

Electrical Technology

Basic Electricity

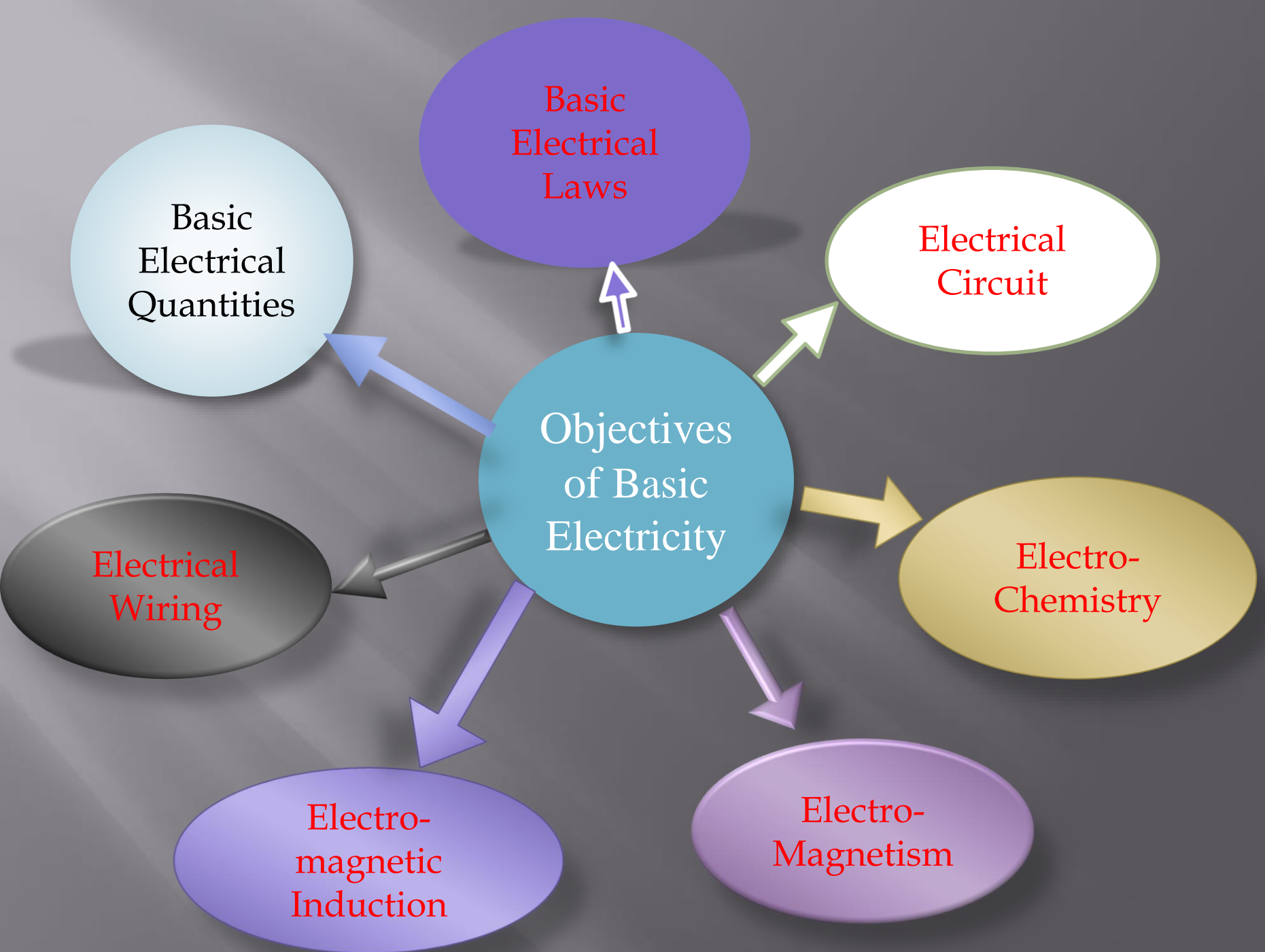


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Theory:3+Practical:3

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Electric Current, Voltage & Resistance

Chapter-01

Electricity and its nature

Meaning of Electricity:

Electricity is the presence and flow of **electric** charge. Using **electricity** we can transfer energy in ways that allow us to accomplish common chores. Its best-known form is the flow of electrons through conductors such as copper wires. ... It is a form of energy which we use to power machines and **electrical** devices.

Effect Of Electric Current

Heating Effect

Electric Light



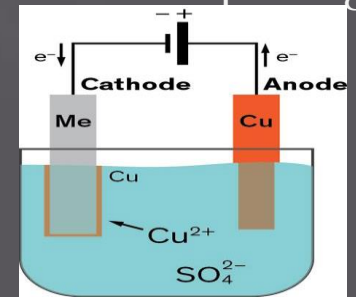
Magnetic Effect

Motor, Generator



Chemical Effect

Electroplating



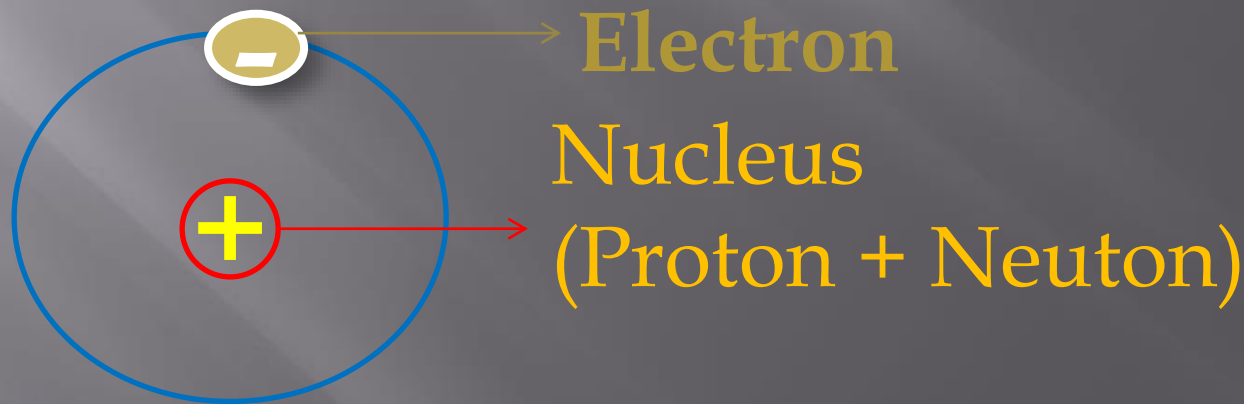
Atomic Structure

Atoms are composed of

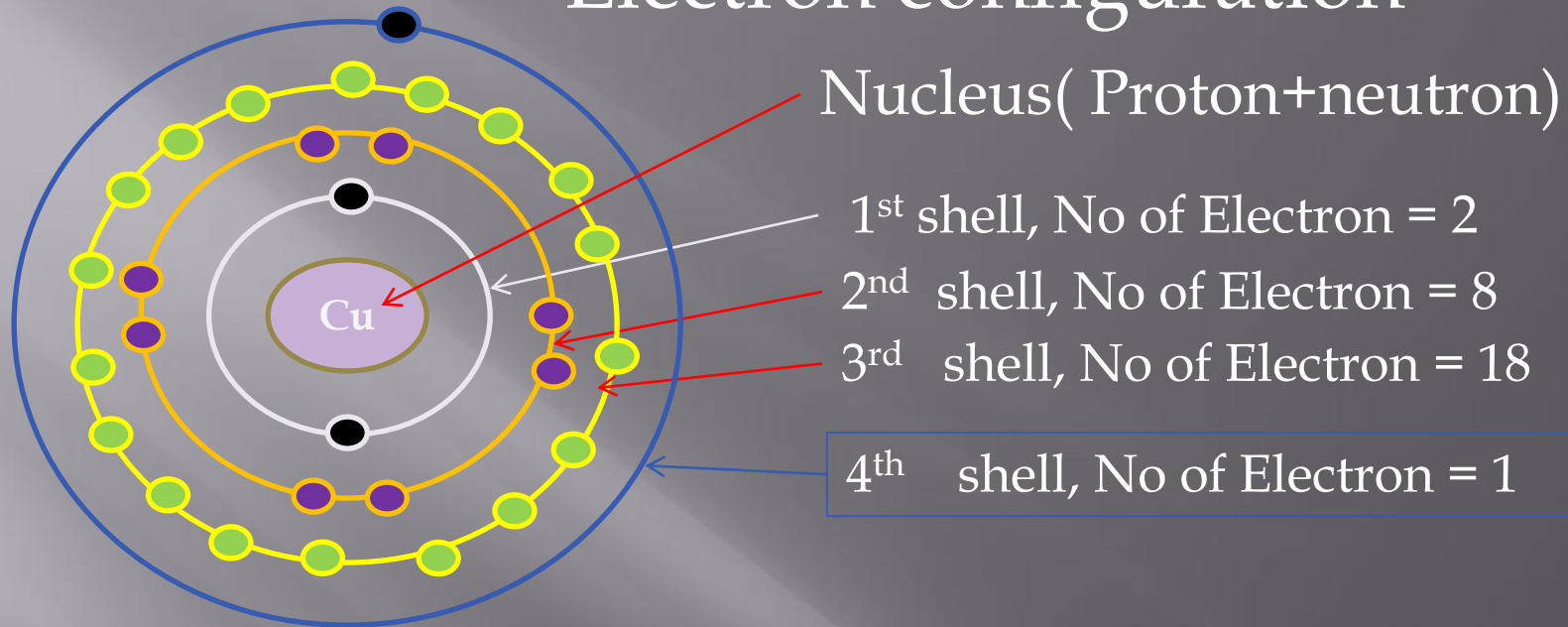
- ❖ **protons** – positively charged particles
- ❖ **neutrons** – neutral particles
- ❖ **electrons** – negatively charged particles

Protons and neutrons are located in the **nucleus**.

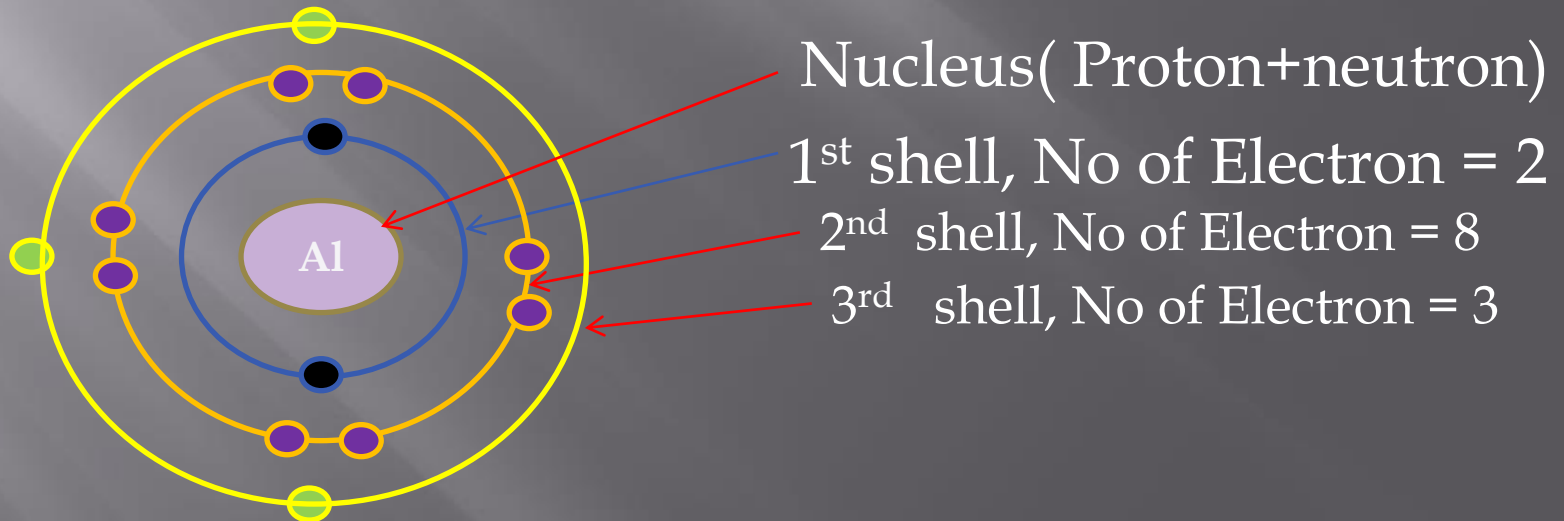
Electrons are found in orbitals surrounding the nucleus.



Electron configuration



Total electron of CU = $2+8+18+1 = 29$



Total electron of Al = $2+8+3 = 13$

Comparison of Sub-atomic Particles

Particle	Symbol	Relative Charge	Location
proton	p^+	+1	inside the nucleus
electron	e^-	-1	outside nucleus
neutron	n^0	0	inside the nucleus

Classification of Electricity

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graph TD; A[Classification of Electricity] <--> B[Static Electricity]; A <--> C[Current Electricity]; C --> D[Direct Current (DC)]; C --> E[Alternating Current (AC)];
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Static Electricity

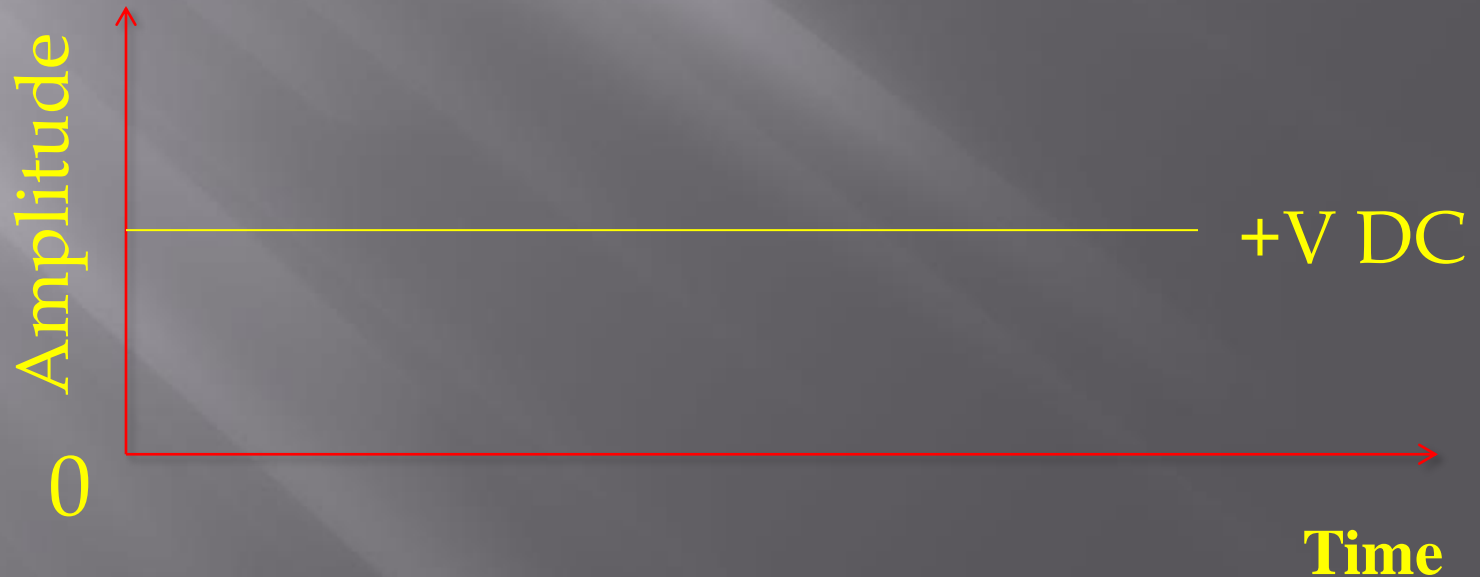
Current Electricity

Direct Current
(DC)

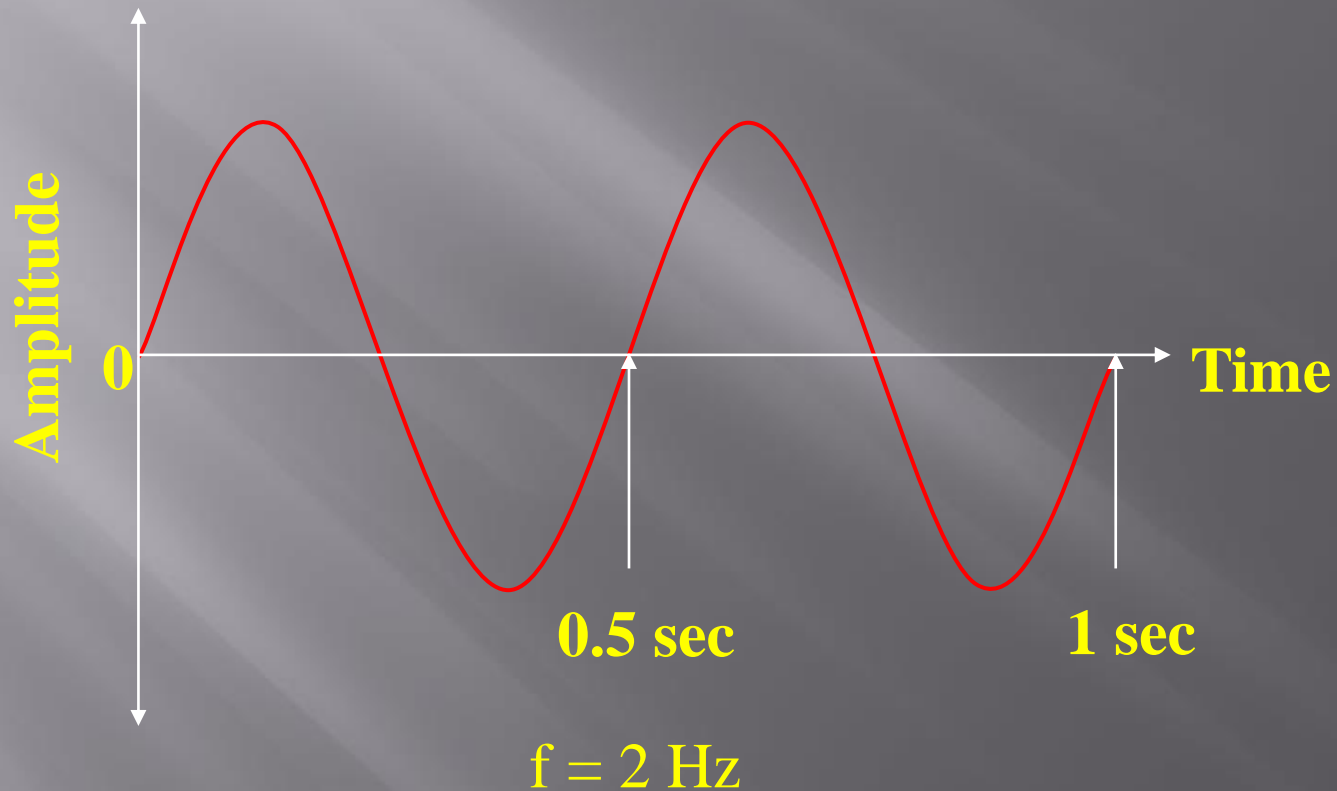
Alternating
Current (AC)

Direct Current (DC)

- Flow of charge in one direction
- **Example:** The terminals of a battery do not switch signs



Alternating Current:



Current

- ▣ Current: flow of charge (electrons) within a conductor or how fast charge is moving.
- ▣ Charge will only flow if there is a voltage source (potential difference).
- ▣ **Symbol for Current = I**
- ▣ **Unit for Current = Amps (A)**

Voltage

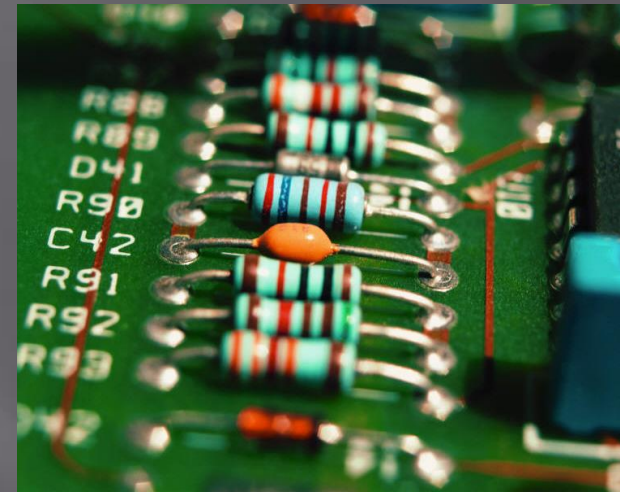
- ▣ Voltage: the charge (electron) “pusher.”
Voltage causes current to flow/move.
- ▣ Voltage sources:
 - Battery
 - Generator
 - Outlets
- ▣ **Symbol for voltage = V**
- ▣ **Unit for voltage = Volts (V)**

Resistance

▣ Resistance: opposes the push from the voltage source. Resistance affects the speed of the current.

▣ Symbol for Resistance = R

▣ Unit for Resistance = Ohms (Ω)



Different Unit Value

Prefix	Current	Voltage	Resistance	Conversion factor
Tera	TA	TV	TΩ	10^{12}
Giga	GA	GV	GΩ	10^9
Mega	MA	MV	MΩ	10^6
Kilo	KA	KV	KΩ	10^3
Main Unit	A	V	Ω	-
Milli	mA	mV	mΩ	10^{-3}
Micro	μA	μV	μΩ	10^{-6}
Nano	nA	nV	nΩ	10^{-9}
Piko	pA	pV	pΩ	10^{-12}

Different Unit Value

The SI prefixes.

Multiplier	Prefix	Symbol
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^2	hecto	h
10	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

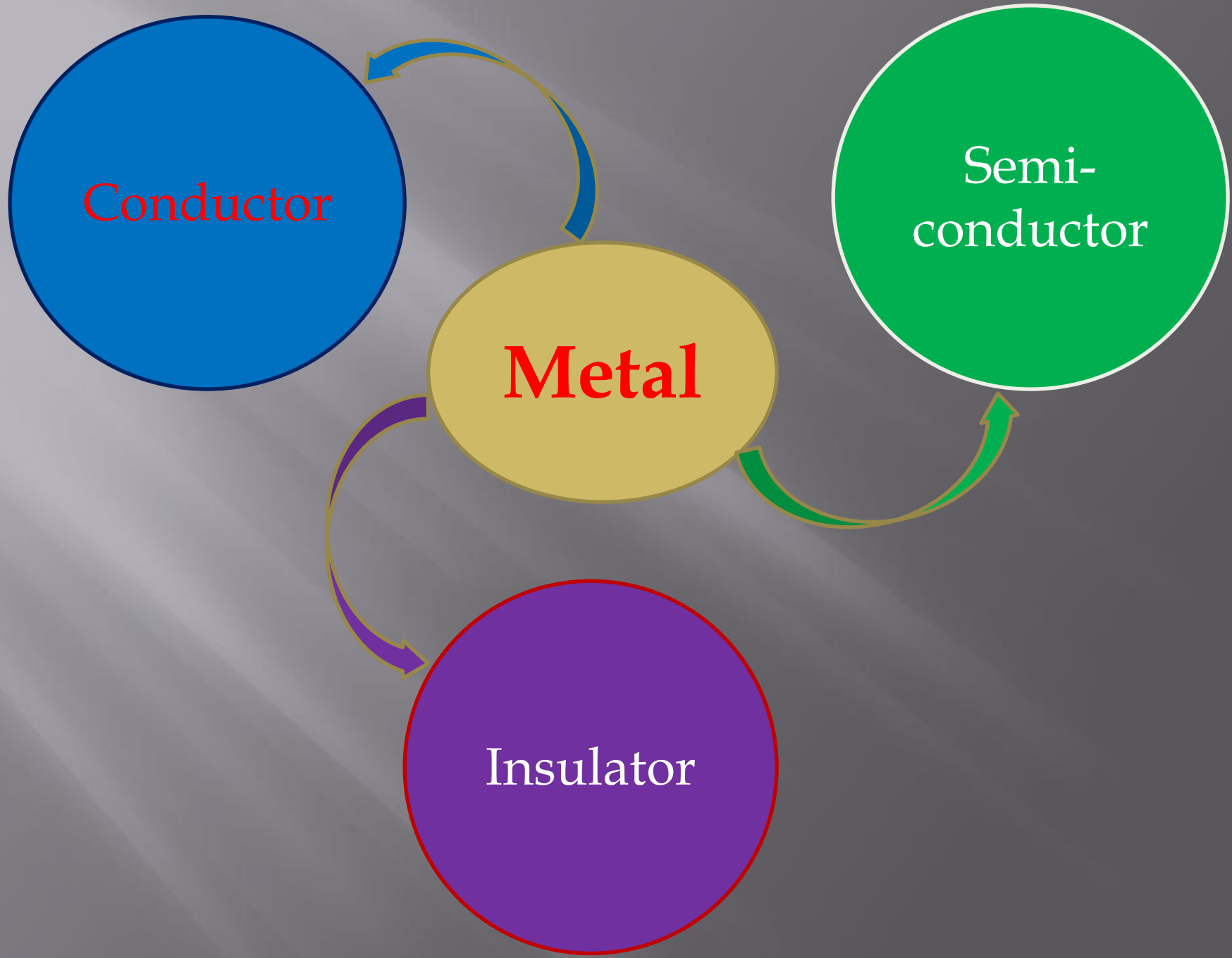
Any Question ?

Thank You Very Much

Chapter-02



Conductor, Semiconductor & Insulator



Conductor

Semi-conductor

Metal

Insulator

Conductor:

- ❖ material that allows the flow of **charge** in one or more directions.
- ❖ The **conductor** is the type of metal which allows the electrical **current** to flow through it.
- ❖ Which have **valence electron** are less than of 4

Examples:

Silver

Gold

Copper

Aluminum

Semiconductor:

- materials that possess the property of electrical conductivity less than conductors
- Which have **valence electron** are equal to 4

Examples:

Silicon

Germanium

Insulator:

- ❖ materials that are not good conductors of electric charges
- ❖ current cannot flow easily through them
- ❖ Which have **valence electron** are more than 4

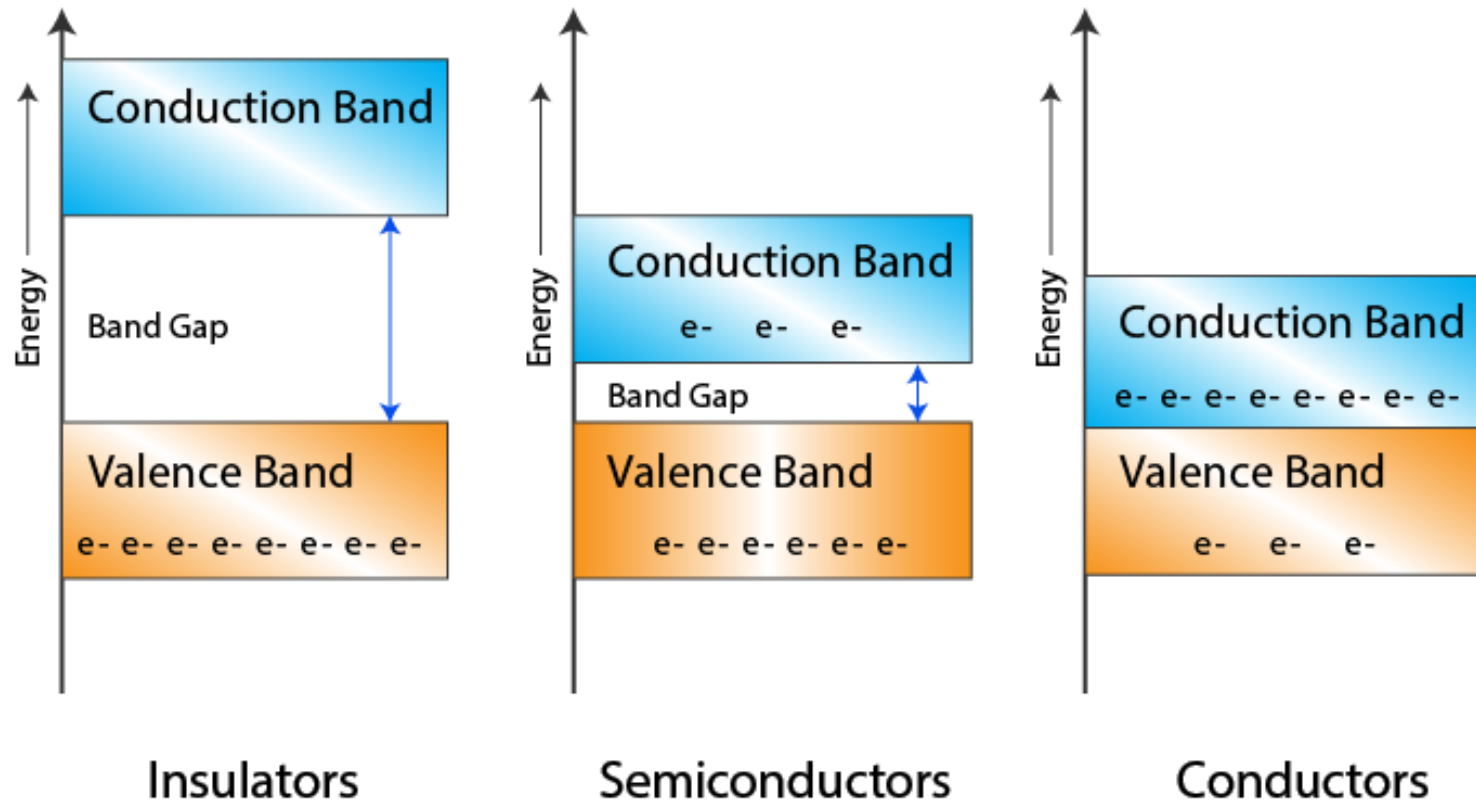
Examples:

Rubber

Plastic

Neon etc.

Energy Band Diagram:



Laws of Resistance:

1. At constant temperature and cross sectional area, The Resistance “R” is directly proportional to it’s length “L”

$$R \propto L \text{ -----(1)}$$

2. At constant temperature and length, The Resistance “R” is Inversely proportional with it’s Cross Sectional Area: “A”

$$R \propto \frac{1}{A} \text{ -----(2)}$$

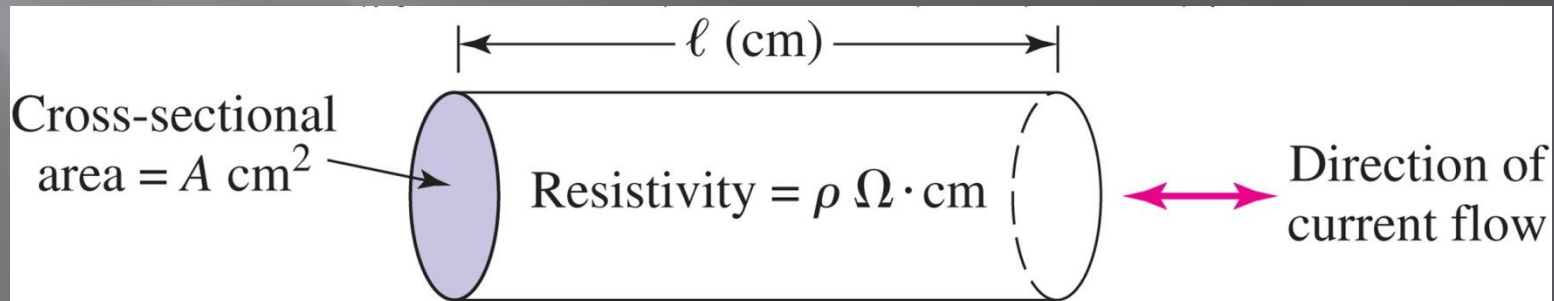
3. The Resistance “R” is dependent on the Nature of the material.

Including equation 1 & 2, we get,

$$R \propto \frac{L}{A}$$

$$R = \rho \frac{L}{A}$$

Where, ρ = Specific Resistivity



Unit of Resistivity:

1. S.I. or M.K.S. Unit:

$$\rho = \frac{\text{ohm} \times \text{m}^2}{\text{m}} = \text{ohm} - \text{m}$$

2. C.G.S. Unit:

$$\rho = \frac{\text{ohm} \times \text{cm}^2}{\text{cm}} = \text{ohm} - \text{cm}$$

3. F.P.S. Unit:

$$\rho = \frac{\text{ohm} \times \text{inch}^2}{\text{inch}} = \text{ohm} - \text{inch}$$

$$\rho = \frac{\text{ohm} \times \text{CM}}{\text{ft}} = \text{ohm} - \text{CM/ft}$$

Solution Of All Mathematical problems

Any Question



Thank You

Chapter-03



Ohm's Law

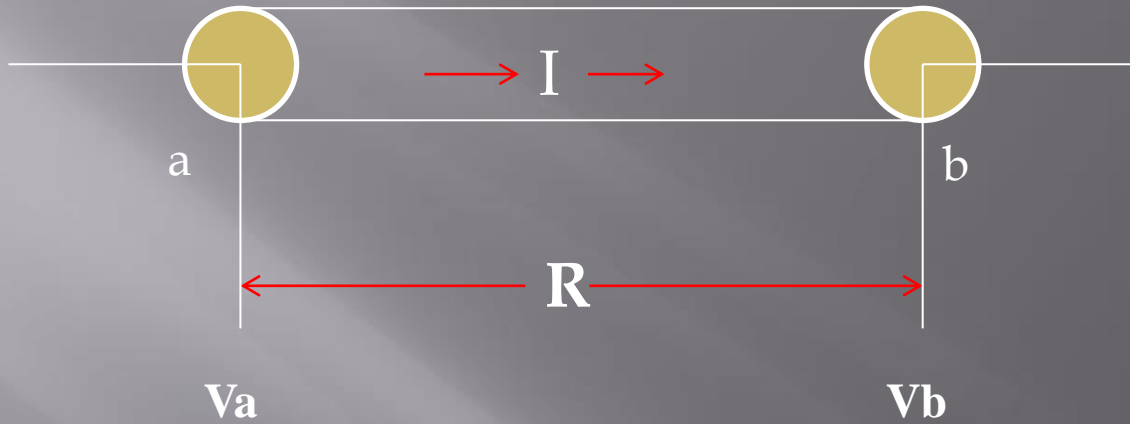
Ohm's Law:

The current through a conductor between two points is directly proportional to the voltage across the two points.

$$V \propto I$$

$$V = IR$$

$$\frac{V}{I} = R = \text{Constant}$$



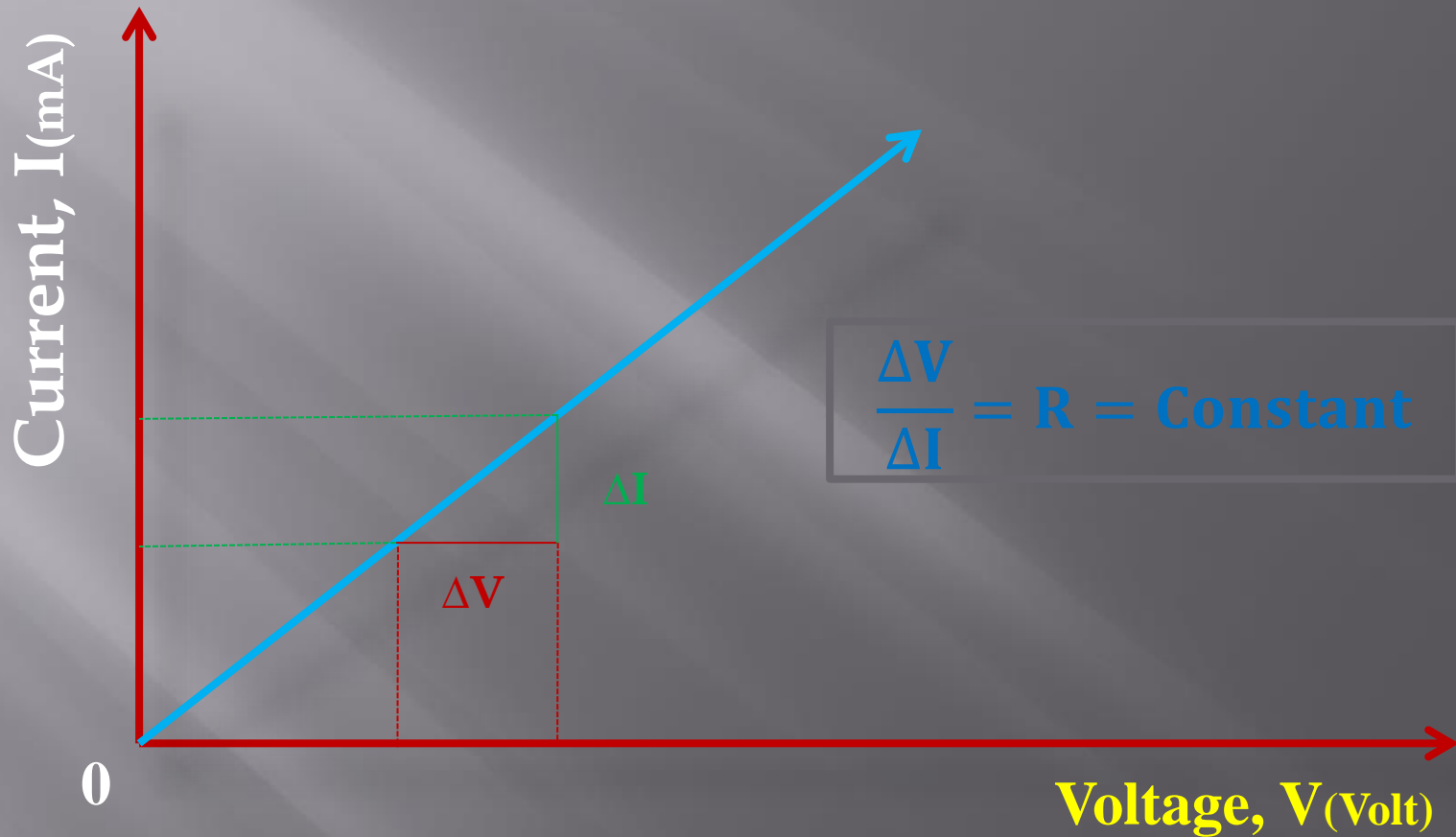
$$I \propto V_a - V_b$$

$$I \propto V$$

$$I = \frac{V}{R}$$

Ohm's law is the mother of all laws

Graphical Representation of ohm's law:



Limitation of Ohm's Law:

- This law cannot be applied to unilateral networks.
- Not applicable in AC circuit.
- Not applicable in complex network.
- Not applicable in variable resistor circuit.
- Ohm's law is also not applicable for non – linear elements.

Solution Of All Mathematical problems

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Chapter-04

Electrical Circuit

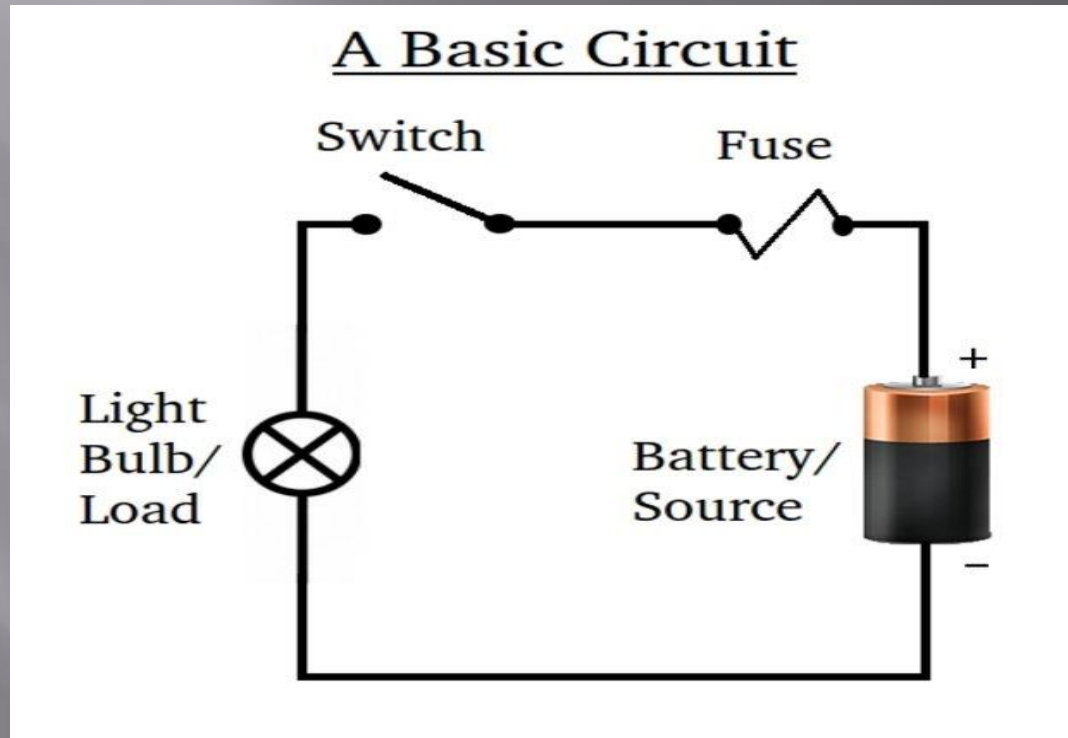


Electric Circuit:



An **electric circuit** is a path in which electrons from a voltage or current source flow. The point where those electrons enter an **electrical circuit** is called the "source" of electrons.

Element of Electric Circuit:

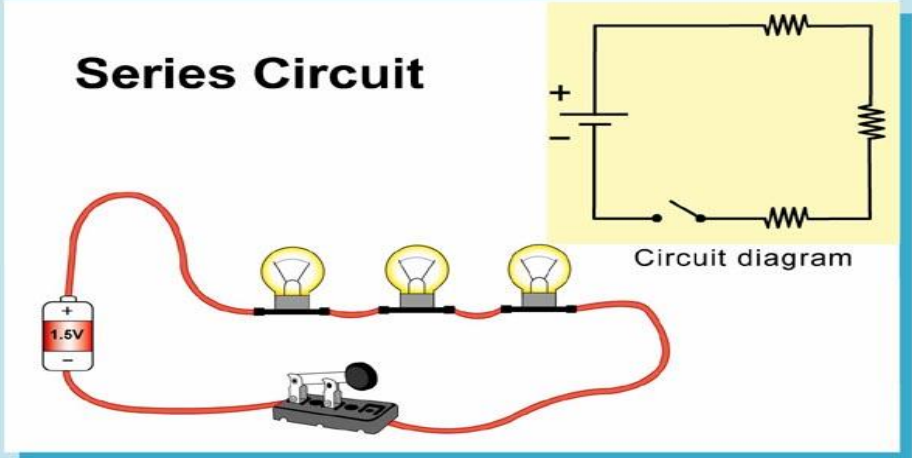
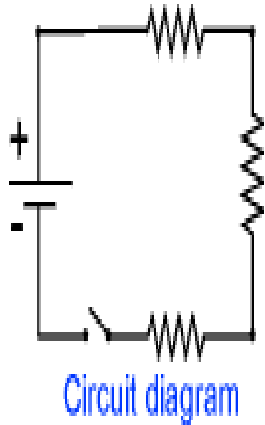
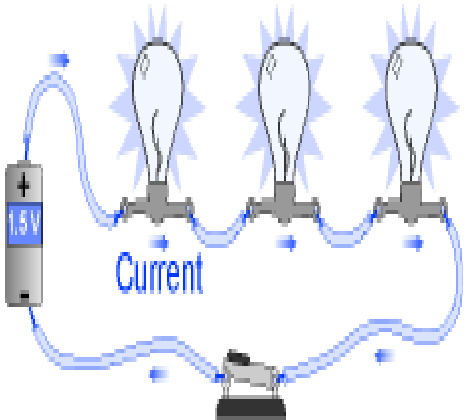


Classification of Electrical Circuit :

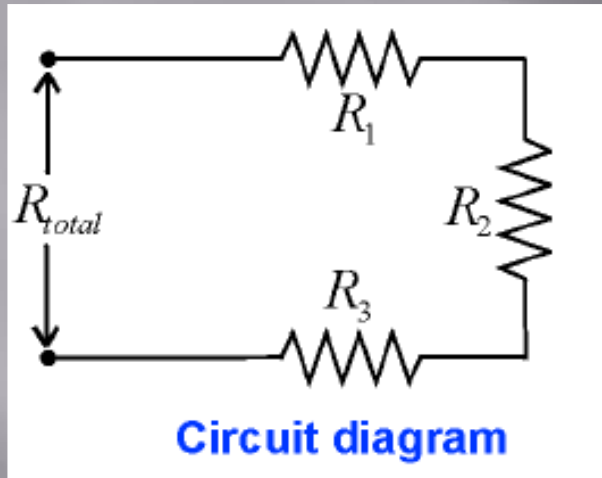
- 1. Series Circuit:** A series circuit is one that has more than one resistor, but only one path through which the electricity (electrons) flows.
- 2. Parallel circuit:** A parallel circuit is a circuit in which the resistors are arranged with their heads connected together, and their tails connected together. The current in a parallel circuit breaks up, with some flowing along each parallel branch and recombining when the branches meet again. The voltage across each resistor in parallel is the same.

Series circuit:

Series circuit



Cont..... Series circuit



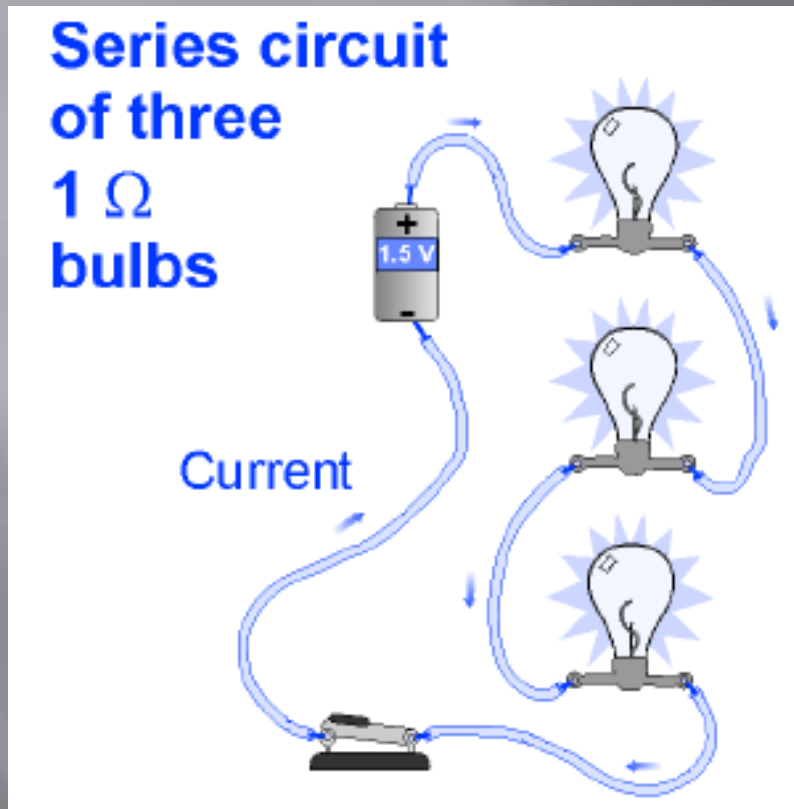
- Each resistance in a series circuit adds to the total resistance of the circuit.

$$R_{total} = R_1 + R_2 + R_3 \dots$$

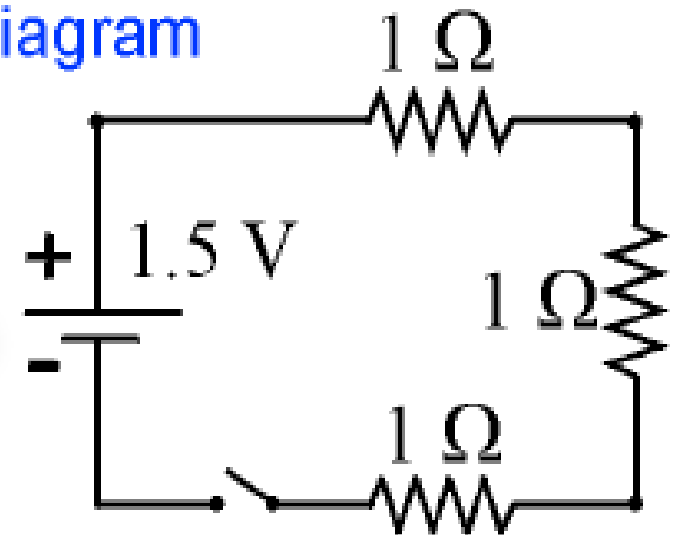
Total resistance
(ohms)

Individual resistances (Ω)

Cont..... Series circuit



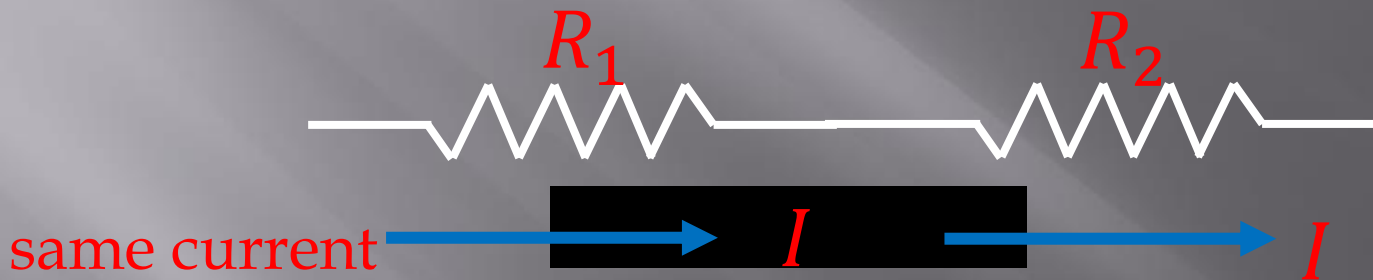
**Circuit
diagram**



Total resistance = $3\ \Omega$

Resistors in series:

- If two resistors are connected in series, what is the total resistance?

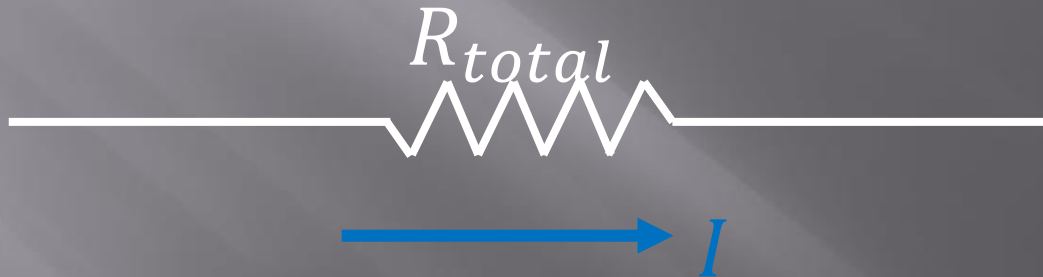


$$\text{Voltage drop } V_1 = I R_1 \quad \text{Voltage drop } V_2 = I R_2$$

$$\text{Total Voltage drop } V = V_1 + V_2 = I R_1 + I R_2 = I (R_1 + R_2)$$

Resistors in series:

- If two resistors are connected in series, what is the total resistance?



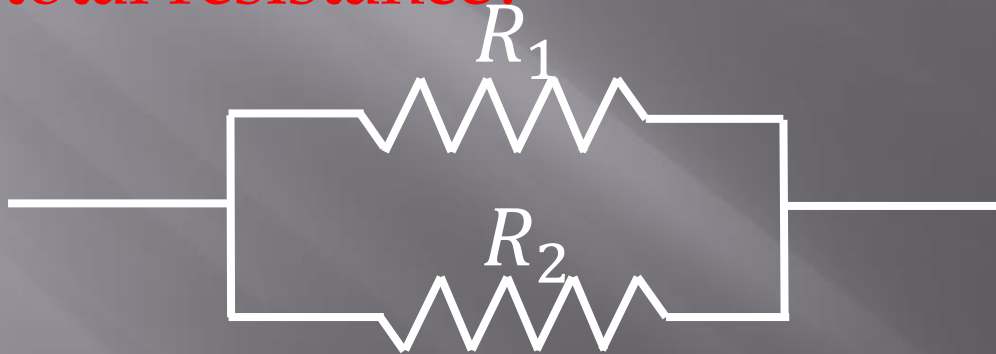
Voltage drop $V = I R_{total} = I (R_1 + R_2)$

$$R_{total} = R_1 + R_2$$

- Total resistance increases in series!

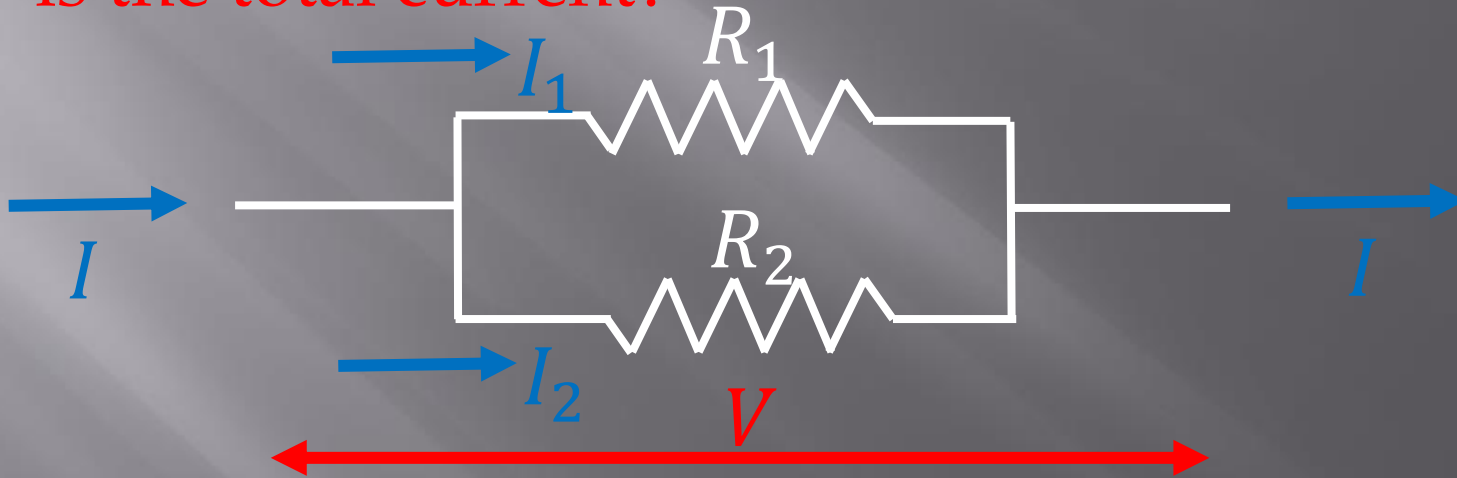
Resistors in parallel:

- If two resistors are connected in parallel, what is the total resistance?



Resistors in parallel:

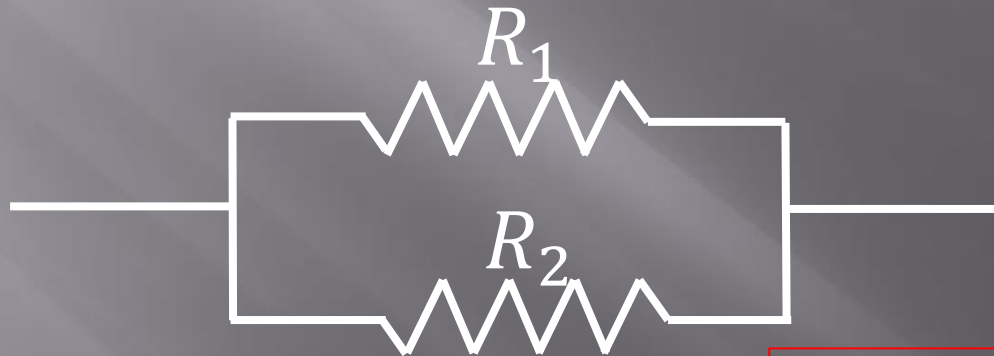
- If two resistors are connected in parallel, what is the total current?



$$\text{Total current } I = I_1 + I_2 = \frac{V}{R_1} + \frac{V}{R_2} = V \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$$

Resistors in parallel:

- If two resistors are connected in parallel, what is the total resistance?

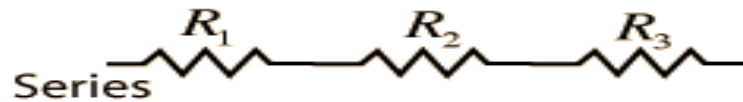


$$\text{Current } I = \frac{V}{R_{total}} = V \left(\frac{1}{R_1} + \right.$$

$$\left. \frac{1}{R_2} \right) = \frac{1}{R_1} + \frac{1}{R_2}$$

- $\frac{1}{R_2}$ Total resistance decreases in parallel!

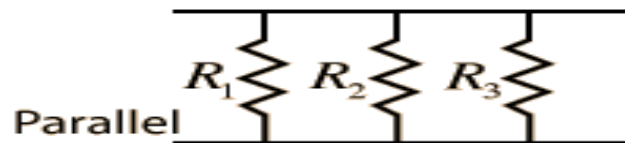
Summary of series parallel circuit:



$$R_{equivalent} = R_1 + R_2 + R_3 + \dots$$

$$R_{equivalent} = \frac{V}{I} = \frac{V_1 + V_2 + V_3 + \dots}{I} = \frac{V_1}{I_1} + \frac{V_2}{I_2} + \frac{V_3}{I_3} + \dots = R_1 + R_2 + R_3 + \dots$$

Series key idea: The current is the same in each resistor by the current law.



$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$$

Parallel:

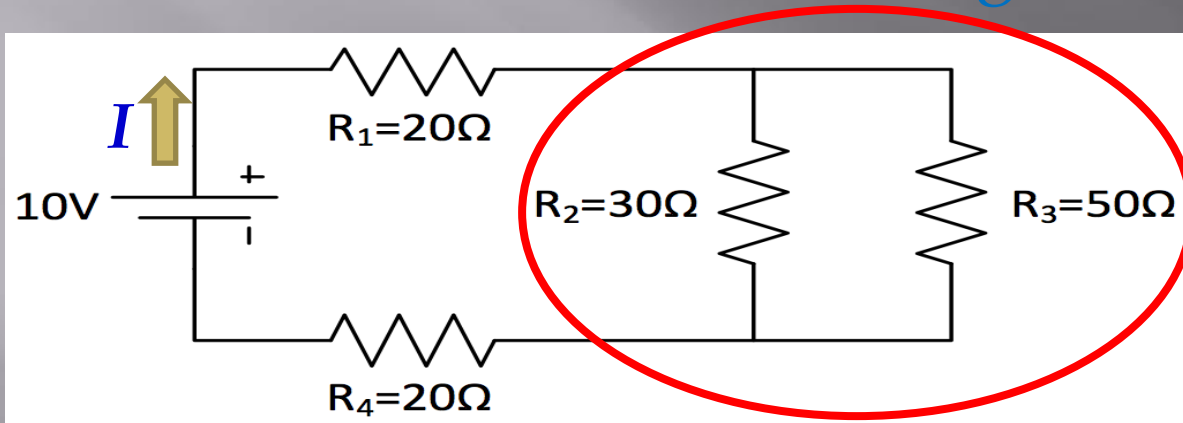
$$\frac{V}{R_{equivalent}} = I = I_1 + I_2 + I_2 + \dots = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \dots$$

$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$$

Parallel key idea: The voltage is the same across each resistor by the voltage law.

Resistors in series/parallel

- What's the current flowing?



(1) Combine these 2 resistors in parallel:

$$\frac{1}{R_{pair}} = \frac{1}{30} + \frac{1}{50}$$

$$R_{pair} = 18.75 \Omega$$

(2) Combine all the resistors in series:

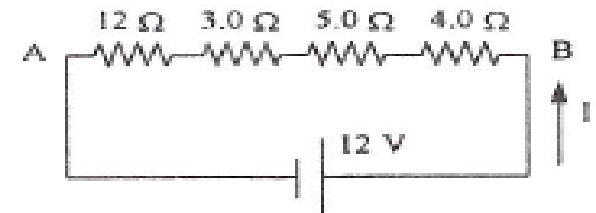
$$R_{total} = 20 + 18.75 + 20 = 58.75 \Omega$$

(3) Total Current $I = \frac{V}{R_{total}} = \frac{10}{58.75} = 0.17 \text{ A}$

- Series connections provide a way to increase total resistance.
- Parallel connections provide a way to decrease total resistance.

In the circuit shown, find:

- (a) the equivalent resistance between points A and B,
 (b) the current through each resistor.



Solution:

Given: $R_1 = 12 \Omega$, $R_2 = 3.0 \Omega$, $R_3 = 5.0 \Omega$, $R_4 = 4.0 \Omega$, $V = 12 \text{ V}$.

Find: (a) R_s (b) I .

(a) All four resistors are in series combination, so

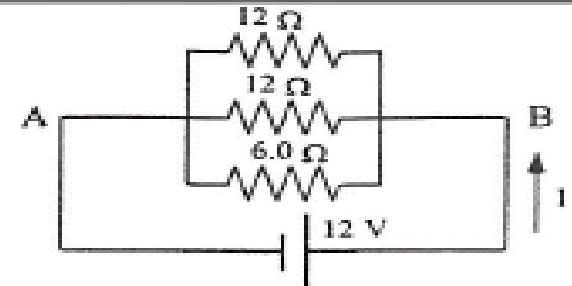
$$R_s = R_1 + R_2 + R_3 + R_4 = 12 \Omega + 3.0 \Omega + 5.0 \Omega + 4.0 \Omega = 24 \Omega.$$

(b) The current through all resistors in series is the same. $I = \frac{V}{R} = \frac{V}{R_s} = \frac{12 \text{ V}}{24 \Omega} = 0.50 \text{ A}$.

Example :

In the circuit shown, find:

- (a) the equivalent resistance between points A and B,
- (b) the current through the battery.



Given: $R_1 = 12 \Omega$, $R_2 = 12 \Omega$, $R_3 = 6.0 \Omega$, $V = 12 \text{ V}$.

Find: (a) R_p (b) I .

Solution:

(a) The three resistors are in a parallel combination.

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{12 \Omega} + \frac{1}{12 \Omega} + \frac{1}{6.0 \Omega} = \frac{1}{12 \Omega} + \frac{1}{12 \Omega} + \frac{2}{12 \Omega} = \frac{4}{12 \Omega} = \frac{1}{3.0 \Omega}$$

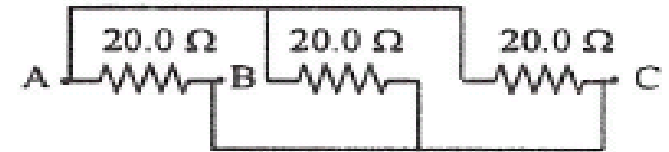
So $R_p = 3.0 \Omega$.

(b) From Ohm's law, $I = \frac{V}{R} = \frac{V}{R_p} = \frac{12 \text{ V}}{3.0 \Omega} = 4.0 \text{ A}$.

Example :

Find the equivalent resistance between points

- (a) A and B,
- (b) A and C,
- (c) B and C.



Solution:

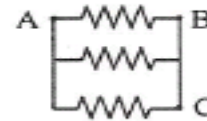
Given: $R_1 = R_2 = R_3 = R = 20.0\ \Omega$.

Find: (a) R_{AB} (b) R_{AC} (c) R_{BC} .

(a) All three resistors are in parallel between points A and B, that is, the ends of all three resistors are across points A and B. We redraw the circuit.

$$\frac{1}{R_{AB}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{3}{R},$$

$$\text{or } R_{AB} = \frac{R}{3} = \frac{20.0\ \Omega}{3} = 6.67\ \Omega.$$

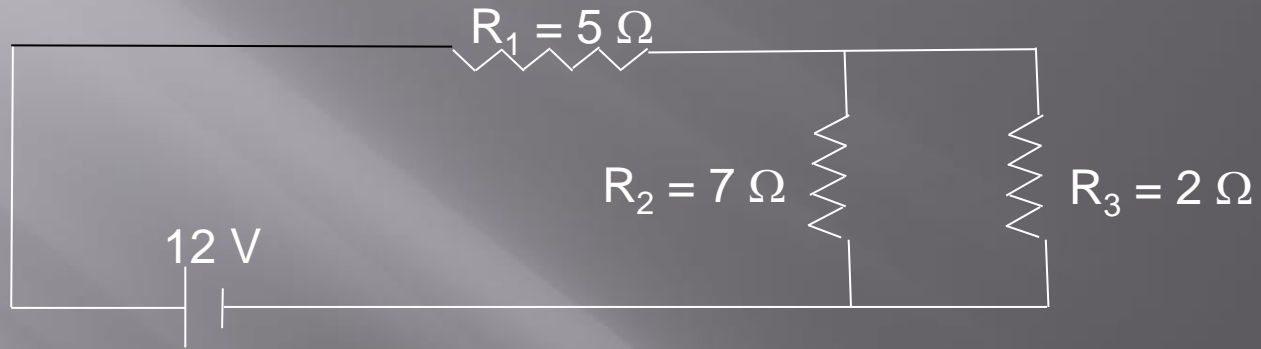


(b) Since point C and point B are connected (they are the same point), $R_{AB} = R_{AC} = 6.67\ \Omega$.

(c) Again since points B and C are connected, there is no resistance between them (short circuit).

So $R_{BC} = 0$.

Example : For the circuit shown, complete a V-I-R table.



Check for Understanding

1. Which of the following is always the same for resistors in series?
 - a) voltage
 - b) current
 - c) power
 - d) energy

Answer: b

2. Which of the following is always the same for resistors in parallel?
 - a) voltage
 - b) current
 - c) power
 - d) energy

Answer: a

Check for Understanding

3. Are the voltages across resistors in series generally the same?

Answer: No

4. Could they be so in certain cases?

Answer: Yes, if all the resistors are equal

5. Are the currents in resistors in parallel generally the same?

Answer: No

6. Could they be so in certain cases?

Answer: Yes, if all the resistors are equal

Any Question ?

Thank You Very Much

Chapter-05



Electric Power & Energy

Electric Power:



⚡ Power is an indication of how much work (the conversion of energy from one form to another) can be done in a specific amount of time; that is, a *rate* of doing work.

Electric Power:

$$P = \frac{W}{t}$$

1 Watt (W) = 1 joule / second

⚡ Power can be delivered or absorbed as defined by the polarity of the voltage and the direction of the current.

Electric Power:

$$\mathbf{P = VI}$$

$$\mathbf{I = \frac{P}{V}}$$

$$\mathbf{V = \frac{P}{I}}$$

$$\mathbf{P = I^2R}$$

$$\mathbf{R = \frac{P}{I^2}}$$

$$\mathbf{I = \sqrt{\frac{P}{R}}}$$

$$\mathbf{P = \frac{V^2}{R}}$$

$$\mathbf{R = \frac{V^2}{P}}$$

$$\mathbf{V = \sqrt{PR}}$$

Energy :

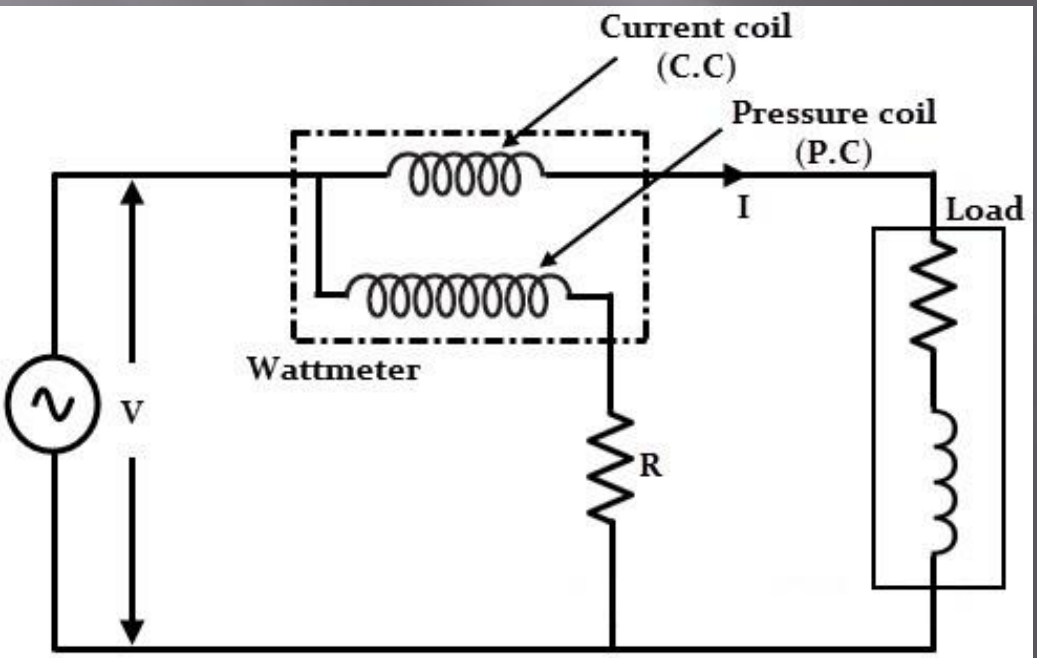
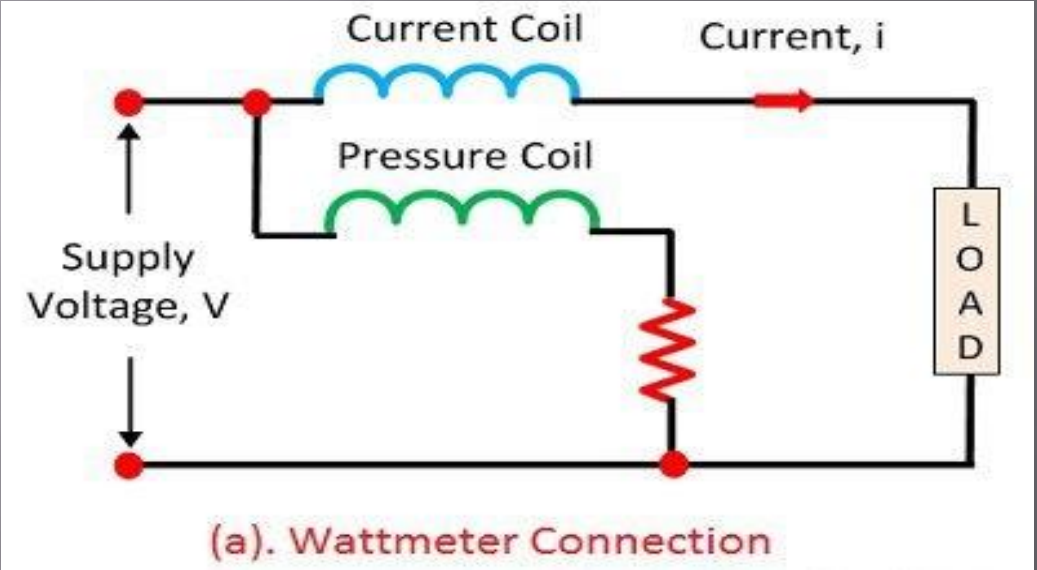
- ▣ The watt-second is too small a quantity for most practical purposes, so the *watt-hour* (Wh) and *kilowatt-hour* (kWh) are defined as follows:

$$\text{Energy (Wh)} = \text{power (W)} \times \text{time (h)}$$

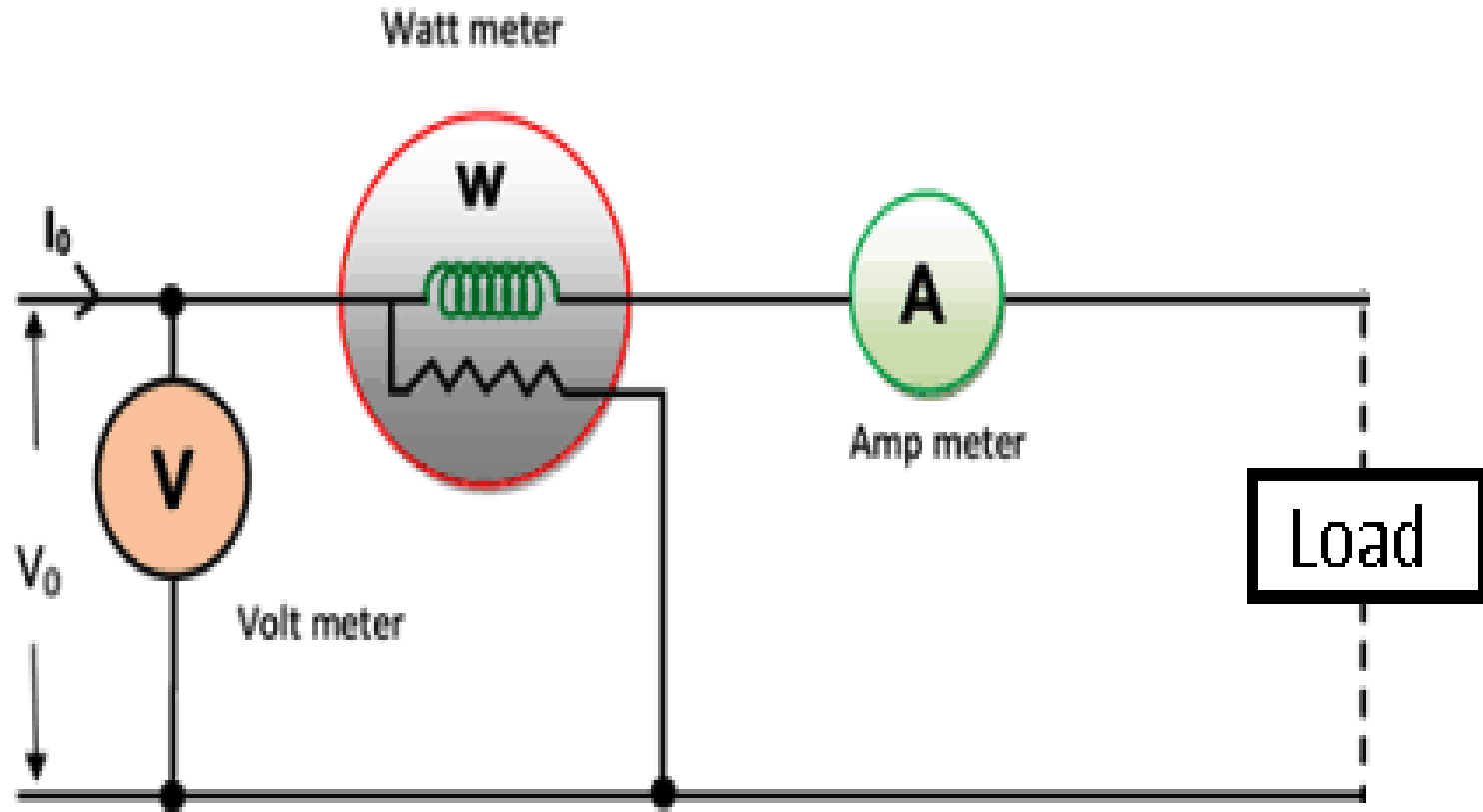
$$\text{Energy (kWh)} = \frac{\text{power (W)} \times \text{time (h)}}{1000}$$

- ▣ The **kilowatt-hour meter** is an instrument used for measuring the energy supplied to a residential or commercial user of electricity.

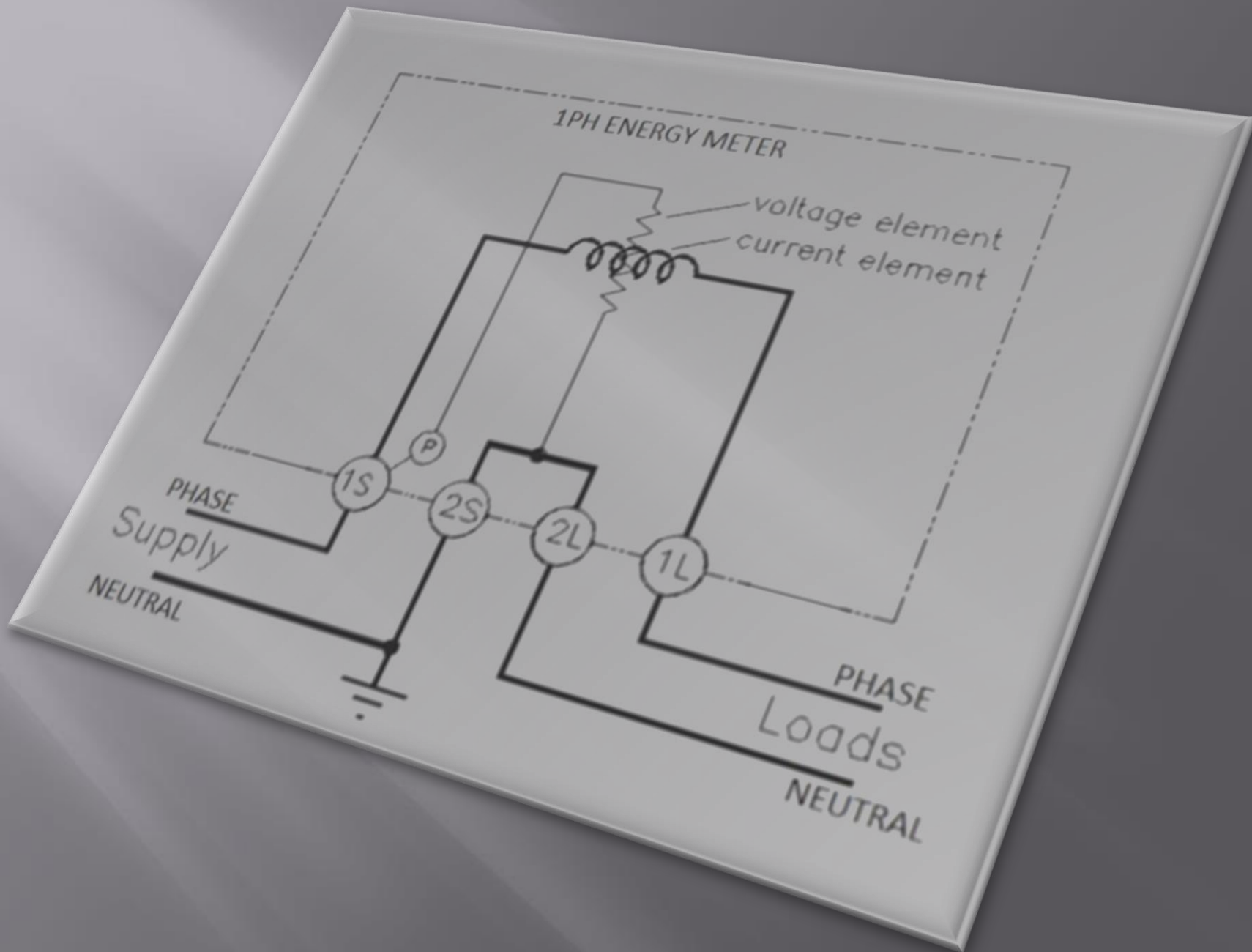
Watt Meter Connection Diagram:



Ammeter, Voltage and Wattmeter Connection Diagram



Energy meter Connection Diagram



Solution Of All Mathematical problems



Chapter-06

Joule's Law

Joules Law:

The English physicist **James Prescott Joule** discovered in 1840 that the amount of **heat** per second that develops in a wire carrying a **current is proportional** to the electric **Resistance** of the wire and the **square** of the current.

The mathematical representation and explanation of **Joule's law** is given in the following manner.

1. The amount of heat produced in a current conducting wire, is proportional to the square of the amount of current that is flowing through the wire, when the electrical resistance of the wire and the time of current flowing are constant.

$$H \propto I^2, \text{ Where, } R \text{ \& } t \text{ are constant}$$

Cont..... Joules Law:

2. The amount of heat produced is proportional to the electrical resistance of the wire when the current in the wire and the time of current flowing are constant.

$$H \propto R, \text{ Where, } I \ \& \ t \ \text{are constant}$$

3. The heat generated due to the flow of current is proportional to the time of current flowing, when the electrical resistance and the amount of current is constant.

$$H \propto t, \text{ Where, } R \ \& \ I \ \text{are constant}$$

Cont..... Joules Law:

When these three conditions are merged, the resulting formula is like this –

$H \propto I^2 R t$ Where, I, R, t are variables

$$H \propto \frac{1}{J} I^2 R t$$

Here, 'J' is a constant, known as Joule's mechanical equivalent of heat. Mechanical equivalent of heat may be defined as the number of work units which, when completely converted into heat, furnishes one unit of heat. $J = 4.2 \text{ joules/cal}$ (1 joule = 10^7 ergs) = 1400 ft. lbs./CHU = 778 ft. lbs/B Th U.

Cont..... Joules Law:

Therefore,

$$\begin{aligned} H &= \frac{I^2 R t \text{ Joules}}{4.2 \text{ Joules/cal}} \\ &= \frac{I^2 R t}{4.2} \text{ cal} \\ &= 0.24 I^2 R t \text{ cal} \end{aligned}$$

Solution Of All Mathematical problems