# CHAPTER 12
# CURRENT ELECTRICITY

* $I = \frac{Q}{t}$

* $V = IR$

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

* $G = \frac{1}{R}$ (G: conductance)

* $\sigma = \frac{1}{\rho} = \frac{L}{RA}$ ($\sigma$: Conductivity)

* $R_T - R_o = \alpha R_o T$

* $\rho_T = \rho_o (1 + \alpha T)$

* $\varepsilon = \frac{W}{q}$



* $V = \varepsilon - Ir$ (r: internal resistance of supply)

  or $IR = \varepsilon - Ir$

Day: M T W T F S S

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

* $P = VI$

$P = I^2R$

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



* Maximum Power Output

$$P = \frac{\varepsilon^2}{4R}$$

* Thermocouples

$$\varepsilon = \alpha T + \frac{1}{2}\beta T^2$$

* KCL : $\Sigma I = 0$

* KVL : $\Sigma \varepsilon = \Sigma IR$

* Wheatstone Bridge

$$X = \frac{RQ}{P}$$

X : Unknown

P and Q : Fixed

R : Variable

* Potentiometer

$$\frac{\varepsilon_2}{\varepsilon_1} = \frac{l_2}{l_1}$$

* $$\alpha = \frac{R_T - R_0}{R_0 T}$$

* $$\alpha = \frac{\rho_T - \rho_0}{\rho_0 T}$$

* $$R = \frac{\rho^2 l^2}{m}$$

Day: M T W T F S S

* When 2 Resistors are connected in parallel

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

* If 'n' Resistors of equal magnitude are connected in parallel

$$R_{eq} = \frac{1}{n} R$$

* To find Resistance of wire when stretched 'n' times.

$$R' = n^2 R$$

* In series the lamp with smaller rated power shows maximum glow

* $$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$

* When wire is stretched, why does area becomes halved when length is doubled?

Volume of wire remains constant before and after stretching

Volume = $A \times l$

When length is doubled area must be divided by 2 to keep volume constant

# * TEMPERATURE CO-EFFICIENT OF RESISTANCE ($\alpha$)

+ve value → Resistance increase with increasing temperature ($R \propto T$)
e.g metals

-ve value → Resistance decrease with increasing temperature ($R \propto 1/T$)
e.g graphite, non-metals

Large $\alpha$ Value:
Greater change in resistance per kelvin i-e if change in resistance is rapidly taking place and with greater magnitude w.r.t temperature (e.g tungsten)

Small $\alpha$ Value:
Not rapid change and with smaller magnitude.
e.g Copper → that's why copper is good conductor bcz its resistance doesnot change easily

Unit of $\alpha$: $K^{-1}$

# WIRE-WOUND VARIABLE RESISTORS

* Wire wound variable resistors are:
  - → Highly stable
  - → Highly accurate

* Generally nickel-chromium is used bcz of its very small temperature co-efficient of resistance

* Wire wound resistor can be used as:
  1. Rheostats
  2. Potential Divider

## 1. RHEOSTAT

An electrical resistance used to control current by varying resistance

TYPES:

1. Rotatory Rheostat (e.g used in fans)
2. Linear Rheostat (or cylindrical Rheostat)

SYMBOL:



BASIC PRINCIPLE

$$R \propto l$$

($l$ is length of coiled wire)

Rheostat is used to increase or decrease the volume of radio or increase or decrease the speed of an electric motor.

## 2 POTENTIAL DIVIDER (OR VOLTAGE DIVIDER)

A resistor or series of resistors connected to a voltage source and used to provide voltages that are fractions of that of the source

Date:

Day: M T W T F S S

# MAXIMUM POWER OUTPUT

→ If the load resistance is less or greater than the source resistance, then the power delivered to the load will be minimum.

→ Maximum power is delivered to load R when internal resistance of the source of emf is equal to the load resistance.

The value of maximum power output is:

$$(P_{out})_{max} = \frac{\varepsilon^2}{4r} = \frac{\varepsilon^2}{4R}$$

# THERMISTOR

* A resistor made of semiconductors having resistance that varies rapidly and predictably with temperature is known as thermistor.

* Thermistor → short for thermal resistor

* Temperature co-efficient of thermistor is very high. May be positive or negative (NTC or PTC)

* Thermistors are made from semiconductor oxides of iron, nickel and cobalt

* They may be in the form of discs or rods.
  → The rod and bead thermistors are used in temperature probes
  → They may be in the form of flat discs for applications where they need to be in contact with a flat surface

ARRANGEMENT :

Pair of platinum leads are attached at the two ends of electrical connections. The arrangement is enclosed in a very small glass bulb and sealed

Date:

Day: M T W T F S S

## TEMPERATURE RANGE:

Metallic oxide thermisters are generally used for temperature in range 200 to 700K. (-73°c to 427°c)

## APPLICATIONS

1. May be used as thermostat
2. NTC thermisters are used as thermometers in a very low-temperature measurements.

## * CHARGE MOVING IN A CIRCLE:

If a charged particle of charge q is moving in circular path of radius r with constant speed v and constant frequency f then

$$I = fq$$

$$I = \frac{vq}{2\pi r} \quad \left(\because f = \frac{v}{2\pi r}\right)$$

* The slope of I-V Graph of Ohm's Law is equal to reciprocal of resistance of conductor

## * CURRENT DENSITY:

The current flowing per unit normal area of cross section is defined as current density

* Electromotive force is not a force but it is energy or work.

## * INTERNAL RESISTANCE:

$$r = \frac{\varepsilon - V}{I} \quad \therefore V = \varepsilon - Ir$$

$$\text{or} \quad r = \left(\frac{E - V}{V}\right)R$$

Day: M T W T F S S

* Charge on α- Particle → $+2e$

* The resistance b.w the ends of a diameter of a circle is like two resistors in parallel. So $4\Omega$ resistor ~~connect~~ converted to 2 resistors of $2\Omega$.

* Resistance of Light Dependant Resistor LDR decreases upon increasing the intensity of falling light. It is used as light sensors.

* DIAMETER RELATION WITH 'I' AND 'R'

$$I \propto d^2$$

$$R \propto \frac{1}{d^2}$$

* To increase the scale of Galvanometer to twice of its initial value we need to connect a shunt?

Ans: $R_s = R_g$

Solution:

$$R_s = \frac{I_g}{I - I_g} R_g$$

As $I_g = 2I_g$

$$R_s = \left(\frac{I_g}{2I_g - I_g}\right) R_g$$

$$R_s = R_g$$

* Resistivity depends on
  1) Nature of material
  2) Temperature

* Silver is best conductor and copper is second best conductor of electricity.

# * COMBINATION OF BULBS (SERIES)

1. TOTAL POWER CONSUMED

$$\frac{1}{P_{TOTAL}} = \frac{1}{P_1} + \frac{1}{P_2} + \cdots$$

2. IF 'n' BULBS ARE IDENDICAL

$$P_{TOTAL} = \frac{P}{n}$$

3. BRIGHTNESS

$$P_{consumed}\,(\text{Brightness}) \propto V \propto R \propto \frac{1}{P_{rated}}$$

i-e in series combination bulb of lesser wattage will give more bright light and potential difference appeared across it will be more

Day: M T W T F S S

# Bulbs In Parallel

1. Total Power Consumed

$$P_{TOTAL} = P_1 + P_2 + P_3 \cdots P_n$$

2. For 'n' Identical Bulbs -

$$P_{TOTAL} = nP$$

3. Brightness

$$P_{consumed} \text{ (Brightness)} \propto P_R \propto I \propto \frac{1}{R}$$

In parallel combination bulb of greater wattage will give more bright light and more current will pass through it.

MCQ: A 100W, 200V bulb is connected to a 160V supply. The actual power consumption would be :

$$\text{Resistance of bulb} = \frac{V^2}{P} = \frac{(200)^2}{100} = 400\,\Omega$$

Actual Power Consumption

$$P = \frac{V^2}{R} = \frac{(160)^2}{400} = 64W$$

Date:

Day: M T W T F S S

* Neutral Temperature for Copper-Iron Thermocouple:
518°F or 270°C

* Inversion Temperature for Copper-Iron Thermocouple:
1004°F or 540°C

* Electro encephalogram (EEG)
⇒ to measure and record electrical activity in the brain
→ measures voltage fluctuations resulting from ionic current flows within neurons of the brain
→ Brain electrical current consist mostly of $Na^+$, $K^+$, $Ca^{+2}$ and $Cl^-$ ions that are pumped through channels in neuron membranes.