STD 12 PHYSICS SLOW LEARNER'S MATERIAL

UNIT 2 CURRENT ELECTRICITY

Two Mark Questions

1. Why current is a scalar?

Current is defined as the scalar product of the current density and area vector in which the charges cross.

2. Define current density.

Current per unit Area of a cross-section of the conductor. (Am^2)

3. Distinguish between drift velocity and mobility.

Drift velocity	Mobility
Average velocity acquired by the electrons inside the conductor in the electric field.	The magnitude of drift velocity per unit electric field.
SI unit: ms^{-1}	SI unit: $m^2V^{-1}s^{-1}$

4. State the microscopic form of Ohm's law.

$$\vec{J} = \sigma\vec{E} \ (\vec{J} - current\ density, \vec{E} - Electric\ field, \sigma - conductivity)$$

5. State the macroscopic form of Ohm's law.

V = IR The resistance is the ratio of potential difference across the given conductor to the current passing through the conductor.

6. What are ohmic and non-ohmic devices?

Ohmic devices:

Materials for which the current versus voltage graph is a straight line through the origin, are said to obey Ohm's law and their behaviour is said to be Ohmic

Non-Ohmic devices:

Materials or devices that do not follow Ohm's law are said to be non-ohmic.

7. Define electrical resistivity.

The resistivity of a material is equal to the reciprocal of its conductivity.

Electrical resistivity of a material is defined as the resistance offered to current flow by a conductor of unit length having unit area of cross-section.

8. Define temperature coefficient of resistance.

It is defined as the ratio of increase in resistivity per degree rise in temperature to its resistivity at T_0.

9. Write down the various forms of expression for power in an electrical circuit.

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

10. State Kirchhoff 's current rule.

The algebraic sum of the currents at any junction of a circuit is zero.

11. State Kirchhoff's voltage rule or loop rule.

In a closed circuit, the algebraic sum of the products of the current and resistance of each part of the circuit is equal to the total emf included in the circuit.

12. State the principle of the potentiometer.

The emf of the cell is directly proportional to the balancing length.

13. What do you mean by the internal resistance of a cell?

Resistance to the flow of charges within the battery.

14.State Joule's law of heating.

$$H = I^2Rt$$

The heat developed in an electrical circuit due to the flow of current varies directly as

(i) the square of the current.

(ii) the resistance of the circuit.

(iii) the time of flow.

15. What is the Seebeck effect?

Seebeck discovered that in a closed circuit consisting of two dissimilar metals, when the junctions are maintained at different temperatures an emf (potential difference) is developed. The current that flows due to the emf developed is called thermoelectric current. The two dissimilar metals connected to form two junctions is known as thermocouple.

16. What is Thomson effect?

If two points in a conductor are at different temperatures, the density of electrons at these points will differ and as a result, the potential difference is created between these points. The Thomson effect is also reversible.

17.What is Peltier effect?

When an electric current is passed through a circuit of a thermocouple, heat is evolved at one junction and absorbed at the other junction. This is known as the Peltier effect.

Three mark Questions

1.State the applications of the Seebeck effect.

1. Seebeck effect is used in thermoelectric generators (Seebeck generators). These thermoelectric generators are used in power plants to convert waste heat into electricity.

2. This effect is utilized in automobiles as automotive thermoelectric generators for increasing fuel efficiency.

3. Seebeck effect is used in thermocouples and thermopiles to measure the temperature difference between the two objects.

2. Write a short note on superconductors.

Resistance becomes zero below the critical temperature.

Current once induced in a superconductor persists without any potential difference.

Mercury exhibits superconductor behaviour at 4.2 K.

3. What is electric power and electric energy?

The electrical power P is the rate at which the electrical potential energy is delivered.

The total electrical energy = power x duration of the time when it is ON.

4. Derive the expression for power P = VI in an electrical circuit.

$$P = \frac{dU}{dt}$$

$$P = \frac{d}{dt}(V.dQ) \qquad U = V.dQ$$

$$= V.\frac{dQ}{dt}$$

$$= VI \qquad I = \frac{dQ}{dt}$$

P = VI

5. Explain the determination of the internal resistance of a cell using a voltmeter.

The potential difference across R = V

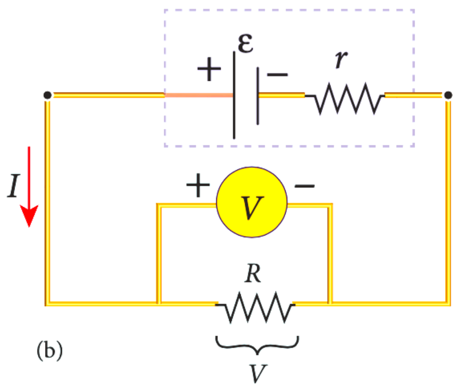
Internal potential difference - Ir (Internal resistance - r)

Emf of the cell - ϵ

$V = \epsilon$ - Ir ==> Ir = ϵ - V

$$\frac{Ir}{IR} = \left(\frac{\epsilon - V}{V}\right)$$

$$r = \left(\frac{\epsilon - V}{V}\right)R$$



(b)

6. State and explain Kirchhoff 's rules.

Current rule:

The algebraic sum of the currents at any junction of a circuit is zero.

By convention, the current **entering** the junction is taken as **positive** and the current **leaving** the junction is taken as **negative**.

It is a statement of law of conservation of electric charge.

Voltage rule:

In a closed circuit, the algebraic sum of the products of the current and resistance of each part of the circuit is equal to the total emf included in the circuit.

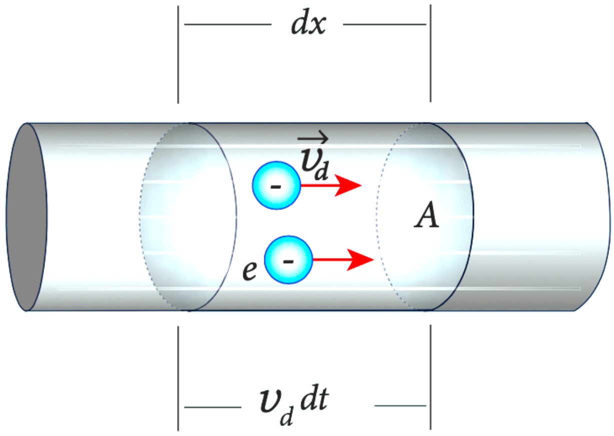
All currents in the circuit reach a steady state condition

The product of current and resistance is taken as positive when the direction of the current is followed otherwise it is taken as negative.

Law of conservation of energy for an isolated system

Five mark Questions

1.Describe the microscopic model of current and obtain the general form of Ohm's law.



$v_d = \frac{dx}{dt}$ dx = $v_d\ dt$

dQ = (e) (A $v_d\ dt$) n

I = $\frac{dQ}{dt}$

I = $\frac{(e)(Av_d dt)n}{dt}$

I = $v_d enA$

Current density:

J = $\frac{I}{A}$

J = $v_d enA$/A = $v_d en$

J = $v_d en$

J =($-\frac{e\tau}{m}E$)en $v_d = -\frac{e\tau}{m}E$

$\vec{J}$ = - $\frac{ne^2\tau}{m}\vec{E}$

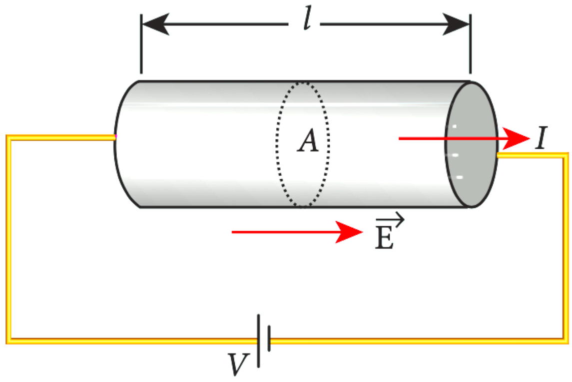
$\vec{J} = -\sigma\vec{E}$ $\sigma = \frac{ne^2\tau}{m}$

But conventionally, we take the direction of (conventional) current density as the direction of the electric field.

$$\vec{J} = \sigma\vec{E}$$

This is called the microscopic model of ohm's law.

2. Obtain the macroscopic form of Ohm's law from its microscopic form and discuss its limitation.



Microscopic form: $\vec{J} = \sigma \vec{E}$

V = El ==> $E = \frac{V}{l}$

$$J = \sigma \frac{V}{l}$$

J = $\frac{I}{A}$

$$\frac{I}{A} = \sigma \frac{V}{l}$$

$$V = I\left(\frac{l}{\sigma A}\right)$$

$$V = IR$$

The resistance is the ratio of potential difference across the given conductor to the current passing through the conductor.

Ohmic devices:

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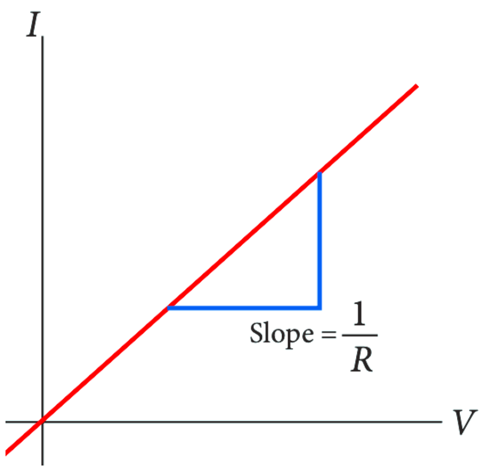
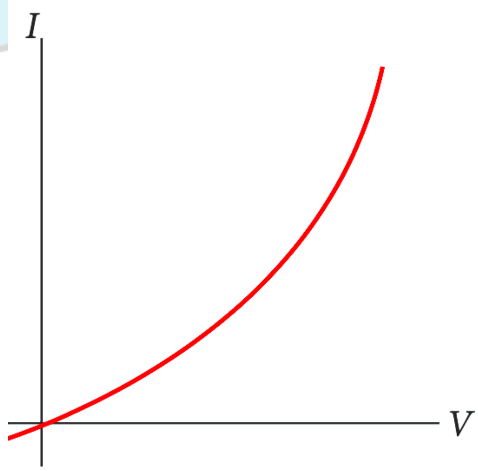
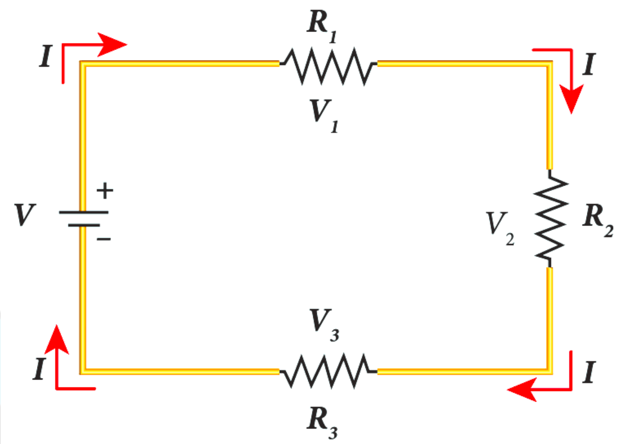
Current against voltage graph for:

Ohmic conductors ***Non-Ohmic conductors***





3. Explain the equivalence resistance of a series and a parallel network.



Resistors in series:

$V = V_1 + V_2 + V_3$

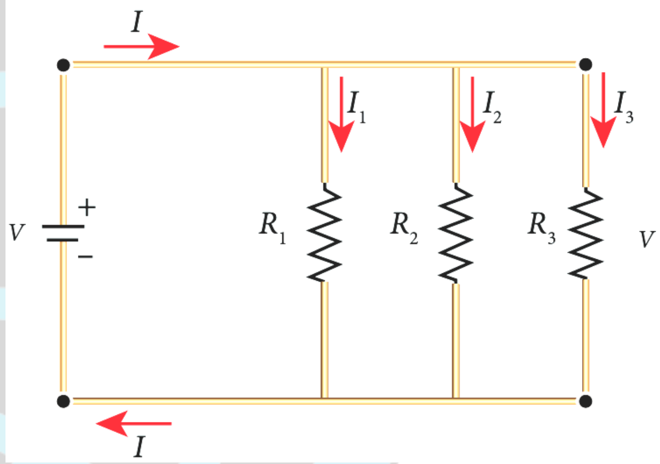
$= IR_1 + IR_2 + IR_3$

$= I\,(R_1 + R_2 + R_3)$

$IR_s = = I\,(R_1 + R_2 + R_3)$

$R_s = R_1 + R_2 + R_3$

Resistors in parallel:



$I = I_1 + I_2 + I_3$

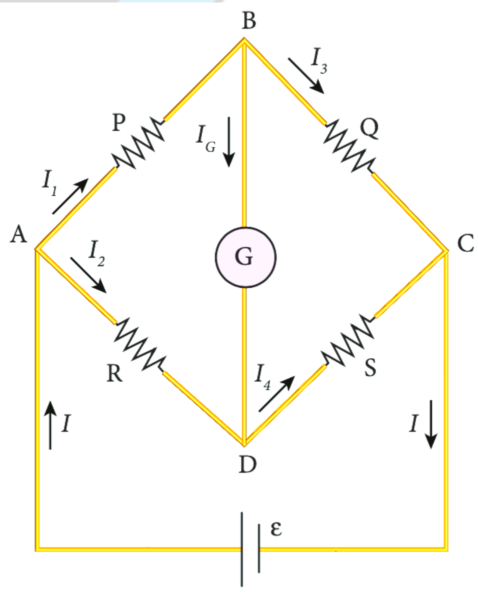
$$= \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\frac{V}{R_s} = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\frac{1}{R_s} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

4. Obtain the condition for bridge balance in Wheatstone's bridge.



The bridge consists of four resistances *P, Q, R* and *S* connected .

A galvanometer *G* is connected between the points *B* and *D*

When the points *B* and *D* are at the same potential, the bridge is said to be balanced.

$$I_G = 0$$

Apply Kirchhoff's current rule:

At Junction B: $I_1 - I_G - I_3 = 0$ ==> **$I_1 = I_3$** ($I_G = 0$) ——>(1)

At Junction D: $I_2 + I_G - I_4 = 0$ ==> **$I_2 = I_4$** ($I_G = 0$) ——>(2)

Apply Kirchhoff's voltage rule:

At loop ABDA: $I_1P + I_GG - I_2R = 0$ ===> **$I_1P = I_2R$** ($I_G = 0$) ——>(3)

At loop ABCDA: $I_1P + I_3Q - I_4S - I_2R = 0$ ==> **$I_3Q = I_4S$** ($I_1P = I_2R$) ———>(4)

Dividing (3) and (4)

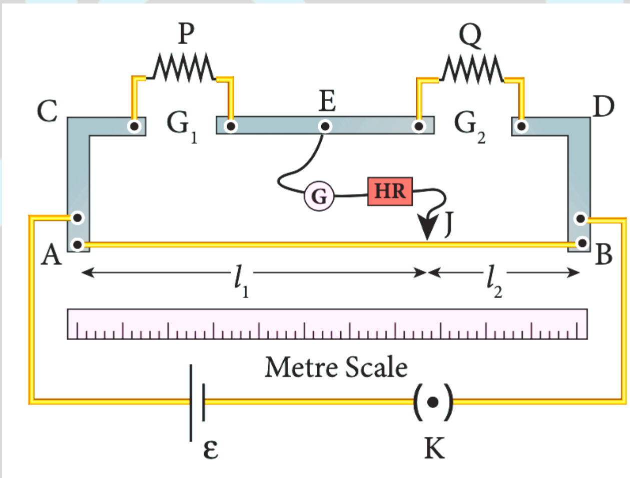
$$\frac{I_1P}{I_3Q} = \frac{I_2R}{I_4S}$$

$$\frac{P}{Q} = \frac{R}{S}$$ (Using (1) and (2))

This is the condition for bridge balance. Only under this condition, galvanometer shows null deflection

5. Explain the determination of unknown resistance using meter bridge.

It consists of a uniform wire of manganin AB of one meter length.	
P	Unknown resistance
Q	Standard resistance
G	Galvanometer
HR	High resistance
J	Jockey
Lechlanche cell and a key (K) are connected between the ends of the bridge wire.	



The position of the jockey on the wire is adjusted so that the galvanometer shows zero deflection

Then for the bridge balance $\frac{P}{Q} = \frac{R}{S} = \frac{r.AJ}{r.JB} = \frac{l_1}{l_2}$ $\qquad$ $P = Q\frac{l_1}{l_2}$

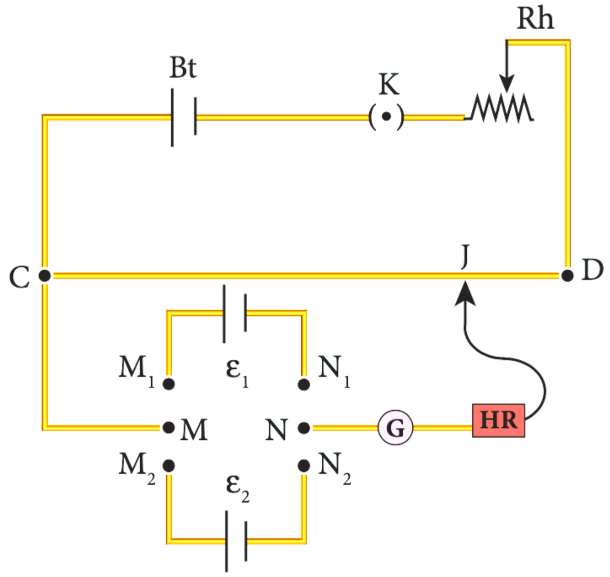
The error can be eliminated, if another set of readings is taken with *P* and *Q* interchanged and the average value of *P* is found.

To find the specific resistance $\rho = Resistance x \frac{A}{l}$

$$\rho = Px\frac{\pi a^2}{l}$$ (P- unknown resistance)

6. How the emf of two cells are compared using a potentiometer?

Primary circuit	
Bt	Battery
K	Key
CD	Potentionometer wire
Secondary circuit	
DPDT switch	Double Pole Double throw
J	Jockey
G	Galvanometer
HR	High resistance



The DPDT switch is pressed towards MN_1 so that cell ε_1 is included in the secondary circuit and the balancing length l_1 is found by adjusting the jockey for zero deflection. Then the second cell ε_2 is included in the circuit and the balancing length l_2 is determined. Let r be the resistance per unit length of the potentiometer wire and I be the current flowing through the wire

$$\epsilon_1 = Irl_1 \longrightarrow (1)$$

$$\epsilon_2 = Irl_2 \longrightarrow (2)$$

By dividing (1) by (2)

$$\frac{\epsilon_1}{\epsilon_2} = \frac{l_1}{l_2}$$

By including a rheostat (Rh) in the primary circuit, the experiment can be repeated several times by changing the current flowing through it.

All the best