DRGP Institute

## Chapter 3

# Current Electricity

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## BOARD- 2013

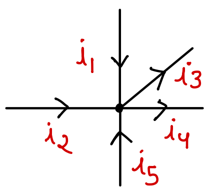
1. write the corresponding values of X and Y for which the lengths of conductors X = 4Ω and Y = $48\times10^{-8}$ Ω-m are reduced to half. (1)

⇒ X = 4Ω
↳ Resistance ($R \propto l$)
So when length reduces to half -
X = 2Ω

Y = $48\times10^{-8}$ Ω-m
↳ Resistivity
($\rho$ doesn't depends on length)
So, y = $48\times10^{-8}$ Ω×m

2. write Kirchhoff's first rule (Law of junction). Drawing a circuit diagram of wheatstone bridge, derive condition for zero deflection in the bridge.

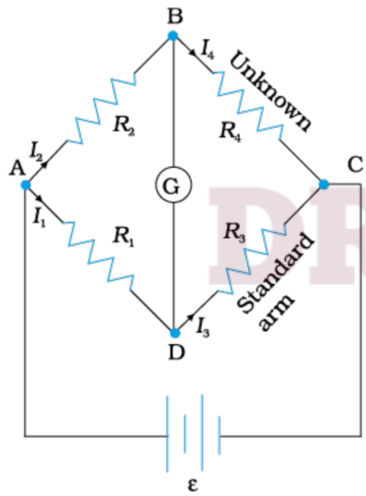
⇒ Kirchhoff's Junction Rule - At any junction, the sum of the currents entering the junction is equal to the sum of currents leaving the junction.




$$i_1 + i_2 + i_5 = i_3 + i_4$$
(Incoming) (outgoing)

→ Applicable for both loop and open type cir.
→ conservation of charge.

Wheatstone bridge - Suppose there are four resistors $R_1, R_2, R_3, R_4$ connected in W.B.
Battery is connected b/w A & C and Galvanometer connected b/w B & D.
AC = Battery arm
BD = Galvanometer arm




→ In balanced conditions resistor are such that there are no current through Galvanometer.

→ By Kirchhoff's junction rule on junction B & D -
$$I_1 = I_3$$
$$I_2 = I_4$$

→ By Kirchhoff's loop rule in ADBA -
$$-I_1R_1 + I_gG + I_2R_2 = 0$$
$$-I_1R_1 + I_2R_2 = 0 \quad \{I_g = 0\}$$
$$I_1R_1 = I_2R_2 \quad -①$$

in loop CDBA -
$$-I_3R_3 + I_gG + I_4R_4 = 0$$
$$-I_1R_3 + I_2R_4 = 0$$
$$I_1R_3 = I_2R_4 \quad -②$$

$eq^n$ ① ÷ $eq^n$ ②

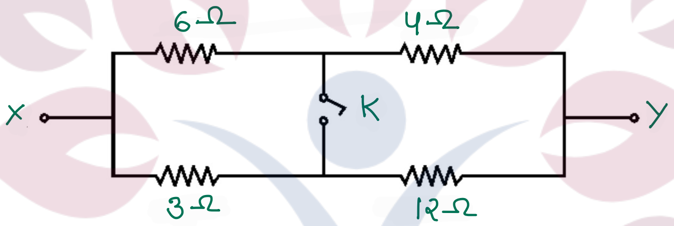
$$\frac{I_1 R_1}{I_1 R_3} = \frac{I_2 R_2}{I_2 R_4}$$

$$\boxed{\frac{R_1}{R_3} = \frac{R_2}{R_4}}$$

Note - If $R_1, R_2, R_3$ are known resistor and $R_4$ are unknown resistor then

$$\boxed{R_4 = \frac{R_2 R_3}{R_1}}$$

3. In the given circuit write the value of resultant resistance in b/w X and Y when key K is -
(i) open (ii) closed




1. when key is open:- $R_1 = 6\Omega$ & $R_2 = 4\Omega$ are in series
$R_3 = 3\Omega$ & $R_4 = 12\Omega$ are in series

$$R_{12} = R_1 + R_2 = 6 + 4 = 10\Omega$$

$$R_{34} = R_3 + R_4 = 3 + 12 = 15\Omega$$

→ Now $R_{12}$ & $R_{34}$ are in parallel.

$$\frac{1}{R} = \frac{1}{R_{12}} + \frac{1}{R_{34}}$$

$$\frac{1}{R} = \frac{1}{10} + \frac{1}{15} = \frac{3+2}{30}$$

$$R = \frac{30}{5} = 6\Omega$$

2. when key is close - $R_1$ & $R_3$ are in parallel
& $R_2$ & $R_4$ are in parallel

$$\frac{1}{R_{13}} = \frac{1}{R_1} + \frac{1}{R_3}$$

$$\frac{1}{R_{13}} = \frac{1}{6} + \frac{1}{3} = \frac{1+2}{6}$$

$$R_{13} = 2\Omega$$

$$\frac{1}{R_{24}} = \frac{1}{R_2} + \frac{1}{R_4}$$

$$\frac{1}{R_{24}} = \frac{1}{4} + \frac{1}{12} = \frac{3+1}{12}$$

$$R_{24} = 3\Omega$$

$$R = R_{13} + R_{24}$$

$$R = 2 + 3 = 5\Omega$$

# BOARD:- 2013 (Supp.)

4. write unit and dimension of mobility of charge. (1 Marks)

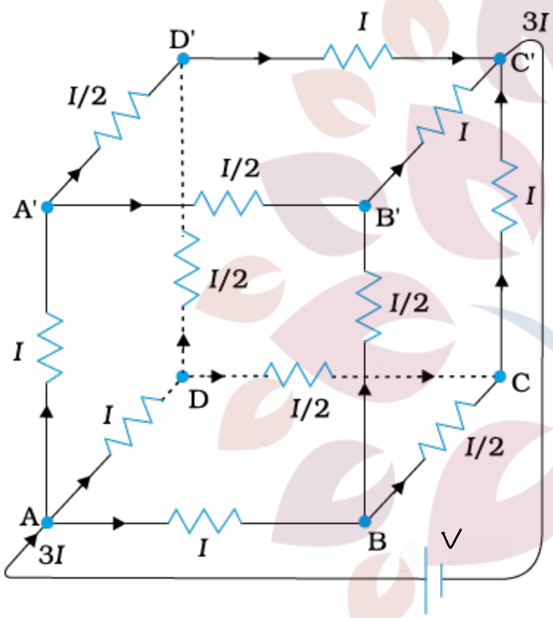
⇒ $\mu = \frac{V_d}{E}$

(Drift velocity per unit electric field)

Unit - $\frac{m/s}{V/m} = m^2/Vs$

Dimension - $[M^{-1}L^0T^2A^1]$

5. 12 resistance each of r-Ω resistance are joined in cubical network, then calculate the equivalent resistance R at the corner opposite to diagonals of this network.




→ This network is not reducible to a simple series and parallel combination of resistors.

→ So, we use symmetric arrangement obtain eq. resistance.

→ Apply Kirchoff's second Rule b/w A & C' point -

$-Ir - \frac{Ir}{2} - Ir + V = 0$

$V = Ir + \frac{Ir}{2} + Ir$

By ohm's Law

$3IR = I\left(r + \frac{r}{2} + r\right)$

$3R = \frac{2r + r + 2r}{2}$

$R = \frac{5r}{6}\ \Omega$

# BOARD:- 2014

6. Obtain equation of $\vec{J} = \sigma\vec{E}$ (2 Marks)
(Basis of drift velocity)

Ans - J (current density) - $J = \frac{I}{A}$ —①

Relation b/w I & $V_d$ (drift velocity)

$I = nAV_de$

put in eq$^n$ ①

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

$J = nV_de$ —②

By definition of drift velocity -

$V_d = \frac{eE}{m}\tau$

where $e = e^-$
$E$ = Electric field
$m$ = mass
$\tau$ = Relaxation time

$$J = ne\left(\frac{eE}{m}\right)\tau$$

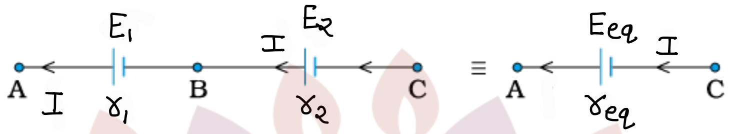
$$J = \frac{ne^2\tau}{m}E$$

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

$\sigma = \frac{ne^2\tau}{m}$
↳ Conductivity

7. Two cells of emf $E_1$ & $E_2$ are connected in series. Their internal resistance are $r_1$ & $r_2$. compute eq. resistance & eq. emf.

Ans.




Combination of cells in which one terminal of a cell is joined with opposite terminal of 2nd cell, is known as series combination.

→ Suppose two cells of $E_1$ & $E_2$ emf and $r_1$ & $r_2$ internal resistance. Current flowing in both are same but terminal voltage is on both cell is different i.e $V_1$ & $V_2$.

$$V = V_1 + V_2$$
$$V = E_1 - Ir_1 + E_2 - Ir_2$$
$$V = (E_1 + E_2) - I(r_1 + r_2)$$

→ If we wish to replace the combination by a single cell b/w A & C of emf $E_{eq}$ and $r_{eq}$ internal resistance we would have -

$$V = E_{eq} - I(r_{eq})$$

→ Compare both-

$$E_{eq} = E_1 + E_2$$
$$r_{eq} = r_1 + r_2$$

→ Current (I) ⇒

$$I = \frac{E.m.f}{\text{Total resistance}}$$

$$I = \frac{E_{eq}}{R + r_{eq}}$$

$$I = \frac{E_1 + E_2}{R + r_1 + r_2}$$

→ if n cell -

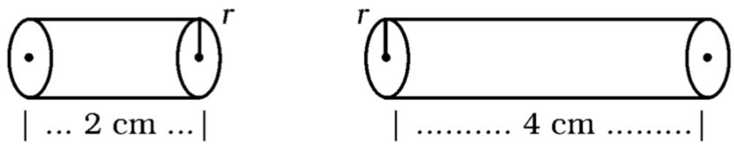
$$E_{eq} = E_1 + E_2 + \cdots\cdots$$
$$r_{eq} = r_1 + r_2 + \cdots\cdots$$
$$I = \frac{E_{eq}}{R + r_{eq}}$$

→ if n cell of same emf and internal resistance -

$$E_{eq} = nE$$
$$r_{eq} = nr$$
$$I = \frac{nE}{R + nr}$$
$$I = \frac{E}{R + r/n}$$

## BOARD - 2015

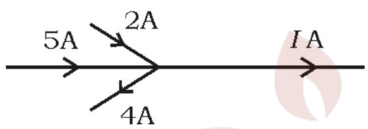
8. Find Ratio of resistivity -




⇒ $\rho_1/\rho_2 = 1$ both have same resistivity because, resistivity only depends on nature and

9. Find value of I - [1]

⇒

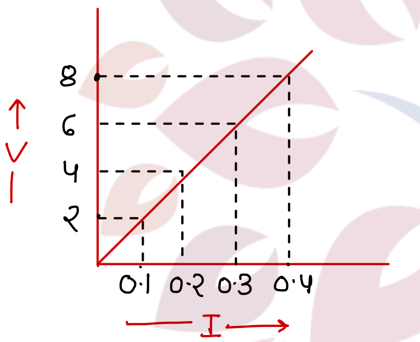



At Junction - $5+2 = 4+I$

$I = 3A$

## BOARD - 2016

10. Determine Resistance - [1]




$$R = \frac{\Delta V}{\Delta I} = \frac{8-2}{0.4-0.1}$$

$$R = \frac{6}{0.3} = 20\,\Omega$$

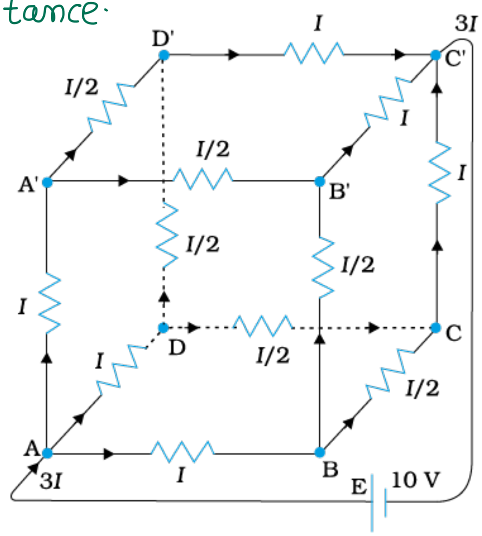
11. write the unit of current density. [1]

⇒ Current flowing perpendicular to unit area of cross-section is called current density.

$\vec{J} = \frac{I}{\vec{A}}$ Unit :- $A/m^2$

12. write Kirchoff's first rule. A battery of 10V and negligible internal resistance is connected to diagonally opposite corner of cubic network consisting of 12 resistor each of 12Ω. Determine eq. resistance. [3 Marks]

⇒




→ This network is not reducible to a simple series and parallel combination of resistors.

→ So, we use symmetric arrangement obtain eq. resistance.

→ Apply Kirchoff's second Rule b/w A & C' point -

$$-Ir - \frac{Ir}{2} - Ir + V = 0$$

$$V = Ir + \frac{Ir}{2} + Ir$$

$$(3I)R = I\left(r + \frac{r}{2} + r\right)$$

$$3R = \frac{2r + r + 2r}{2}$$

$$R = \frac{5r}{6} = \frac{5}{6} \times 12 = 10\,\Omega$$

## BOARD - 2017

13. Define drift velocity of electrons in a conductor. [1]

⇒ Average velocity of $e^-$ in opposite direction of electric field is called Drift velocity.

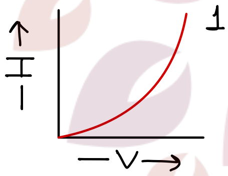
$$\vec{V}_d = \frac{-e\vec{E}\tau}{m} \qquad \text{Unit :- } m/s$$

14. What is ohm's Law? Write its two limitation. [2 Marks]

⇒ If physical condition such as length of conductor, cross-section area, temperature, nature of material remain constant then potential difference across the conductor will be directly proportional to the electric current flowing in the conductor.

$$V \propto I$$
$$V = IR$$

Limitation :-




1. Ohm's Law is not valid for semi-conductor electronic devices like diode & transistor.

2. Ohm's Law is only valid for metallic conductor. Even not valid for metallic conductor at high potential difference.

15. A battery of emf 12V and internal resistance of $2\Omega$ connected to resistor. If 0.5 A current flow through circuit then calculate resistance of resistor. If the circuit is closed what will be terminal voltage of cell. [1+1=2]

⇒ $E = 12V$

$r = 2\Omega$

$I = 0.5A$

$R = ?\,, V = ?$

$$V = E - Ir$$
$$V = 12 - (0.5 \times 2)$$
$$V = 12 - 1$$
$$V = 11\,V$$

$$V = IR$$
$$R = \frac{V}{I}$$
$$R = \frac{11}{0.5}$$
$$R = 22\,\Omega$$

## BOARD-2018

16. The resistance of a conductor is $x\,\Omega$ at 0°C temp. Find the temp. at which resistance of conductor become $3x\,\Omega$. The temp. coefficient of resistance for conductor is $0.4\times10^{-2}\,°C^{-1}$ which is constant.

⇒
$R_1 = x\,\Omega$
$R_2 = 3x\,\Omega$
$T_1 = 0°C$
$T_2 = ?$
$\alpha = 0.4\times10^{-2}\,°C^{-1}$

$$R_2 = R_1\,[1+\alpha(T_2-T_1)]$$
$$\frac{R_2}{R_1} = 1+\alpha(T_2-T_1)$$
$$\frac{3x}{x} = 1+\alpha(T_2-T_1)$$
$$2 = \alpha(T_2-T_1)$$
$$T_2-T_1 = \frac{2}{0.4\times10^{-2}}$$
$$T_2 = 5\times10^{2}+T_1$$
$$T_2 = 500+0°C$$
$$T_2 = 500°C$$

17. Wheat stone Bridge.

## BOARD-2018 (SUPP)

18. The value of physical quantities P & ρ for a conductor is 4 Ω and $24\times10^{-8}\,\Omega\times m$. Write new values of P & ρ if length becomes one fourth. [1]

⇒ $P = 4\,\Omega$ $\quad \rho = 24\times10^{-8}\,\Omega\times m$
↳ Resistance $\quad$ ↳ Resistivity

if length becomes 1/4th
(i) $P = 1\,\Omega$ (Resistance [P] ∝ length)
(ii) $\rho = 24\times10^{-8}\,\Omega\times m$ (Resistivity (ρ) doesn't depend on length).

19. Deduct the microscopic form of ohm's Law [2 Marks]

⇒ $V = IR$ (Ohm's Law) is often stated in an equivalent form $J = \sigma E$ where-

$J$ = current density
$\sigma$ = Conductivity
$E$ = Electric field

vector form:-
$$\vec{J} = \sigma\vec{E}$$

**Derivation** -

$V = IR \quad -①$

Resistivity $\rho = \frac{RA}{l}$ then $R = \frac{\rho l}{A}$

Put in eqⁿ ①

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

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

$E = \frac{I\rho}{A}$ $\quad \{E = \frac{V}{l}\}$ → Electric field

$E = J\rho$ $\quad \{J = I/A\}$ → current density

$E = J \times \frac{1}{\sigma}$ $\quad \{\sigma = \text{Conductivity}\}$

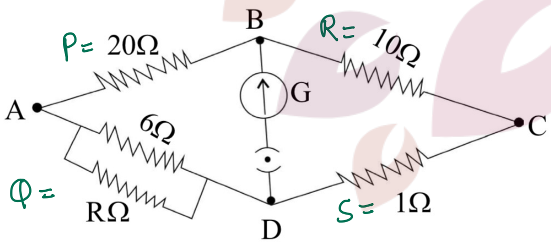
$J = \sigma E$

or

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

## BOARD - 2019

20. Find unknown resistance in balanced state of WSB.




⇒ At Balanced state

$\frac{P}{Q} = \frac{R}{S}$

$\frac{20}{Q} = \frac{10}{1}$

$Q = \frac{20}{10} = 2\Omega$

6Ω & RΩ are in parallel and equivalent is $Q = 2\Omega$

$\frac{1}{6} + \frac{1}{R} = \frac{1}{2}$

$\frac{1}{R} = \frac{1}{2} - \frac{1}{6}$

$\frac{1}{R} = \frac{3-1}{6}$

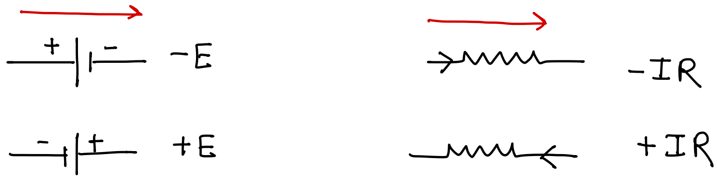
$R = 6/2 = 3\Omega$ Ans.

## BOARD - 2020

21. Write Kirchoff's Second Rule.

⇒
- → Also Known as Loop Law / Mesh Law
- → Algebric sum of all the voltage in any loop is always zero.
- → Only valid for closed circuit

→ Based on Law of Conservation of Energy.




## BOARD:- 2020 (Supp)

22. Define current density. [1]

23. The length of wire is 1.5m and its cross-section area is $6\times10^{-7}m^2$. If the potential difference at its end is 0.9V. Calculate the current flowing in it. [$\rho = 5.6\times10^{-8}\ \Omega\times m$] [2]

⇒ $l = 1.5m$ $A = 6\times10^{-7}m^2$

$V = 0.9V$ $I = ?$

$\rho = 5.6\times10^{-8}\ \Omega\times m$

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

$R = \frac{5.6\times10^{-8}\times1.5}{6\times10^{-7}}$

$R = 1.4\times10^{-1}\Omega$

$V = IR$

$I = \frac{V}{R} = \frac{0.9}{14\times10^{-2}}$

$I = \frac{90}{14} = 6.42A.$

## BOARD:- 2021

24. Unit of electromotive force.

⇒ Volt.

25. Define internal resistance of cell.

⇒ Resistance offered by electrolyte solution in flow of current in cell is called Internal resistance of cell.

SI unit = $\Omega$

26. Draw a Labelled diagram of WSB and obtain condition of balanced point by Kirchoff's Rule.

## BOARD:- 2022

27. If two cells of emf $E_1$ & $E_2$ and internal resistance $r_1$ & $r_2$ are in parallel combination. find formula of equivalent emf.

⇒ $E_{eq} = \frac{E_1r_2 + E_2r_1}{r_1+r_2}$

$r_{eq} = \frac{r_1r_2}{r_1+r_2}$

28. If 12 resistor of 12Ω resistance are joined in a cubical network, then calculate the equivalent resistance at corner opposite to diagonals of this network.

## BOARD:- 2023

29. On increasing the temperature, the resistivity of semiconductor ________.

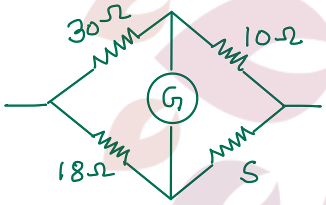
⇒ Decreases.

30. Draw a Labelled diagram of WSB and obtain condition of balanced point by Kirchoff's Rule.

## BOARD:- 2024

31. The SI Unit of Resistivity -

⇒ $\Omega \times m$

32. 

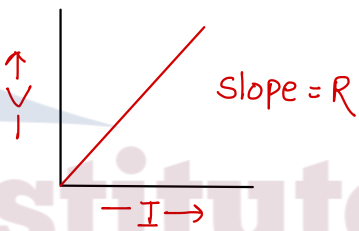

find S.

⇒ $$\frac{30}{18} = \frac{10}{S}$$

$$S = \frac{10 \times 18}{30}$$

$$S = 6\Omega$$

33. Draw VI Graph for ohm's law.

⇒ 




34. Define electromotive force.

⇒ Potential difference across the terminal of cell when no current is drawn from the cell.

SI Unit ⇒ volt