Electrical Circuits

MCQs

1) Kirchhoff's voltage law of eletrical circuit is based on the principle of conservation of

a) Charge
b) Mass
c) Energy
d) Linear momentum

2) If specific resistance of a potentiometer wire is 10^{-7} m current flowing through it is 0.1 A & cross sectional area of wire is 10^{-6} m^2, the potential gradient will be,

a) 10^{-2} V/m
b) 10^{-4} V m^{-1}
c) 10^{-6} V m^{-1}
d) 10^{-8} V m^{-1}

Soln : $S = 10^{-7}$, $I = 0.1$ A

$V = IR$

$\frac{V}{L} = IR$

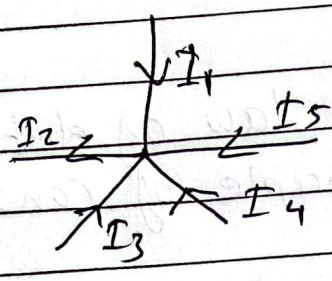
Or, $\frac{V}{L} = \frac{I S K}{K A}$ $\left[\because R = S\frac{L}{A}\right]$

Or $\frac{V}{L} = \frac{I S}{A}$

Or $\frac{V}{L} = \frac{0.1 \times 10^{-7}}{10^{-6}}$

$\{\because V/L = 10^{-2}\ V m^{-1}\}$

3) What is the relation between current in the fig:



a) $I_2 = I_1 + I_3 + I_4 + I_5$

b) $I_2 - I_1 = I_3 - I_4 + I_5$

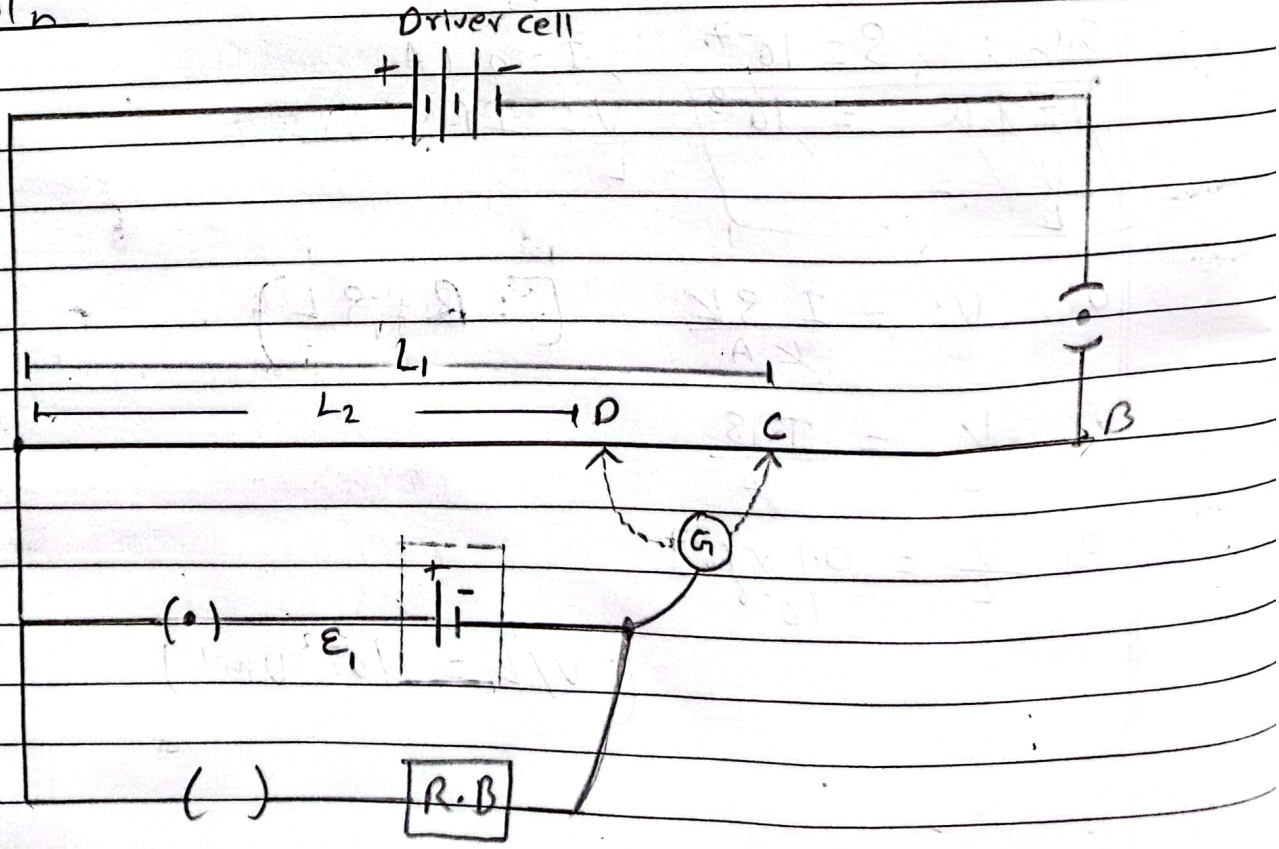
c) $I_3 + I_4 = I_2 + I_1 + I_5$

d) $I_1 + I_5 = I_2 + I_3 + I_4$

Conseptual Answer question

1) Draw a circuit diagram of a potentiometer to measure the internal resistance of cell. Write the formula used.

Soln



Formula used:

$$\frac{K L_1}{K L_2} = \frac{(R+r)}{R}$$

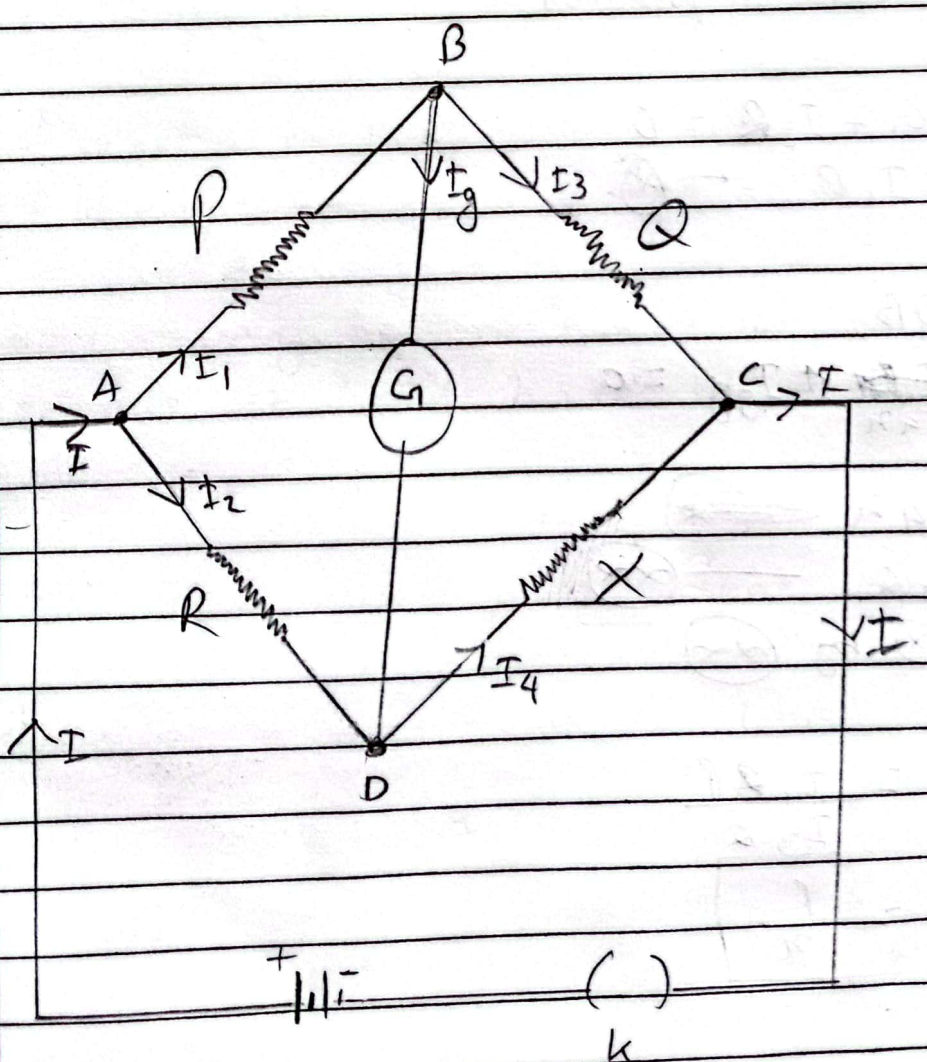
Or,

$$\boxed{\frac{L_1}{L_2} = 1 + \frac{r}{R}}$$

$$\boxed{\therefore r = R\left(\frac{L_1 - L_2}{L_2}\right)}$$

2) Draw a Wheatstone bridge circuit & mention the balance condition for it?

→



The required blanced condition is obtained when ~~Potential~~ Potential at Junction (B) is equal to Potential (D)
ie:

$V_B = V_D$

$\Delta V = V_B - V_D = 0$

At this condition no current flows through terminal B.D ie: {null point}

$I_g = 0$

Now,

$I_1 = I_3$ — (1)

$I_2 = I_4$ — (2)

from kirchhoff's law of Potential

for loop ABDA

$-I_1 P - I_g G + I_2 R = 0$

$\Rightarrow I_2 R = I_1 P$ — (A)

For loop BCDB,

$-I_3 Q + I_4 n + I_g g = 0$

$\Rightarrow I_3 Q = I_4 n$

$\Rightarrow I_4 n = I_3 Q$ — (xx)

Dividing (A) by (xx)

Hence

$\frac{I_1 R}{I_4 n} = \frac{I_1 P}{I_3 Q}$

$\therefore \boxed{\frac{P}{Q} = \frac{R}{n}}$

3) State principle of potentiometer & write its one application.

→ Potentiometer is based on the principle that states "The potential drop across the length of a conductor having uniform cross-section and composition due to steady current is directly proportional to its length".

ie:

$V \propto L$

or $V = KL$

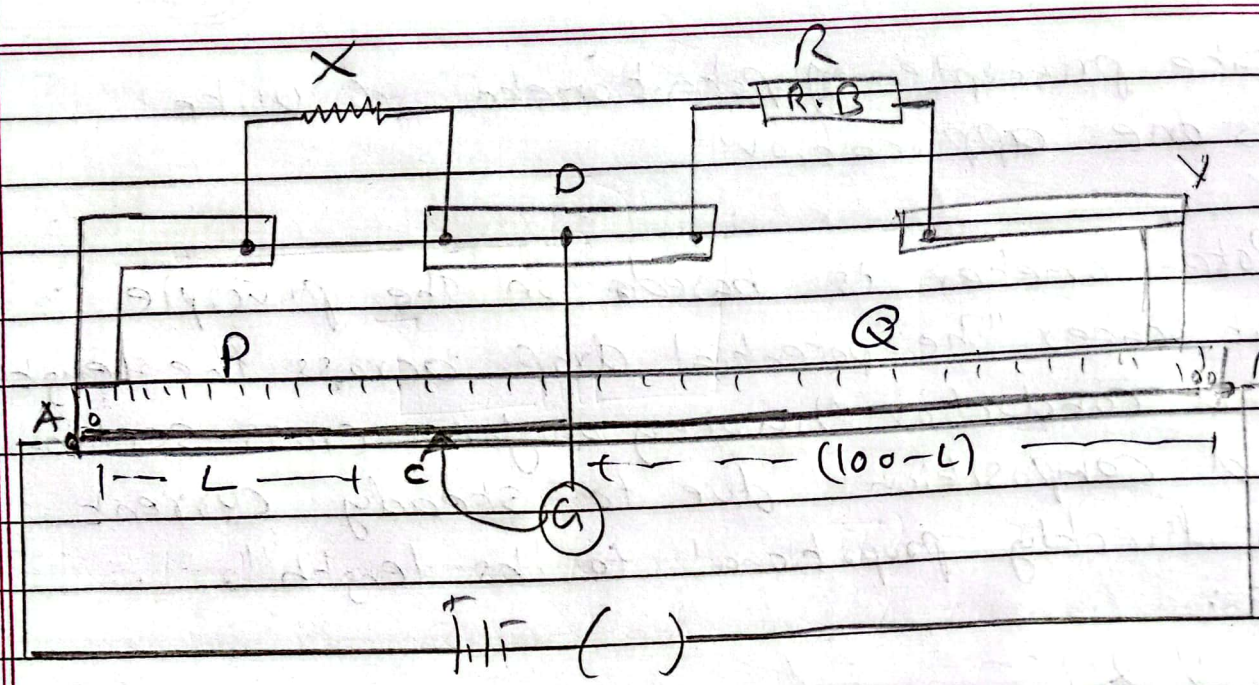
It one of the application is that it is used to ~~find~~ find the internal resistance of the cell.

4) A Voltmeter has a high resistance. Why?

→ A voltmeter has a high resistance because a voltmeter is connected // to the circuit. With a very high resistance it draws no current towards it and hence which results precise and accurate reading.

5) How would you convince that the principle of measurement of resistance of wire by meter bridge is based on Wheatstone ~~bridge~~ bridge principle? Explain.

P.T.O →



Both meter bridge & Wheatstone ~~de~~ bridge work on the principle of null point deflection.

At balancing condition ie: (null point deflection) no current passes from the terminal CD. ie: ($V_D - V_C = 0$). At this ~~point~~ condition, ~~the~~ current flowing through ~~AC & BD~~, AD and DX, AC and CB are equal Hence the resistance are in ratio:

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

Which is the same principle that Wheatstone bridge works on.

6) An ammeter is always connected in series. Why?

-) Ammeter is used to measure the amount of current in circuit. In series combination the current doesn't distributes into multiple path but gets accumulated in a same path which results more accurate reading of current.

7) The resistance of an ammeter must essentially be very small. why?

-) Ammeter is used to measure current in the circuit.

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

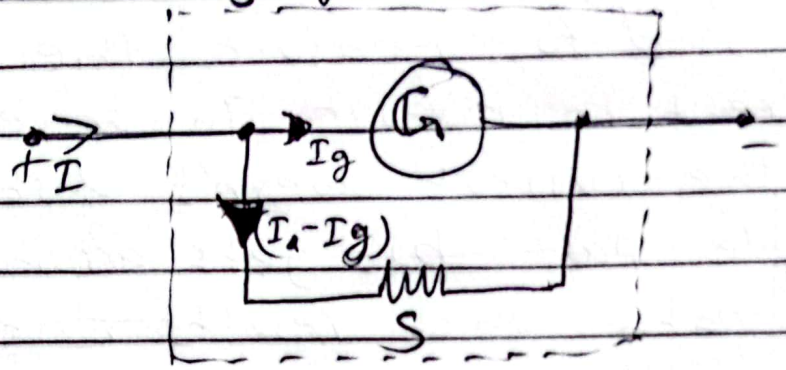
For an constant Potential (V)

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

Hence, with least resistance there is no fluctuation in the current or there is no interference in the current which results more accurate reading in the current without altering the current.

P.T -O-)

8) Explain the significance of a shunt.



An ideal ammeter Resistance (R) $\longrightarrow 0$,
Shunt is connected in // to the galvanometer
So that the $(R)_{eq}$ is minimized. i.e. reduces the internal resistance of the galvanometer.
ALSO,
It distributes the total current comming towards the ~~gla~~ galvanometer and prevents from overheating of galvanometer.

LONG QUESTIONS

1)

Kirchhoff's law are very useful in solving the complicated circuit connections:

a) What is the significance of the first law?

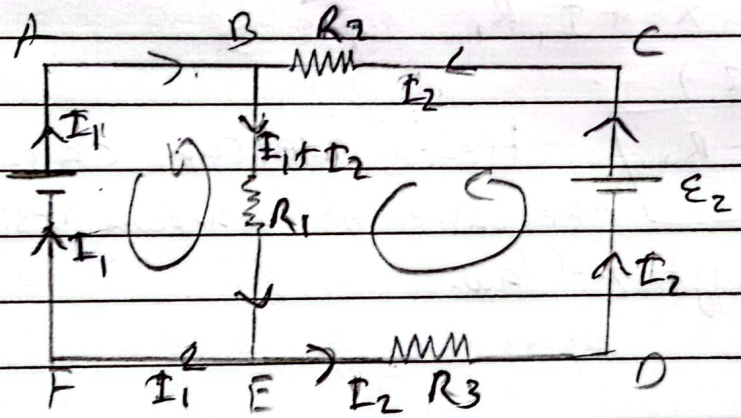
→ The first law is based on the conservation of charge which signifies that the current inbaing a junction is equal to the current leaving the junction.

b) State & explain the second law with circuit diagram.

→ The second law states that "around any closed circuit or loop the algebric sum of emfs (ΣE) is equal to the total or sum of P.ds (ΣV) around the loop.

ie: $\Sigma E = \Sigma V$

$\Rightarrow \Sigma(\mathcal{E}) = \Sigma(IR)$



For loop ABEFA

$\Sigma(E) = \Sigma(IR)$

Also or $\Sigma(\mathcal{E}) + \Sigma(IR) = 0$

Now,

$0 = -\mathcal{E}_1 + (I_1+I_2)R_1$

$\Rightarrow \mathcal{E}_1 = (I_1+I_2)R_1 \Rightarrow \Sigma(\mathcal{E}) = \Sigma(IR)$

For LOOP BCDEB

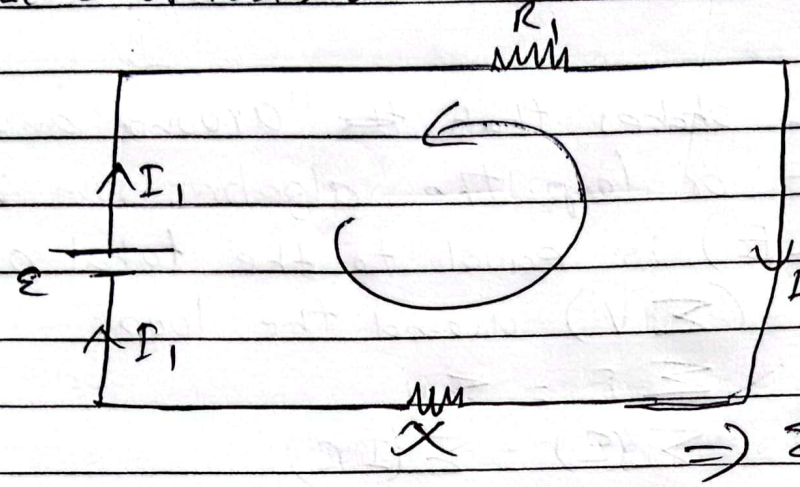
$\Sigma(\mathcal{E}) + \Sigma(IR) = 0$

or, $0 = \mathcal{E}_2 - I_2R_2 - (I_1+I_2)R_1 - I_2R_3$

$\Rightarrow \mathcal{E}_2 = I_2R_2 + (I_1+I_2)R_1 + I_2R_3$ #

$\Rightarrow \Sigma(\mathcal{E}) = \Sigma(IR)$ #

c) Apply mesc law to calculate unknown value of resistance.



$\Rightarrow \Sigma(\varepsilon) + \Sigma(IR) = 0$

$0 = -\varepsilon + I_1 x + I_1 R_1$

$\varepsilon = I_1(x + R_1)$

$\therefore x = \frac{\varepsilon}{I_1} - R_1$

Hence, we can calculate the value of unknown resistance through Kirchhoff's 2nd law.

d) What is meter bridge? ~~What~~ Write the material used to construct meter bridge.

→ Meter bridge is an electrical instrument that works on the principle of wheat stone bridge and is used to find the unknown resistance.

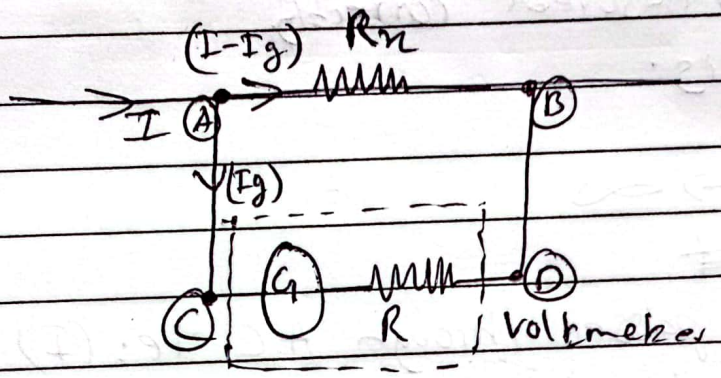
The material of wire used is constantan or magnanin which has very low temperature coefficient.

2) What is galvanometer? How do you convert into voltmeter? Why should the resistance of voltmeter be high?

Sol^b

→ Galvanometer is an ~~electrical~~ electromagnetic device that detects the current in the circuit.

Conversion of galvanometer to voltmeter



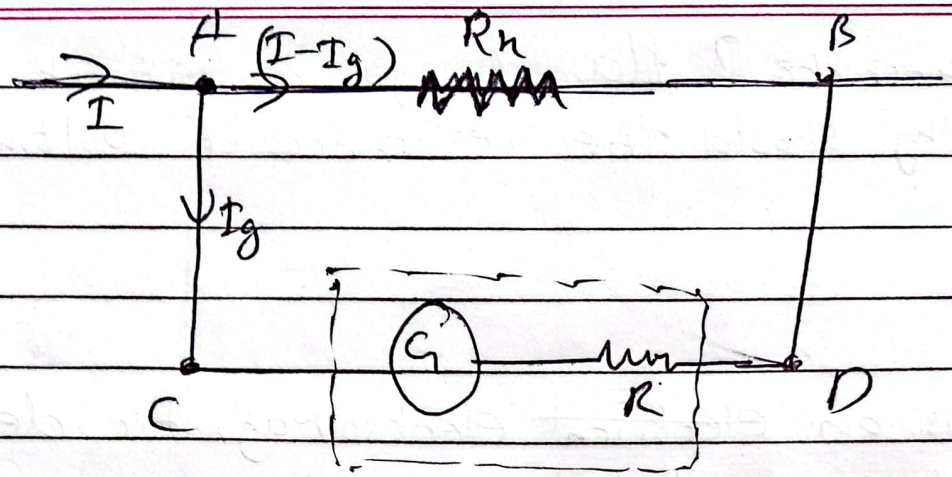
For conversion of galvanometer (G) to voltmeter (V)
- galvanometer is connected in parallel to the circuit with a multiplier (resistance, R) in series with galvanometer.

let (g) be the internal resistance of the galvanometer
Then

$V_{AB} = V_{CD}$

$\Rightarrow V_{CD} = I_g(R+g)$

$\therefore R = \frac{V}{I_g} - g$ is the required expression for the multiplier of resistance (R).



The resistance of a voltmeter should be high because it draws no current and Hence the potential is measured correctly.
In above ~~fig~~ fig.

assuming $R \longrightarrow \infty$

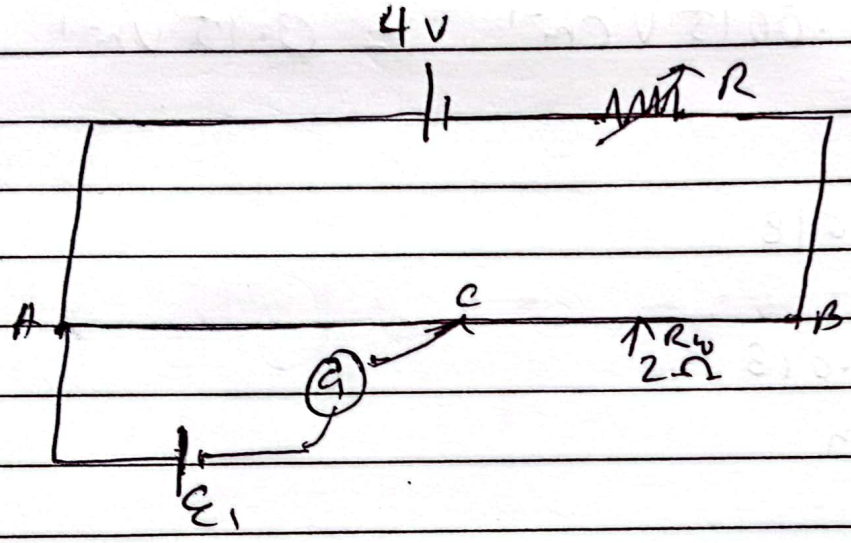
~~Then the current I~~

Then no current passes through AC ie: (I) Current doesn't gets drawn towards voltmeter, because current moves towards path with lower resistance as $I \propto 1/R$ {at const(V)}
Hence
(V_{AB}) can be accurately measured.

Numericals.

A simple potentiometer circuit is setup as in fig. Using a uniform wire AB, 1 m long which has resistance of 2Ω. The internal resistance of 4V battery is negligible. If the variable resistor (R) are given a value of 2.4 Ω, what would be the length AC for null deflection

Soln



$V_{AC} = \mathcal{E}_1$

$\frac{V}{L} \times n = \mathcal{E}_1$ — (1)

Now

$V = IR$

$4 = I(R + 2)$

$\therefore I = \frac{4}{(2.4+2)} = 0.91A$

Now,

$V_{AB} = I \times R_{AB} \Rightarrow 0.91 \times 2$

$\Rightarrow 1.82V$

$\frac{V_{AB}}{L} = \frac{1.82}{1}$

Now eqn (2) (1) is:

$1.82 \times n = \mathcal{E}_1$

$\therefore n = \frac{\mathcal{E}_1}{1.82}$

$\therefore n =$

2) The total length of wire of a potentiometer is 10m. A potential gradient of 0.0015 V/cm is obtained when a steady current is passed through it.

Sol:

i) Distance of null point on connecting standard cell of 1.018 V.

Given $K = 0.0015\ V\,cm^{-1} = 0.15\ V\,m^{-1}$

$\varepsilon_1 = 1.018\ V$

Now

$\frac{V}{L} \propto n = 1.018$

$0.15 \times n = 1.018$

$\therefore n = 6.78\ m$

ii) Unknown P.d if null point is obtained at 940 cm.

Sol:

$n = 940\ cm = 940 \times 10^{-2}\ m = 9.4\ m$

$\varepsilon_1 = \frac{V}{L} \times n$

$\varepsilon_1 = 0.15 \times 9.4$

$\therefore \varepsilon_1 = 1.41\ V$

iii) Maximum P.d which can be measured by the device

$\mathcal{E} = \frac{V}{L} \propto$ total length of wire.

$= 0.15 \times 10$

$\mathcal{E} = 1.5V$ #

3) In the adjacent circuit find:

current

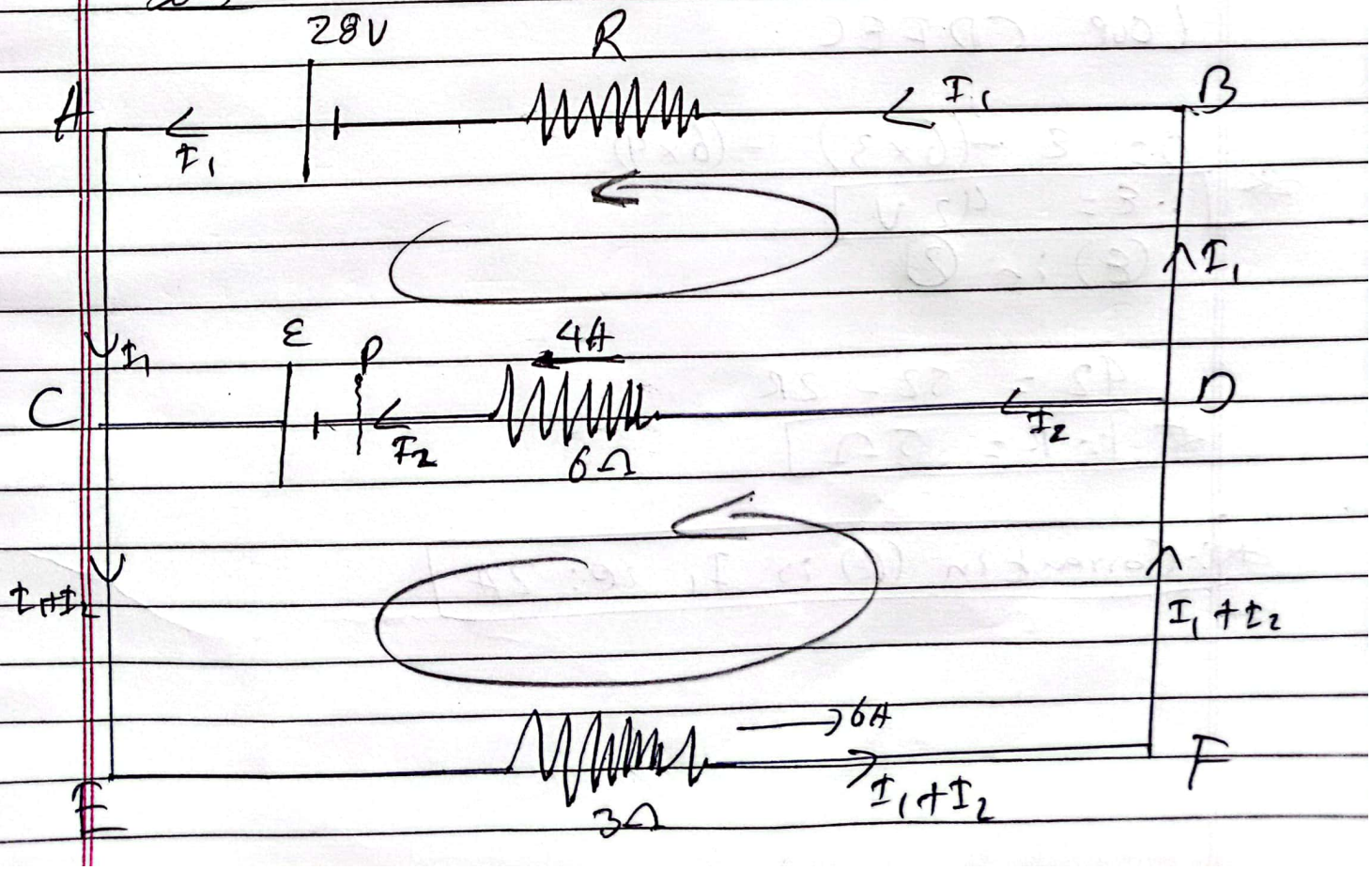
i) The ~~Circuit~~ in resistor (R)

ii) resistance (R)

iii) Unknown emf ($\mathcal{E}$)

iv) If the circuit is broken at (P), current at (R)?

Sol



In loop ABCDEA

$0 = 28 - \mathcal{E} + (4 \times 6) - I_1 R$

$\mathcal{E} = 28 + 24 - I_1 R$

$\mathcal{E} = 52 - I_1 R \quad - (1)$

We know

$I_1 + I_2 = 6A$

$I_1 = 6A - I_2$

$= 6 - 4 = 2A$

$\therefore I_1 = 2A$

Now (1) is

$\mathcal{E} = 52 - 2 \times R \quad - (2)$

Loop CDFEC

$0 = \mathcal{E} - (6 \times 3) - (6 \times 4)$

$\therefore \mathcal{E} = 42\ V$

($\mathcal{E}$) in (2)

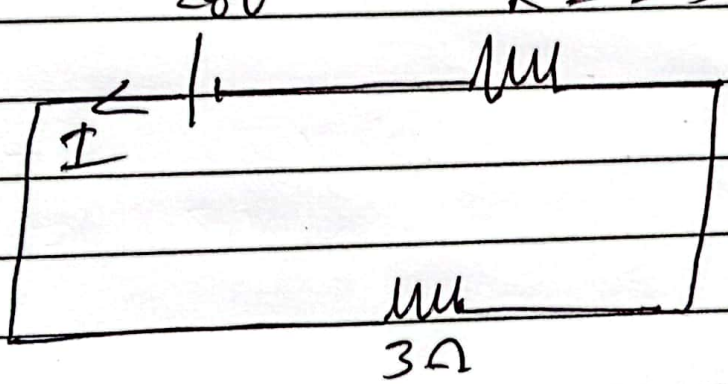
$42 = 52 - 2R$

$\therefore R = 5\Omega$

$\therefore$ Current in (R) is I_1 i.e: 2A

If circuit is broken at P, the current in R be:

Circuit is:



$V = IR$

$28 = I(3+5)$

$\therefore I = \frac{28}{8} = 3.5\,A$