CURRENT ELECTRICITY.

Electric current - the directed flow of electric charges is called current. current can be measured as the amount of charge flowing through an area in unit time.
If q coulomb of charge is flowing through an area in t sec, then current $I = \frac{q}{t}$. current is a scalar quantity and its unit is Ampere.

$$1 \text{ Ampere} = \frac{1 \text{ coulomb}}{1 \text{ second}}$$

current is said to be one ampere if a charge of 1 coulomb is passing through an area in 1 sec.

Instantaneous current - can be defined as the rate of flow of charges i.e $I = \frac{dq}{dt}$.

Ohm's law - the law states that the current flowing through a conductor is directly propotional to the potential difference across its ends, when physical conditions like temperature, mechanical strain etc remains constant

i.e $I \propto V$

$$I = \frac{1}{R} V.$$

$R = \frac{V}{I}$ where R is a constanct called the resistance.

Resistance - Resistance is the property of a material by which it can oppose the electric current flowing through it.
It is a Scalar quantity and its S.I unit is ohm.
$1\,\Omega = \frac{1V}{1A}$. The resistance of a conductor is said to be 1Ω if a current of 1 Ampere is flowing through it under a potential difference of 1 V.

Factors affecting resistance of a conductor.
(i) Nature of the conductor
(ii) length of the conductor
(iii) Area of cross-section
(iv) Temperature

Resistivity (Specific Resistance)
Resistance of a conductor is directly proportional to its length and inversely proportional to its area of cross section
i.e $R \propto l$

$R \propto \frac{1}{A}$

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

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

where ρ is a constant called the resistivity
let $l = 1m$ $A = 1m^2$, then $R = \rho$.
$\therefore$ Resistivity of a conductor can be defined as the resistance per unit length per unit

area of cross-section of that material. the unit of resistivity is Ωm.

note - the resistivity of a material is independent of its dimensions (length and area) but depends on the nature of the material.

Conductance (G)-
the reciprocal of resistance is called the conductance. It is the measure of ability to conduct electric current

$$G = \frac{1}{R}.$$

Its unit is Ω^{-1}

Conductivity (σ)
the reciprocal of resistivity is called the conductivity
i.e $\sigma = \frac{1}{\rho}$ Its unit is $\Omega^{-1} m^{-1}$

Current density - the current flowing through unit area, (normal to the current) is called the current density. $j = \frac{I}{A}$ its unit A/m^2.

consider a conductor of length l, area of crosssection A, and resistivity ρ. then its resistance, $R = \frac{\rho . l}{A}$
then the potential difference across the ends, $V = IR$.

$$V = \frac{I \, \rho . l}{A} \text{ --- (1)}$$

But $V = E l$. --- (2).

where E is the electric field inside the conductor from ① & ②

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

$$E = \frac{I \rho}{A}$$

$$E = j . \rho .$$

where $j = \frac{I}{A}$, the current density

$$j = \frac{E}{\rho}$$

$\boxed{j = \sigma . E}$ (where $\sigma = \frac{1}{\rho}$, conductivity)

Drift velocity - The average velocity acquired by free electrons subjected to an electric field is called the drift velocity.
When an electric field is applied across a conductor, the free electrons will move in a particular direction. During its motion, it may collide with other charged particles. The time interval b/w 2 successive collisions is called the relaxation time (τ).

Expression for drift velocity.
Consider an electron of mass 'm' and charge e is accelerated in an electric field of intensity E.
then $F = eE$. ($F = qE$)

$$ma = eE$$

$$a = \frac{eE}{m}$$

we have, $v = u + at$

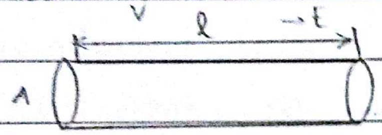
Here $u = 0$, $v = V_d$ & $t = \tau$.

$\therefore V_d = \frac{Ee}{m}\tau$.

2.

Deduction of ohm's law from drift velocity

Consider a conductor of length 'l' and area of cross section 'A'. Let n be the no of electrons per unit volume.



Volume of the conductor $= Al$

Total no of e's in the conductor $= nAl$

Total charge of the conductor $q = nAle$.

we have the current flowing through the conductor

$$I = \frac{q}{t}$$

$$= \frac{nAle}{t}$$

$$= neAV_d.$$

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

$$\therefore I = \frac{ne^2AE\tau}{m}$$

But $E = \frac{V}{l}$, where V is the potential difference across the ends of the conductors.

$$\therefore I = \frac{ne^2A}{m}\frac{V}{l}\tau$$

$$V = \frac{I m l}{n e^2 A \tau} \longrightarrow (1)$$

In the above equation, m, l, n, e & A are constants.

If temp is kept constant then
τ = a constant. i.e, at constant temp

$$V = \text{a constant} \times I$$

$$V \propto I$$

this is Ohms law.

(1) can be written as

$V = IR$, where $R = \frac{ml}{ne^2 A \tau} \longrightarrow (2)$

But we have $R = \frac{\rho . l}{A} \longrightarrow (3)$

from (2) & (3)

$$\rho = \frac{m}{ne^2 \tau}$$

$$\rho \propto \frac{1}{\tau}$$

Effect of temperature on resistivity

when temp increases, the rate of collision also increases. $\therefore$ relaxation time decreases and as a result, the resistivity increases i.e the resistivity of a conductor increases with increase in temp.

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Temperature coefficient of resistance.

let R_0 and R be the resistances of a material at temperatures T_0 and T $(T > T_0)$ respectively. then the quantity $\alpha = \frac{R - R_0}{R_0 (T - T_0)}$ is known as the temperature coefficient of resistance.

Case-1

let $R > R_0$.

then α is +ve. It indicate the resistance of the material is increasing with temperature. ex. metallic conductors

Case-2

let $R = R_0$

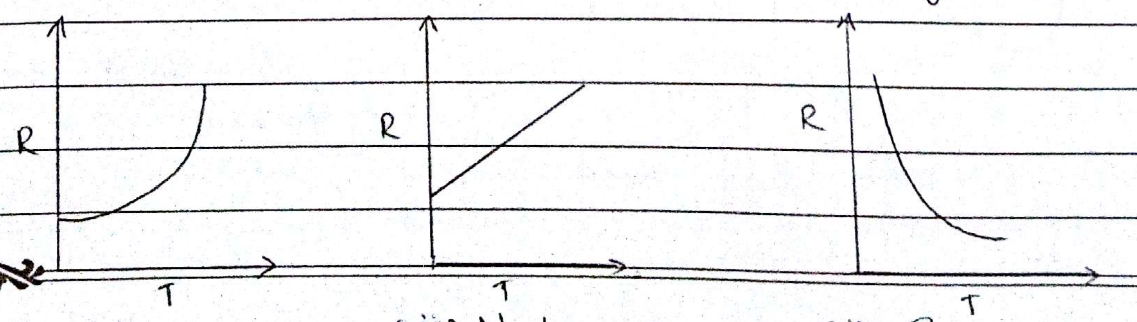
then α is 0. ie, the resistance of the material is independent of the temperature. ex- Insulators.

Case-3

let $R < R_0$.

then α is -ve ie, the resistance decreases with temperature ex- Semiconductors.

the variation of resistance with temperature for different materials is graphically shown in figure.

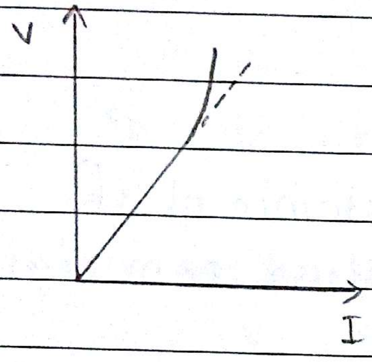


(i) Cu (ii) Nichrome (iii) Semiconductors

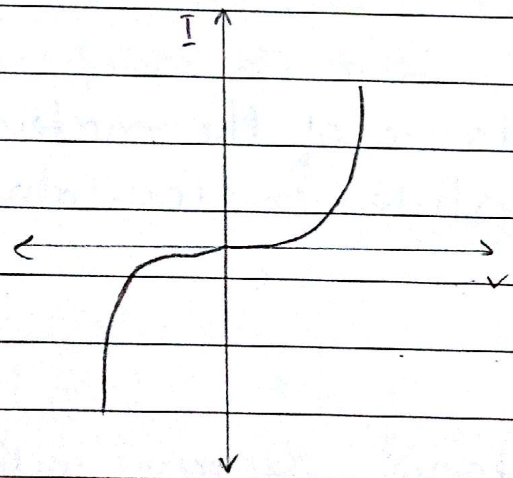
Failures of ohm's law.

According to ohm's law $V \propto I$ i.e. the VI graph is a straight line

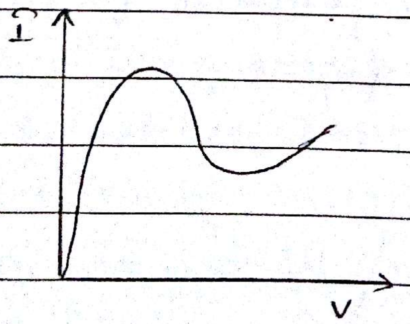
(i) Some conductors are showing some variation from the straight line behaviour of the graph.



(ii) Semiconductors does not obey ohm's law.



(iii) the V-I graph (characteristics) of GaAs crystal is as shown in figure.



(GaAs)

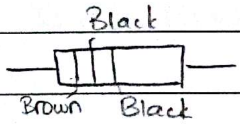
Colour code of resistors.

BB ROY of Great Britan has a Very Good Wife.

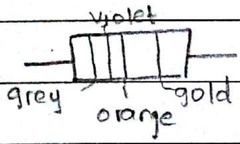
Black - 0
Brown - 1
Red - 2
Orange - 3
Yellow - 4
Green - 5
Blue - 6
Violet - 7
Grey - 8
White - 9

Gold - 5%
Silver - 10%
No colour - 20%

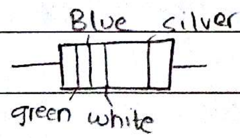
Q Find the resistance of the following resistors.

(i) 

$10 \times 10^{0} \Omega \pm 20\%$

(ii) 

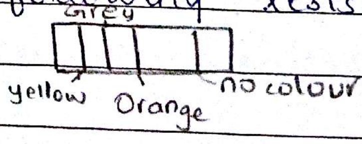
$87 \times 10^{3} \Omega \pm 5\%$

(iii) 

$56 \times 10^{9} \Omega \pm 10\%$

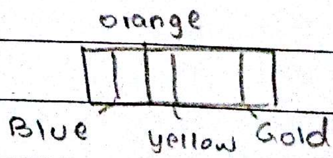
Q Find the colour code of the following resistors.

(i) $48 \times 10^{3} \pm 20\%$

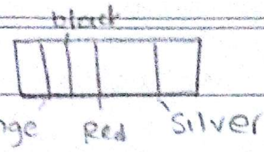


(ii) $630\,k\Omega \pm 5\%$

$63 \times 10^{4} \Omega \pm 5\%$

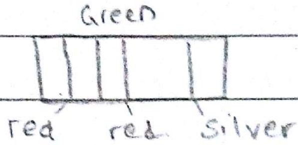


(iii) $30 \times 10^2\ \Omega \pm 10\%$



(iv) $2.5\ k\Omega \pm 10\%$

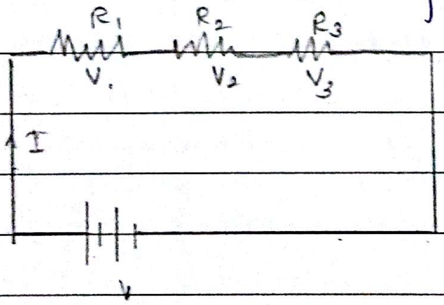
25×10^2



- <u>combination of resistors.</u>

(1) <u>Resistors in Series.</u>

Consider three resistors R_1, R_2 and R_3 connected in series across a cell of EMF 'V' volt. Since the resistors are connected in series, the current flowing through them is the same. let V_1, V_2 and V_3 be the P.D's across R_1, R_2, R_3 respectively



then $V = V_1 + V_2 + V_3$

$IR = IR_1 + IR_2 + IR_3$

$\boxed{R = R_1 + R_2 + R_3}$

i.e. the effective resistance increases.

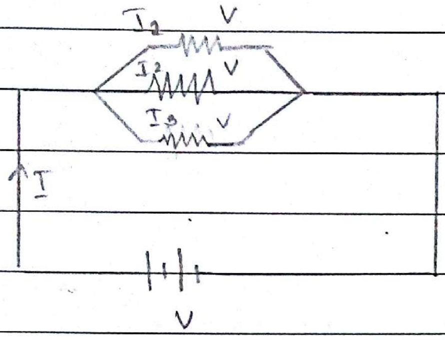
$V = IR$

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

(11)

Resistors in parallel

Consider 3 resistors R_1, R_2 and R_3 connected in parallel across a cell of EMF 'V' volt. Fig



Since the resistors are connected in parallel, the voltage across them is the same.
Let I_1, I_2, & I_3 be the currents through R_1, R_2, and R_3 respectively then $I = I_1 + I_2 + I_3$

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

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

∴ the effective resistance decreases.

Q. Two resistors combined to get a maximum resistance of 9Ω and a minimum resistance of 2Ω. Identify the individual resistance.

$R = R_1 + R_2$

$9 = R_1 + R_2$ — (1)

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{2} = \frac{R_2 + R_1}{R_1 R_2}$$

$$\frac{1}{2} = \frac{9}{R_1 \cdot R_2}$$

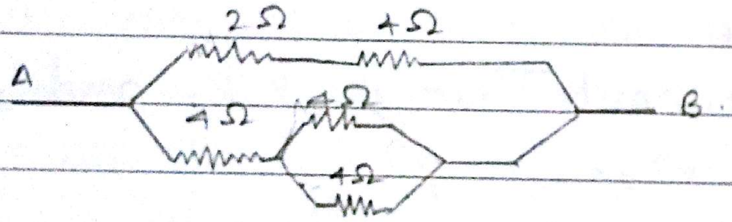
$R_1 \cdot R_2 = 18$

$R_1 + R_2 = 9$

$\therefore R_1 = 3\,\Omega$

$R_2 = 6\,\Omega$

Find the effective resistance across A and B.



$R_s = 6$

$$\frac{1}{R_p} = \frac{1}{4} + \frac{1}{4}$$

$$\frac{1}{R_p} = \frac{4+4}{16}$$

$$R_p = \frac{16}{8} = 2$$

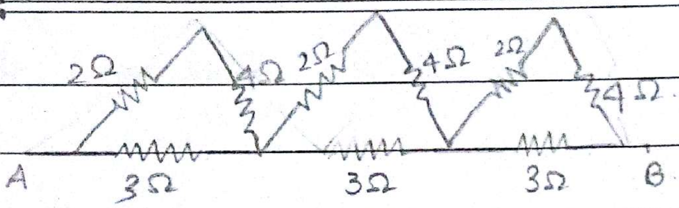
$R_s = 8$

$$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{8}$$

$$\frac{1}{R_p} = \frac{8+6}{86}$$

$$R_p = \frac{42}{14}$$

Q).



$R_s = 2+4$ $R_s = 2+4$ $R_s = 2+4$

$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{3}$ $\frac{1}{R_p} = \frac{1}{6} + \frac{1}{3}$

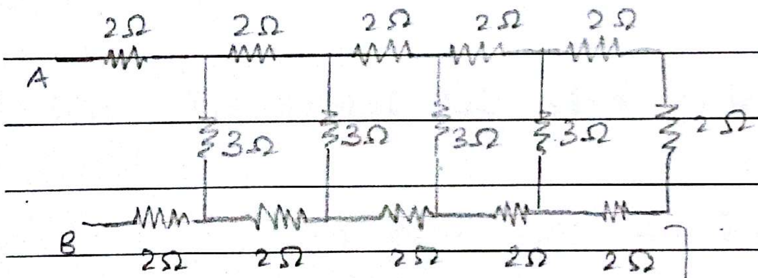
$\frac{1}{R_p} = \frac{3+6}{18}$

$R_p = 2$ $R_p = 2$ $R_p = 2$

$R_s = 2+2+2$

$= 6\ \Omega$

(iii)



$R_s = 2+2+2 = 6.$

$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{3}$

$R_p = \frac{18}{9} = 2.$

Similarly

$R_s = 6$

$R_p = 2$

|||y, $R_s = 6$

$R_p = 2$

|||y $R_s = 6$

$R_p = 2$

finally, $R_s = 2+2+2$

$= 6\ \Omega.$

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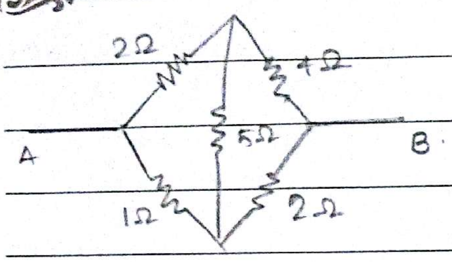


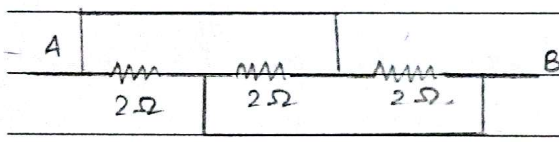
According to wheat stone principle.

$R_s = 6\Omega$

$R_s = 3\Omega$

$\therefore \frac{1}{R_p} = \frac{1}{6} + \frac{1}{3}$.

$R_p = 2\Omega$

(iii) 

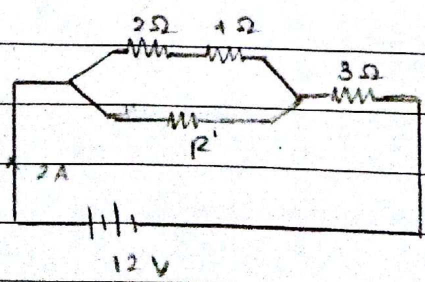
$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

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

$\frac{1}{R} = \frac{3}{2}$

$R = \frac{2}{3}\Omega$

Q Find the value of R, if the current drawn from the cell is 2A.



$R_s = 6\Omega$.

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

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

$R_p = \frac{6R'}{6+R}$

$R = 3 + \frac{6R'}{6+R'}$

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$$R = \frac{3(G+R') + GR'}{(G+R')}$$

$V = IR$

$$12 = 2 \times \frac{3(G+R') + GR')}{(G+R')}$$

$$G = \frac{18 + 3R' + GR'}{G+R'}$$

$$G = \frac{18 + 9R'}{G+R'}$$

$3G + GR' = 18 + 9R'$

$3R' = 18$

$R' = 6\ \Omega$

EMF, Terminal Pd and internal resistance of a cell.

(i) EMF. - EMF of a cell can be defined as the potential difference across its terminal when no current is drawn from it.

(ii) Terminal Pd (V) - Terminal Pd of a cell can be defined as the potential difference b/w its terminals when current is drawn from it

(iii) Internal resistance (r). the resistance offered by the material inside the cell is called its internal resistance

Consider a cell of EMF 'E' and internal resistance 'r' is connected across an external resistance 'R' as shown in the figure

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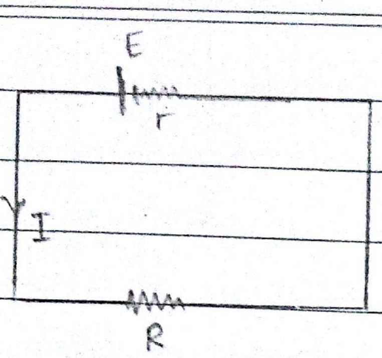


let I be the current flowing through the circuit, then the terminal Pd, $\boxed{V = E - Ir}$ — (1)

But $V = IR$

$\therefore (1) \Rightarrow IR = E - Ir$

$IR + Ir = E$

$I(R+r) = E$

$$\boxed{I = \frac{E}{R+r}}$$

$\therefore (1) \Rightarrow Ir = E - V$

$$r = \frac{E-V}{I}$$

$$= \frac{E-V}{V/R}$$

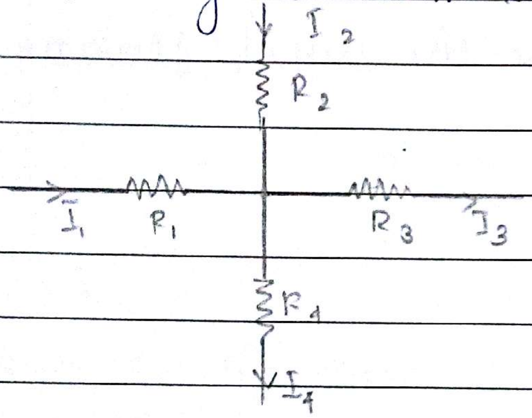
$$= \left(\frac{E-V}{V}\right)R$$

$$\boxed{r = \left(\frac{E}{V} - 1\right)R}$$

KIRCHHOFF'S LAWS

1). kirchhoff's first rule (kirchhoff's junction rule or kirchhoff's current rule).

the rule states that the total current coming to a junction is equal to the total current leaving the junction or the algebraic sum of currents meeting a junction is 0



$$I_1 + I_2 = I_3 + I_4$$

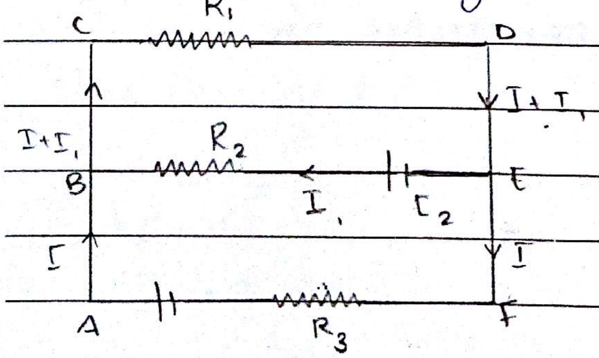
$$I_1 + I_2 - I_3 - I_4 = 0$$

Note.

kirchhoff's current Rule is in accordance with the law of conservation of charge.

Kirchhof's Second Rule (Voltage Rule/ loop Rule)

the law States that in any closed loop of an electrical circuit, the algebraic sum of product of current and resistance is equal to the algebraic sum of EMF's of the loop.



ACDFA

$$(I+I_1)R_1 + IR_3 = E_1$$

ABEFA $(I_1)R_2 - (I)R_3 = E_1 - E_2$

BCDEB $(I+I_1)R_1 + I_1R_2 = E_2$

Kirchoff's Voltage rule is in accordance with law of conservation of energy

Combination of cells

(i) cells in series: Consider 2 cells of EMF's E_1 & E_2 with internal resistance r_1 & r_2, are connected in series As shown in figure. Let I be the current flowing through the circuit

PD across the points A and C

$$V_A - V_C = E_1 - Ir_1$$

PD across the points C and B

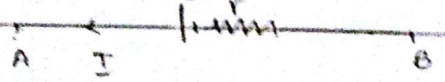
$$V_C - V_B = E_2 - Ir_2$$

$$V_A - V_B = (V_A - V_C) + (V_C - V_B)$$

$$= E_1 - Ir_1 + E_2 - Ir_2$$

$$= E_1 + E_2 - I(r_1 + r_2) \quad \text{—— (1)}$$

Let the combination of the cell behave like a single cell of EMF E and internal resistance r.



$$V_A - V_B = E - Ir \quad \text{—— (2)}$$

From (1) & (2)

we get the equivalent EMF

$E = E_1 + E_2$

and equivalent internal resistance $r = r_1 + r_2$

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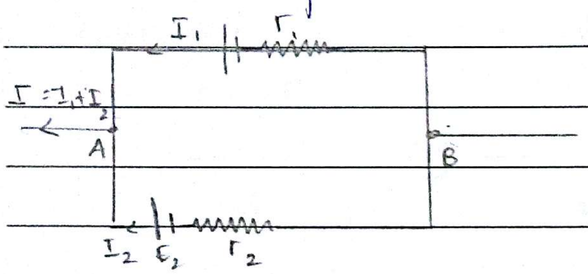
∴ when cells are connected in series the resultant EMF increases.

(ii) Cells in parallel - Consider 2 cells of EMF's E_1 & E_2 with internal resistances r_1 and r_2 connected in parallel across the points A and B as shown in the figure



let I_1 be the current drawn from E_1 and I_2 that from E_2. then the current drawn from the combination

$$I = I_1 + I_2 \quad \text{—— (1)}$$

Since the cells are connected in parallel, the P.D across them will be the same.

for the cell E_1,

$V = E_1 - I_1 r_1$, where V is the PD across A and B

$I_1 r_1 = E_1 - V$

$$I_1 = \frac{E_1 - V}{r_1}$$

for the cell E_2

$V = E_2 - I_2 r_2$

$I_2 r_2 = E_2 - V$

$$I_2 = \frac{E_2 - V}{r_2}$$

(1) ⇒

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

$$= \frac{(E_1 - V) r_2 + (E_2 - V) r_1}{r_1 \cdot r_2}$$

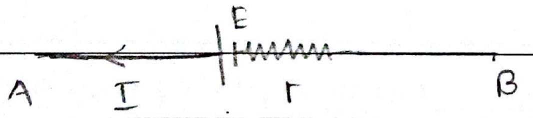
$$= \frac{E_1 r_2 - V r_2 + E_2 r_1 - V r_1}{r_1 \cdot r_2}$$

$$I r_1 r_2 = E_1 r_2 + E_2 r_1 - V(r_1 + r_2)$$

$$V(r_1 + r_2) = E_1 r_2 + E_2 r_1 - I r_1 r_2$$

$$V = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2} - \frac{I r_1 r_2}{r_1 + r_2} \longrightarrow (2)$$

let this combination behave ~~lf~~ like a single cell of EMF E and internal resistance r



$$V = E - Ir \longrightarrow (3)$$

from (2) and (3)

we get the equivalent EMF

$$\boxed{\frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}}$$

and the equivalent internal resistance

$$\boxed{r = \frac{r_1 r_2}{r_1 + r_2}}$$

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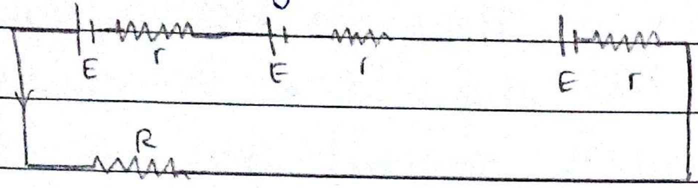
Series and parallel combination of Identical cell



$E_{net} = nE$

$r_{net} = nr$

$R_{net} = nr + R$

$I = \frac{E_{net}}{R_{net}}$

$I = \frac{nE}{nr + R}$

Case. 1

let $R >> r$

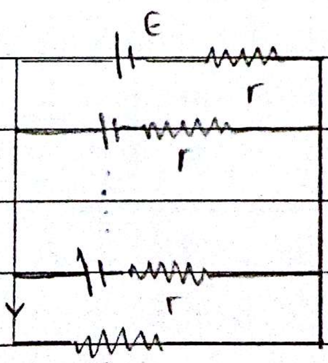
$I = \frac{nE}{R}$

$I = n \times$ current from one cell

Case. 2

let $r >> R$

$I = \frac{nE}{nr} = \frac{E}{r}$ current from one cell



$E_{net} = E$

$\frac{1}{r_{net}} = \frac{1}{r} + \frac{1}{r} + \dots\dots$

$r_{net} = \frac{r}{n}$

$R_{net} = \frac{r}{n} + R = \frac{r + nR}{n}$

$$I = \frac{E_{net}}{R_{net}}$$

$$= \frac{E}{\frac{r + nR}{n}}$$

$$I = \frac{nE}{r + nR}$$

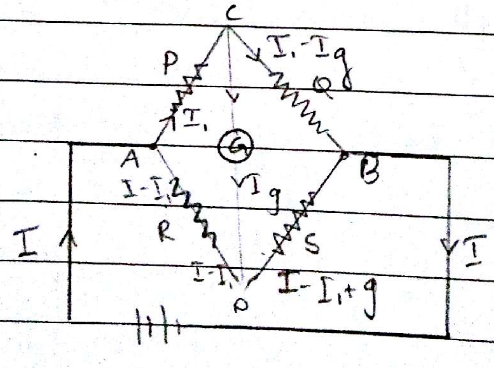
note. 1

If External resistance is greater than internal resistance $R >> r$, the cells should be connected in series to get maximum current.

2. If internal resistance is greater than external resistance $r >> R$, the cells should be connected in parallel to get maximum current.

Wheat Stone's Bridge.

Wheatstone's bridge is a device used to determine the value of the unknown resistors. the circuit diagram of a wheat stones bridge is shown in figure.



It consists of 4 resistors P, Q, R and S connected across a cell of EMF 'V' volt. A galvanometer of resistance 'G' is connected across the points C and D. The currents flowing through each resistor is shown in figure. Let I_g be the current through the galvanometer.

Apply Kirchoff's voltage rule for
(i) the loop ADCA

$$(I-I_1)R - I_gG - I_1P = 0 \longrightarrow (1).$$

(ii) for the loop CDBC

$$I_gG + (I-I_1+I_g)S - (I_1-I_g)Q = 0. \longrightarrow (2).$$

The value of the resistors P, Q, R and S are adjusted such that the galvanometer shows null deflection/zero deflection. Then the bridge is said to be balanced.
i.e. when the bridge is balanced, $I_g = 0$.

$$(1) \Rightarrow (I-I_1)R - I_1P = 0$$
$$I_1P = (I-I_1)R \longrightarrow (3).$$

$$(2) \Rightarrow (I-I_1)S - I_1Q = 0$$
$$I_1Q = (I-I_1)S \longrightarrow (4).$$

$$\frac{(3)}{(4)} \Rightarrow \frac{I_1P}{I_1Q} = \frac{(I-I_1)R}{(I-I_1)S}$$

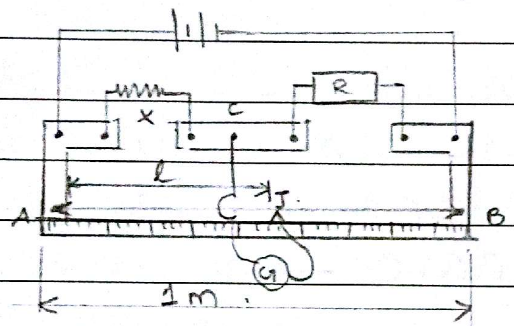
$$\boxed{\frac{P}{Q} = \frac{R}{S}}$$

This result is known as the wheat Stone's principle.

Meter Bridge

Meter bridge is a device used to determine the value of unknown resistance. It works on wheat stone's principle. ie $\frac{P}{Q} = \frac{R}{S}$

connections are made as shown in figure.



AB is a long uniform wire of length 100 cm. the unknown resistance 'X' and a resistance box 'R' are connected in the left and right gaps of the meter bridge respectively. A galvanometer is connected b/w the point 'C' and a jockey J. the jockey is moved along the wire AB until the galvanometer shows null deflection. At that condition, the bridge is said to be balanced. the balancing length 'l' is measured from the end 'A' to the balancing point 'J'.

According to wheat stone's principle $\frac{P}{Q} = \frac{R}{S}$. Here,

$$\frac{X}{R} = \frac{\text{Resistance of AJ}}{\text{Resistance of JB}}$$

let ρ be the resistivity and A be the area of cross section of the wire AB then, Resistance of $AJ = \frac{\rho l}{A}$ and resistance of $JB = \frac{\rho(100-l)}{A}$

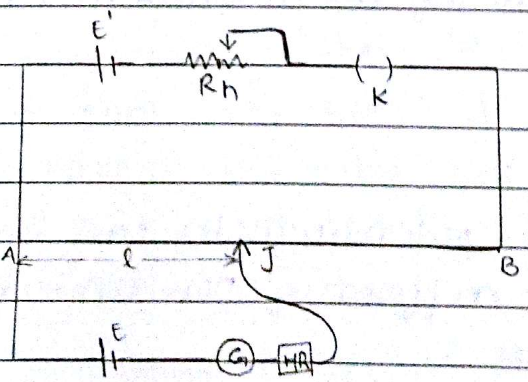
$\therefore$ ① becomes $\frac{X}{R} = \frac{\rho . l/A}{\frac{\rho(100-l)}{A}}$

$\therefore \frac{X}{R} = \frac{l}{100-l}$

$$\boxed{X = \frac{Rl}{(100-l)}}$$

Potentiometer

potentiometer is a device used to measure potential difference accurately. It consists of a long uniform wire (Approx 10 m) connected b/w 2 points A and B. A driver cell of EMF E' is connected across the points A and B through a rheostat and a key. The cell whose EMF E is to be determined is connected across the point A and a jockey through a galvanometer and a high resistance.



The jockey is moved along the wire AB until the galvanometer shows null deflection.
Null deflection indicate that there is no current ~~flo~~ drawn from the cell E. It is possible only when

EMF of the cell E = the potential difference across the wire AJ. where J is the balancing point.
ie. E = Pd across AJ.
= $I \times$ Resistance of AJ. ($V = IR$)
where I is the current drawn from the driver cell.
ie $E = I \times \frac{\rho l}{A}$ where ρ is the resistivity, A is the area of cross section and l is the balancing length of the wire.
Since I, ρ, A ~~are~~ are constants $\boxed{E \propto l}$
this is the principle of potentiometer.

Sensitivity of a potentiometer

Sensitivity of a potentiometer can be defined as the balancing length per unit ~~vo~~ potential difference

Sensitivity $= \frac{l}{E}$.

the sensitivity of a potentiometer can be increased by increasing the length of the potentiometer wire

Potential gradient.

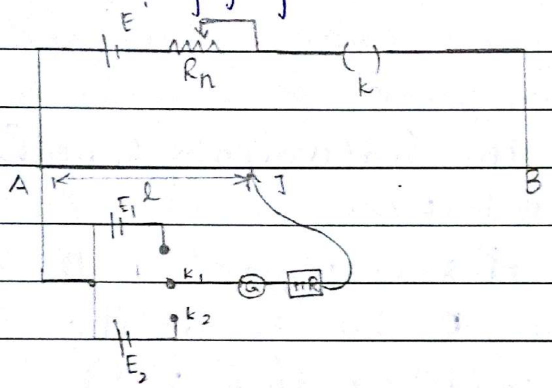
potential gradient of a potentiometer can be defined as the potential difference per unit length of the potentiometer wire.

Potential gradient $= \frac{V}{l}$

Applications of potentiometer.

1) Comparison of EMF's.

The cells whose EMF's E_1 and E_2 are to be compared are connected across a potentiometer through a two way key as shown in the figure



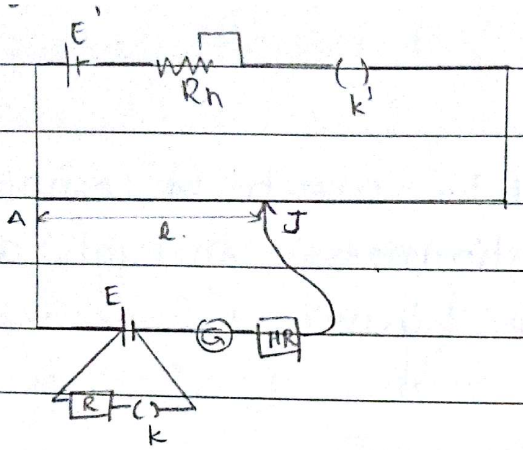
Let the key k_1 is closed and k_2 is open. i.e the cell E_1 is included in the cell. Let the balancing length for E_1 is l_1. Then $E_1 \propto l_1$.
Let the key ~~k2~~ is closed and k_1 is open i.e the cell E_2 is included in the cell. Let l_2 be the balancing length for E_2, then $E_2 \propto l_2$.

then, $$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

If we know the EMF of one cell, we can determine the EMF of the other cell using the above result

Determination of internal resistance of a cell.

The cell whose ~~the~~ internal resistance 'r' is to be determined is connected across a potentiometer as shown in the figure. A resistance box R (known resistance) is connected parallel to the cell through a key 'K'.



let the key 'k' is open and the balancing length is l_1 then the EMF of the cell $E \propto l_1$
when the key 'k' is closed, ~~H~~ some current will flow through the resistance R. let l_2 be the balancing length for that condition then $V \propto l_2$.
where V is the terminal potential difference

$$\frac{E}{V} = \frac{l_1}{l_2}.$$

we have the internal resistance of a cell,

$$r = \left(\frac{E}{V} - 1\right) R$$

$$\therefore r = \left(\frac{l_1}{l_2} - 1\right) R.$$

Q. A potentiometer is more accurate than volt meter. why?
potentiometer is working on null deflection method i.e, no current is drawn from the cell $\therefore$ the measurement will be accurate.

Electric power

power is the time rate of doing work

$P = \frac{W}{t}$. Its unit is watt

let V be the potential difference across the ends of a wire then $V = \frac{W}{Q}$ where W is the work done in bringing the charge Q from one end to the other

$W = VQ$

let t be the time taken by the charge to flow. then

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

$\boxed{P = VI}$ —①

where $I = \frac{Q}{t}$, the current.

According to Ohms law $V = IR$

$\therefore P = IR \cdot I$

$P = I^2R$ —②.

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

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

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

the power of a device is directly propotional to its resistance when the current flowing through it remains constant.

the power of a device is inversly propotional to its resistance when the voltage across it remains constant

PH/XXX.

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

$= \frac{\text{Energy}}{\text{time}}$

Energy = P x time

Heat energy generated across a conductor $H = P \times t$

$$\boxed{\begin{aligned} H &= VI \times t \\ H &= I^2R \times t \\ H &= \frac{V^2}{R} t \end{aligned}}$$

Mobility (μ)

We have the drift velocity $V_d = \frac{eE\tau}{m}$

the drift velocity per unit electric field is called the mobility. i.e $\mu = \frac{V_d}{E}$

$$\boxed{\mu = \frac{e\tau}{m}}$$

Q 2 electric bulbs are marked 220V, 40W and 220V 60W which one has higher resistance

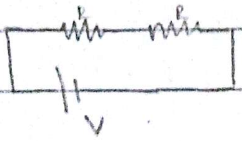
$P = \frac{V^2}{R}$

$40 = \frac{(220)^2}{R}$ $\quad$ $60 = \frac{(220)^2}{R}$

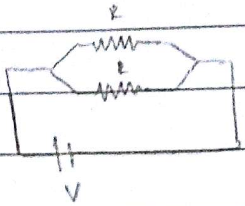
$R = \frac{(220)^2}{4}$ $\quad$ $R = \frac{(220)^2}{6}$

$P \propto \frac{1}{R}$ the one with less power will have high resistance

Q. 2 metal wires of same dimensions are first connected in series and then in parallel to a source of supply. What will be the ratio of heat produced in the two cases.



$R_s = R_1 + R_2 = 2R$



$\frac{1}{R_p} = \frac{1}{R} + \frac{1}{R}$

$R_p = \frac{R}{2}$

$H_s = \frac{V^2 \times t}{R_s}$ $\quad H_p = \frac{V^2 \times t}{R_p}$

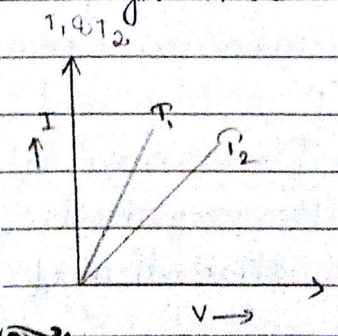
$$\frac{H_s}{H_p} = \frac{\frac{V^2 \times t}{R_s}}{\frac{V^2 \times t}{R_p}}$$

$$\frac{H_s}{H_p} = \frac{R_p}{R_s}$$

$$= \frac{\frac{R}{2}}{2R}$$

$$= \frac{1}{4}$$

Q. VI graph of a metallic wire at 2 different temperatures T_1 and T_2 are shown in figure. Which of the 2 temp. is high and why?



Slope of the graph $= \frac{I}{V}$

$= \frac{I}{R}$

$R \propto \frac{1}{\text{Slope of the graph}}$

Since T_2, is having less slope, it will have high [illegible] temp.

Q. Potential difference V is applied across the copper wire of length 'l' and diameter 'd'. What is the effect on drift velocity on electrons if
(i) V is doubled.
(ii) l is doubled
(iii) d is doubled.

$E = \frac{V}{d}$

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

$$V_d = \frac{e \cdot \frac{V}{d} \tau}{m}$$

$$V_d = \frac{eV\tau}{d \cdot m}$$

(i) If V is doubled
V_d increases 2 times

(ii) If l is doubled

$$V_d = \frac{eV\tau}{2lm}$$

It becomes $\frac{1}{2}$ times

(iii) No change. (It is independent of diameter)

Q. In the potentiometer circuit shown, the balance point is at X. State with reason, where the balancing point will be shifted when (i) Resistance R is increased keeping all parameters unchanged (ii) Resistance S is increased, keeping R constant. (iii) Cell P is replaced by another cell whose EMF is lower than that of cell Q.

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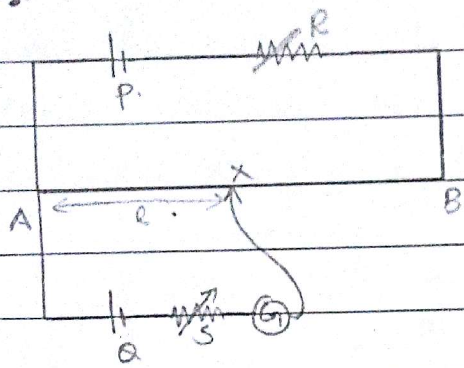

EMF of cell Q = Pd across AX
= I x Resistance of AX.

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

$E \propto Il$.

$l \propto \frac{1}{I}$ (Since E is a constant)

when R increases, I decreases
∴ l increases.

the balancing point will shift towards B.

(ii) No change.
Since at the balancing point no current is flowing through it

(iii) Balancing point will not be obtained because it will go beyond the point B.

Q. In a wheatstone Bridge experiment, a student by mistake connects the cell in place of galvanometer and galvanometer in place of the cell. what will be the change in the deflection of the bridge.

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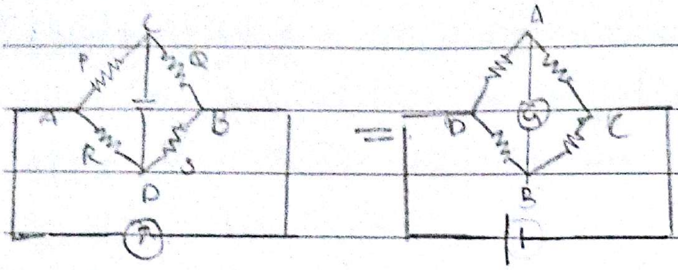
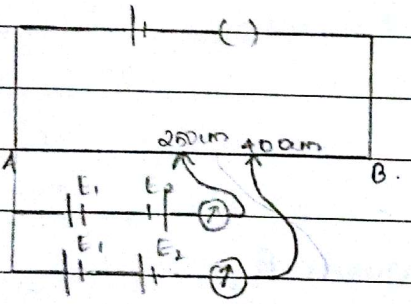


$$\frac{R}{P} = \frac{S}{Q}$$

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

∴ no change in the deflection of the bridge

Q 2 primary cells of EMF is E_1 and E_2 are connected to the potentiometer wire AB as shown in the fig If the balancing length for the 2 combination of the cells are 250 cm and 400 cm. then find the ratio of E_1 and E_2.



$E_1 - E_2 \propto 250$.

$E_1 + E_2 \propto 400$

$$\frac{E_1 - E_2}{E_1 + E_2} = \frac{\cancel{250}^{5}}{\cancel{400}_{8}}$$

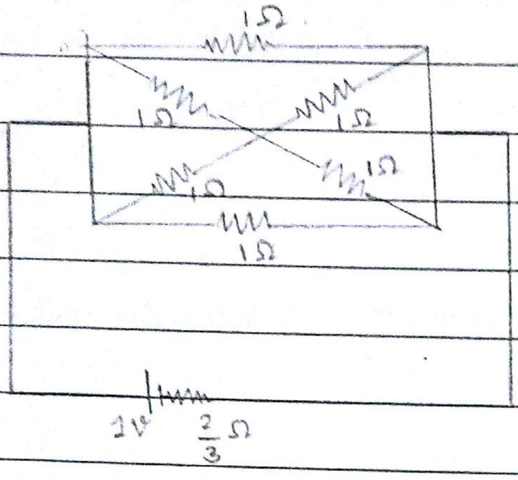
$(E_1 - E_2)8 = (E_1 + E_2)5$

$8E_1 - 8E_2 = 5E_1 + 5E_2$

$3E_1 = 13E_2$

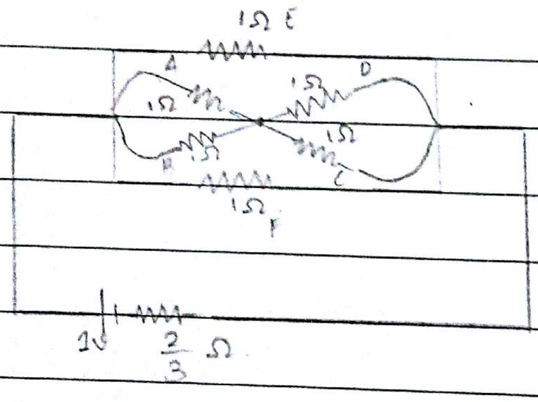
$$\frac{E_1}{E_2} = \frac{13}{3}$$

find the current drawn from the cell of EMF 1 volt and internal resistance $\frac{2}{3}\Omega$ connected to the network shown in the figure



$I = \frac{E}{R+r}$

$R_{tot} =$



$\frac{1}{R_P} = \frac{1}{1} + \frac{1}{1} = 2$

$\therefore R = \frac{1}{2}$ $R' = \frac{1}{2}$

$R_S = \frac{1}{2} + \frac{1}{2} = 1$

$\frac{1}{R_{net}} = \frac{1}{1} + \frac{1}{1} + \frac{1}{1}$

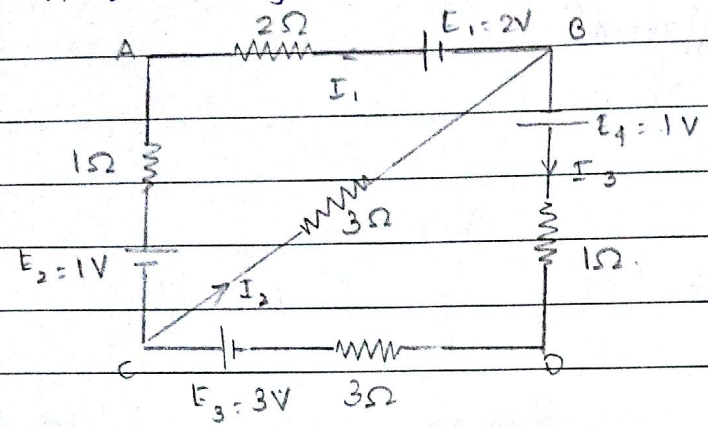
$R_{net} = \frac{1}{3}$

$I = \frac{1}{\frac{1}{3} + \frac{2}{3}}$

$= \frac{1}{\frac{3}{3}} = 1$ Ampere

Subject ______ Day ______

Q. In the network shown, find the values of current I_1, I_2 and I_3



$I_2 = I_1 + I_3$ (kirchoff's first rule)

ABCA

$2I_1 + I_1 + 3I_2 = 1$

$3I_1 + 3I_2 = 1$ —— (1)

BCDB

$3I_2 + I_3 + 3I_3 = 4$

$3I_2 + 4I_3 = 4$ —— (2)

In BACDB

$-2I_1 + 3I_3 + I_3 - I_1 = 3$

$-3I_1 + 4I_3 = 3$ —— (3)

$I_2 = I_1 + I_3$

$3(I_1 + I_3) + 4I_3 = 4$

$3I_1 + 3I_3 + 4I_3 = 4$

$3I_1 + 7I_3 = 4$

$-3I_1 + 4I_3 = 3$

$11I_3 = 7$

$I_3 = \frac{7}{11}$ A

$3I_1 + 7 \times \frac{7}{11} = 4$

$3I_1 = \frac{44 - 49}{11}$

$I_1 = \frac{-5}{11} = \frac{-5}{33}$ A

$I_2 = \frac{-5}{33} + \frac{7}{11} \times \frac{3}{3} = \frac{16}{33}$ A.

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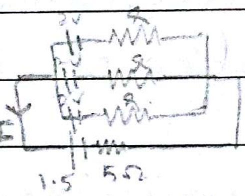
3 identical cells, each of emf 2V and unknown internal resistance are connected in parallel. the combination is connected to a 5Ω resistor. If the terminal voltage across a volt is 1.5V. what is the internal resistance of each cell.



$E_{net} = E$

$R_{net} = \frac{r}{3}$

$\frac{r}{3} = \left(\frac{E}{V} - 1\right)R$

$= \left(\frac{2}{1.5} - 1\right)5$

$= \left(\frac{2 - 1.5}{1.5}\right) \times 5$

$\frac{r}{3} = \frac{0.5}{1.5} \times 5$

$\frac{r}{3} = \frac{5}{\cancel{15}_{3}} \times \cancel{5}$

$r = 5\ \Omega$