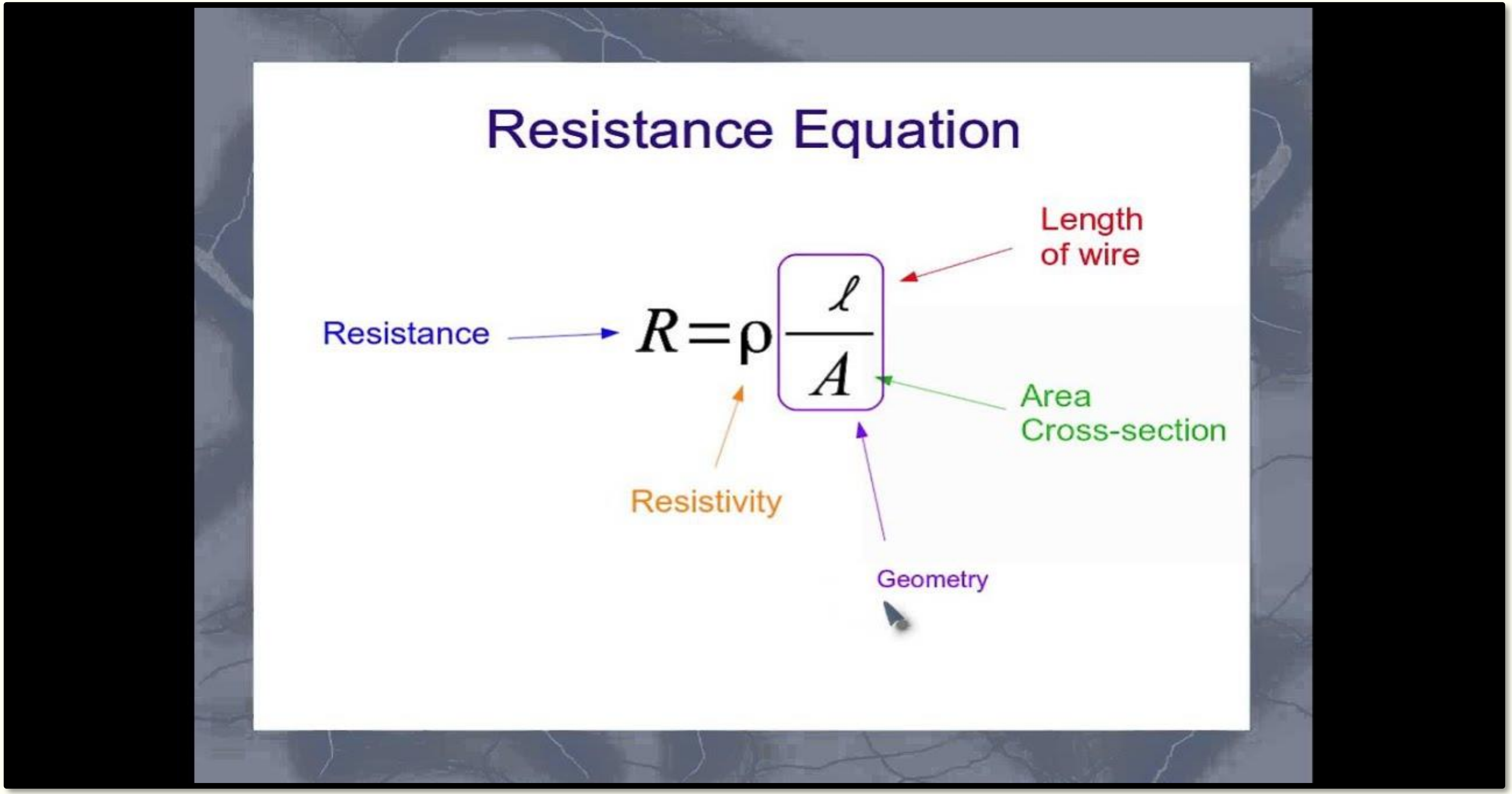


FACTORS AFFECTING RESISTANCE

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,**



FACTORS AFFECTING RESISTANCE



CONECPT OF INDUCTOR AND CAPACITOR

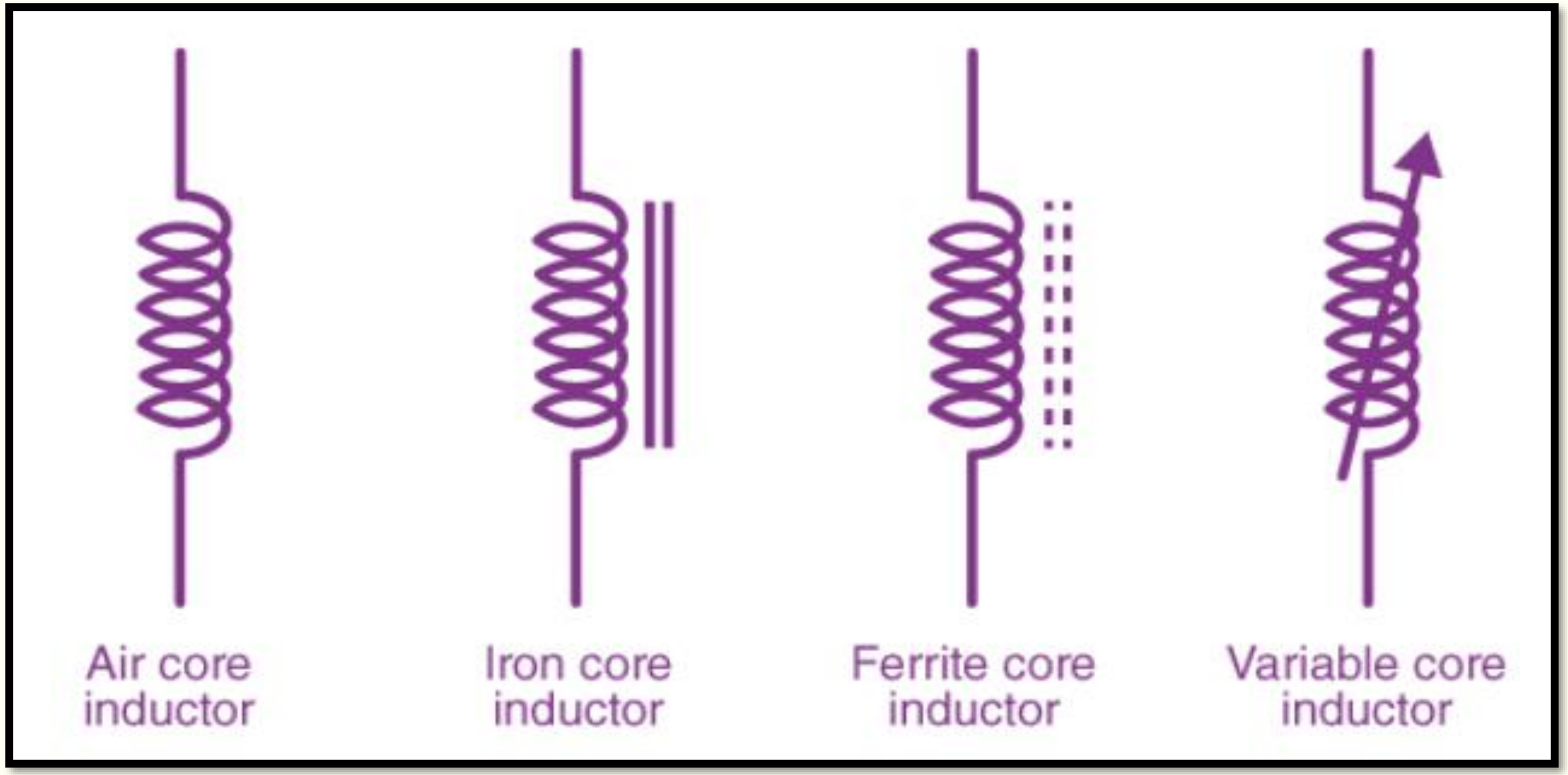
- **INDUCTOR (L):-** Inductors much like conductors and resistors are simple components that are used in electronic devices to carry out specific functions. **Normally, inductors are coil-like structures that are found in electronic circuits. The coil is an insulated wire that is looped around the central core.**

- **Inductors are mostly used to decrease or control the electric spikes by storing energy temporarily in an electromagnetic field and then releasing it back into the circuit.**

- An inductor is a **passive component that is used in most power electronic circuits to store energy in the form of magnetic energy when electricity is applied to it.** One of the key properties of an **inductor is that it impedes or opposes any change in the amount of current flowing through it.** Whenever the current across the inductor changes it either acquires charge or loses the charge in order to equalize the current passing through it. The **inductor is also called a choke, reactor or just coil.**

- **The S.I. unit of inductance is henry (H) and when we measure magnetic circuits it is equivalent to weber/ampere. It is denoted by the symbol L.**

CONECPT OF INDUCTOR AND CAPACITOR



DIFFERENT TYPES OF INDUCTOR

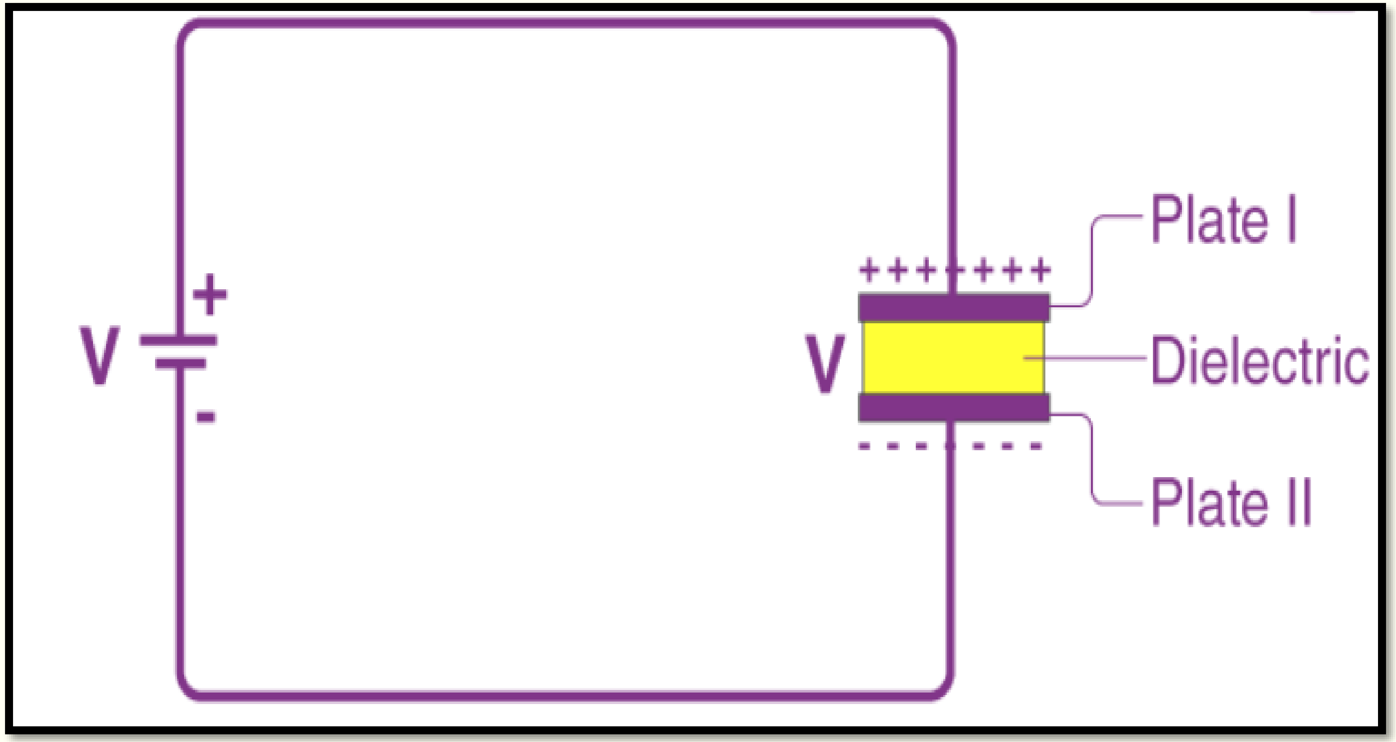
CONECPT OF INDUCTOR AND CAPACITOR

- **CAPACITOR:-** A capacitor is a little like a battery but they work in completely different ways. A battery is an electronic device that converts chemical energy into electrical energy whereas a **capacitor is an electronic component that stores electrostatic energy in an electric field.**

- **capacitor is a two-terminal electrical device that possesses the ability to store energy in the form of an electric charge.** It consists of two electrical conductors that are separated by a distance. The **space between the conductors may be filled by vacuum or with an insulating material known as a dielectric.** The **ability of the capacitor to store charges is known as capacitance.**

- Capacitors store energy by holding apart pairs of opposite charges. The **simplest design for a capacitor is a parallel plate**, which consists of two metal plates with a gap between them. But, different types of capacitors are manufactured in many forms, styles, lengths, girths, and materials.

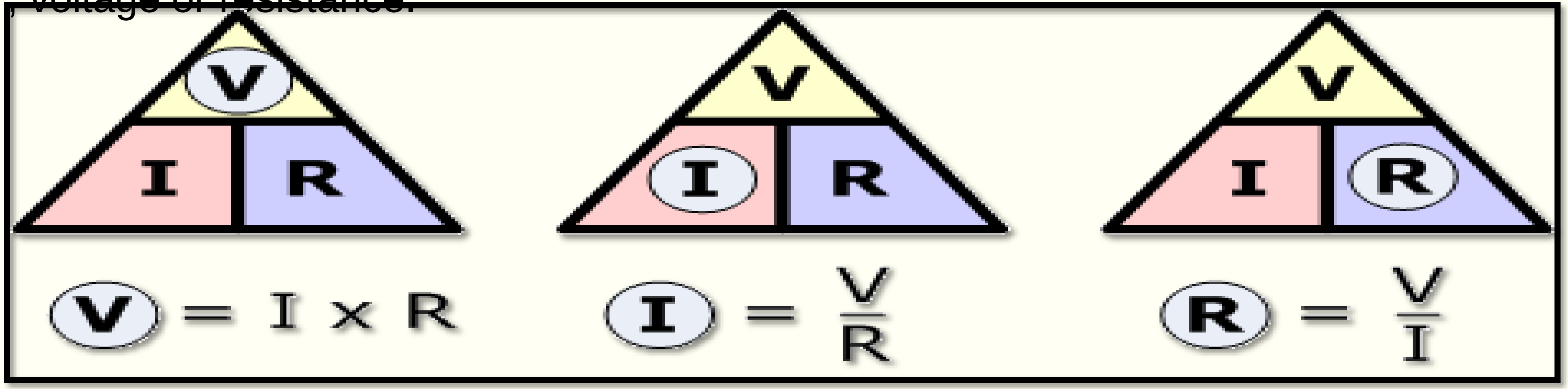
CONECPT OF INDUCTOR AND CAPACITOR



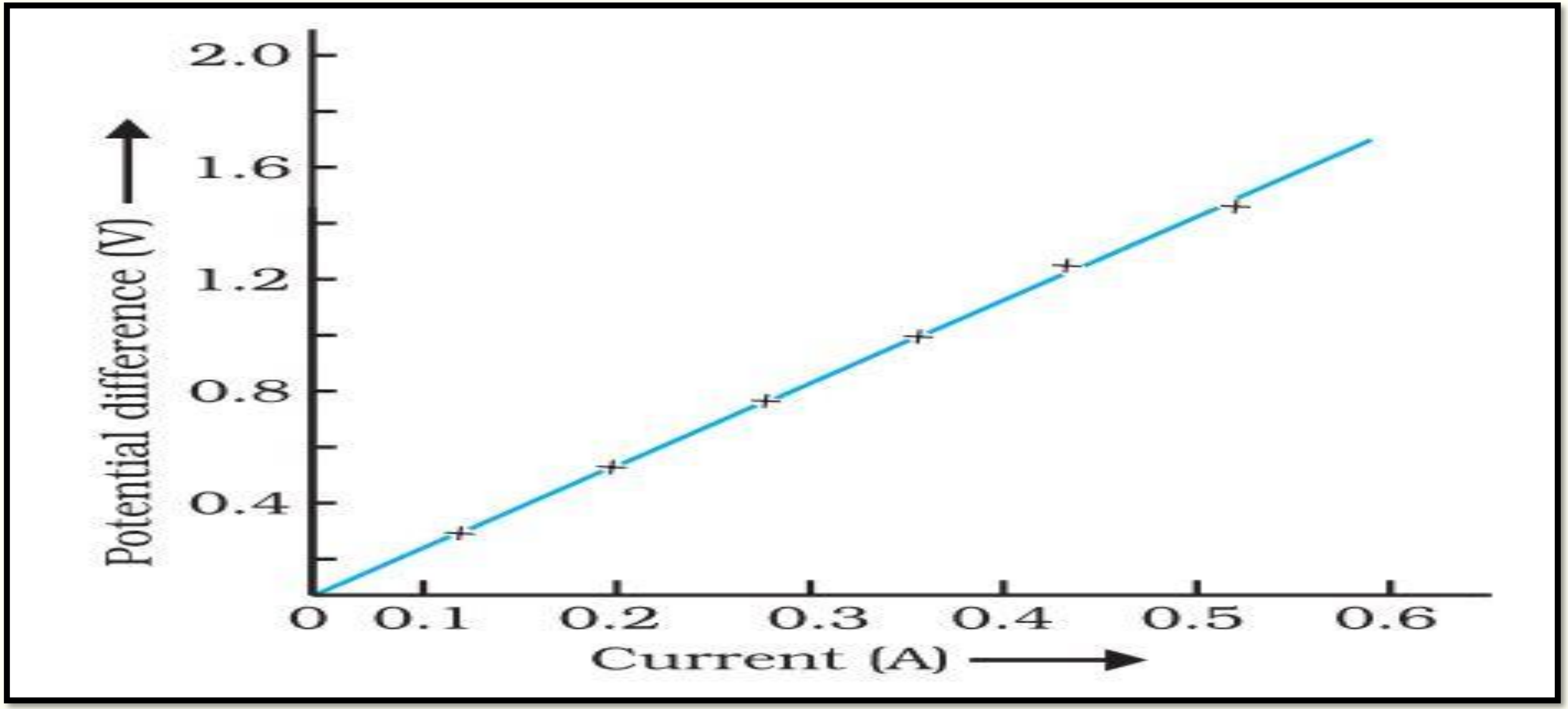
A Battery is Connected Across A Parallel Plate Capacitor

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



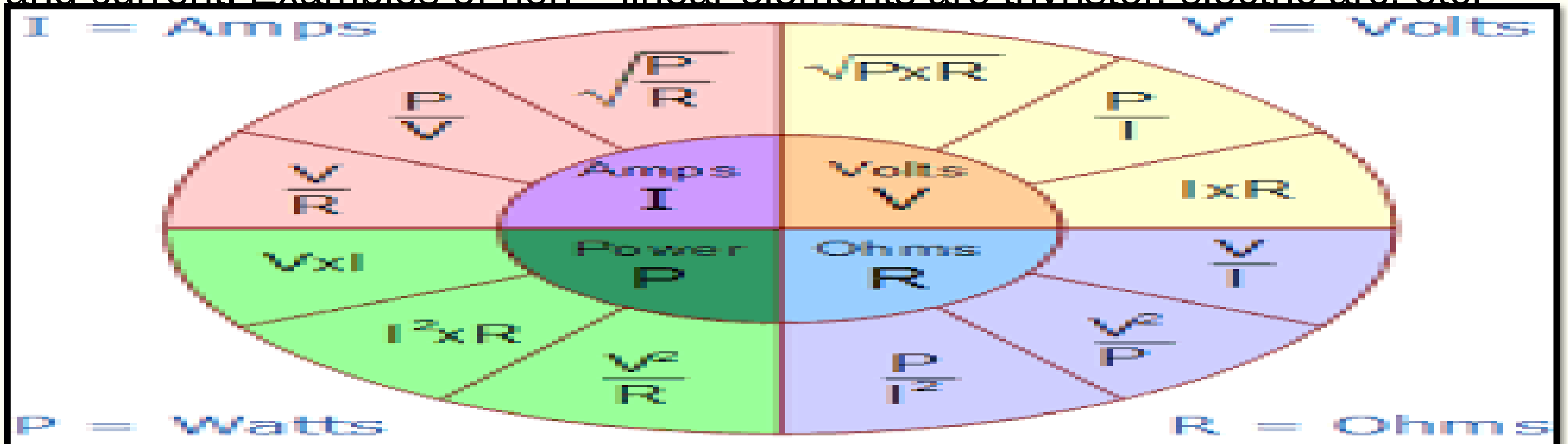
VARIATION OF VOLTAGE V WITH RESPECT TO CURRENT I

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.



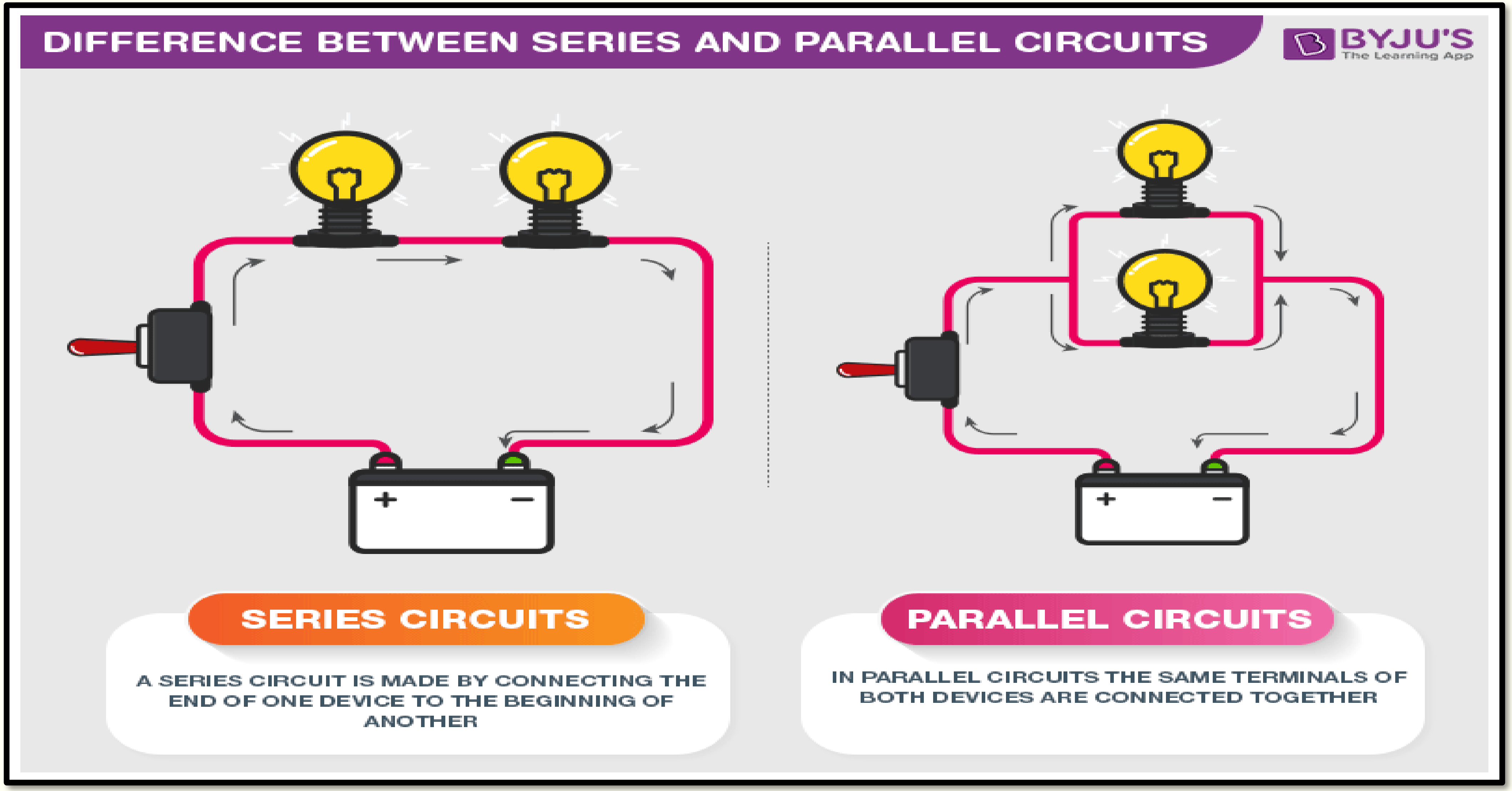
WORK, POWER AND ENERGY

- **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.**

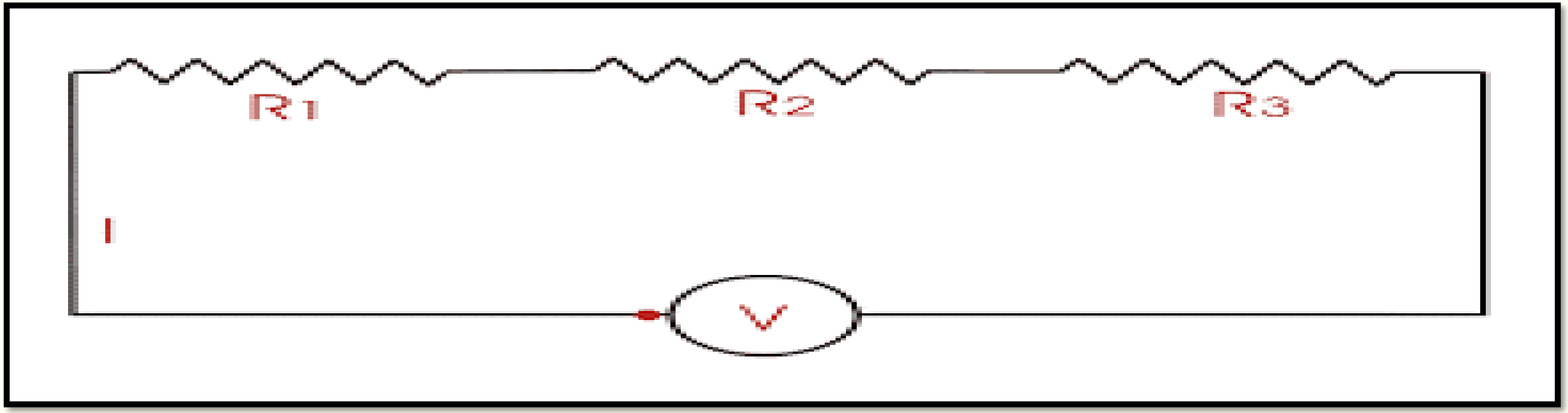
WORK, POWER AND ENERGY

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

SERIES AND PARALLEL CONNECTION OF RESISTANCE

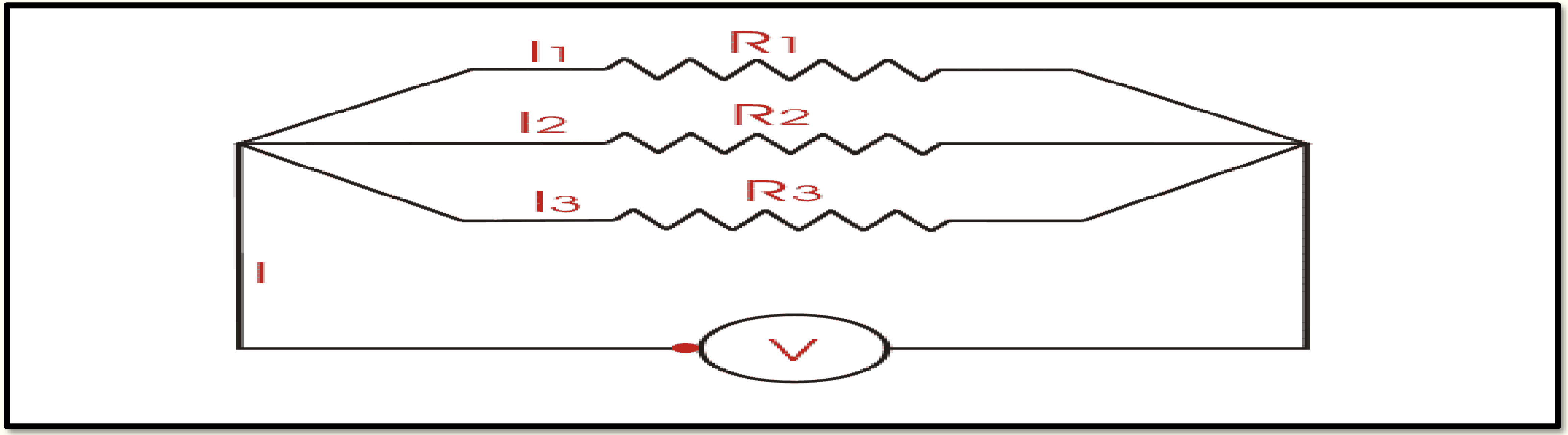


RESISTANCE IN SERIES



- 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,

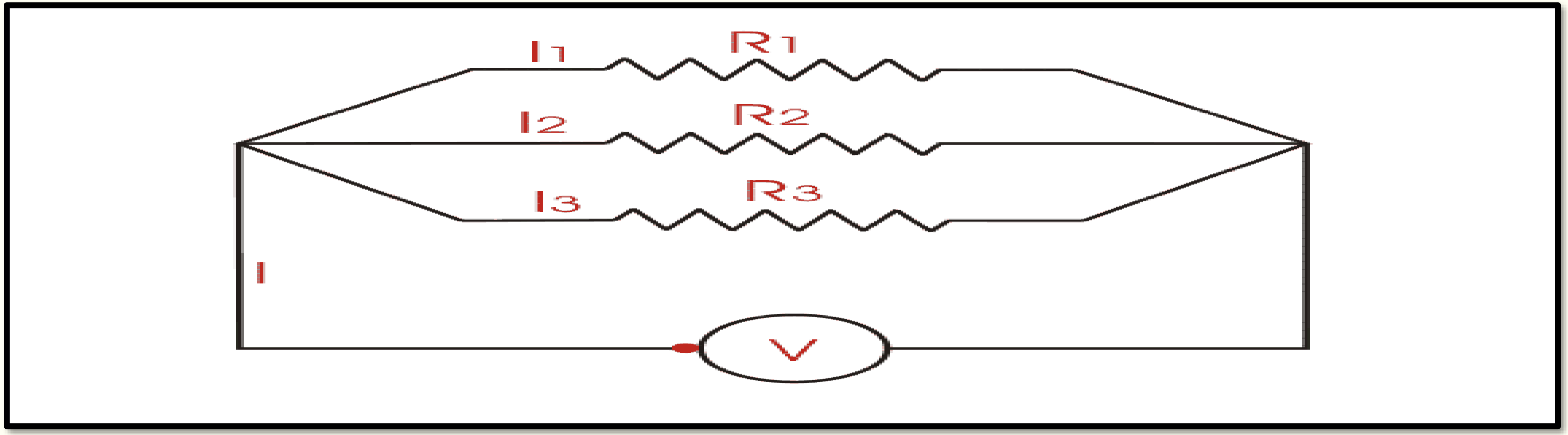
- **CURRENT I = DIVIDED**
- **AND VOLTAGE V = SAME IN THE CIRCUIT**

SO , I=I1+I2+I3………………………………….(1)

According to ohm's law

I=V/R.

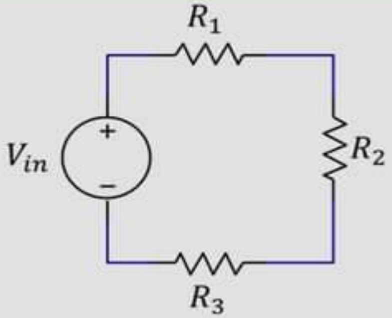
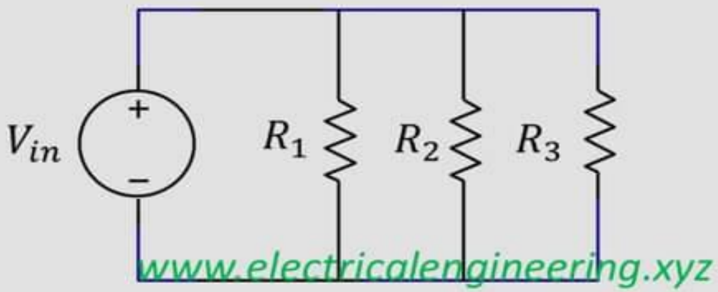
RESISTANCE IN PARALLEL



- **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