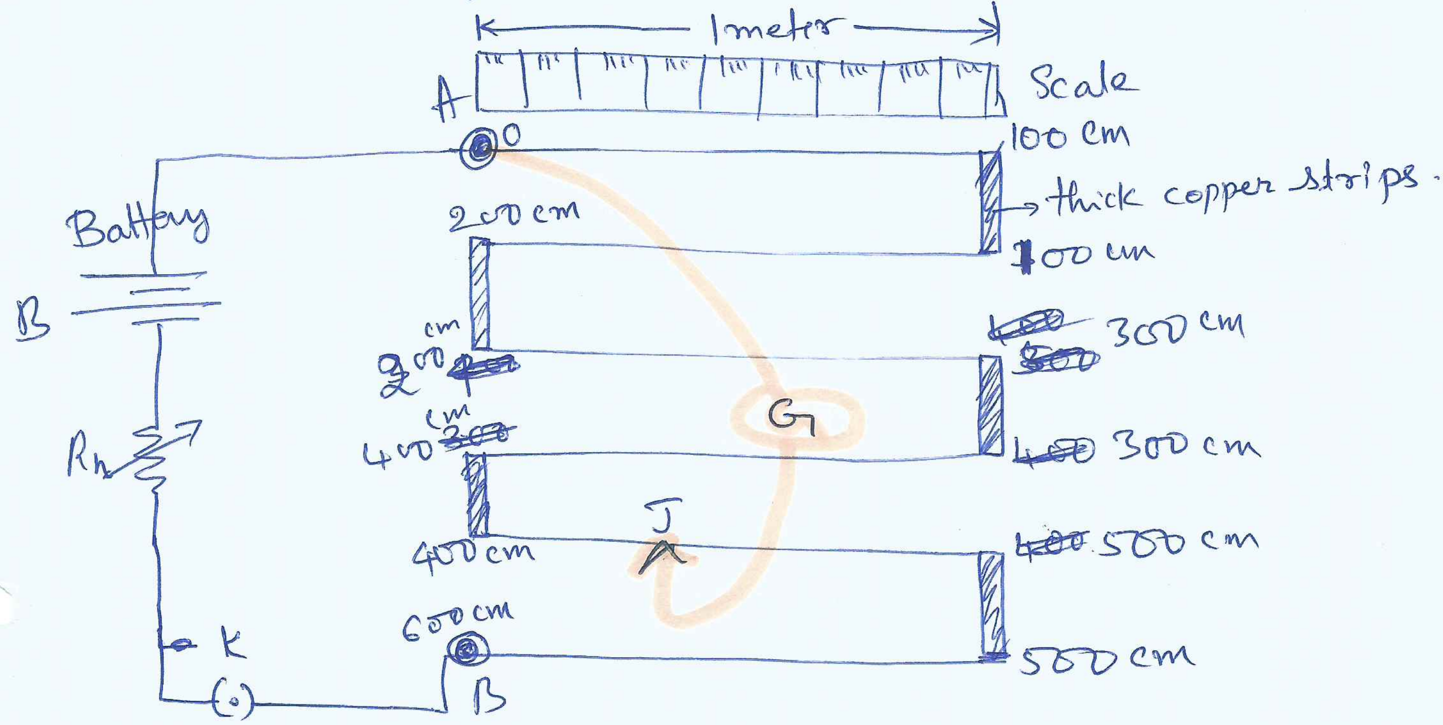
These pieces of wire are joined by thick copper strips



Difference betn potentiometer and voltmeter

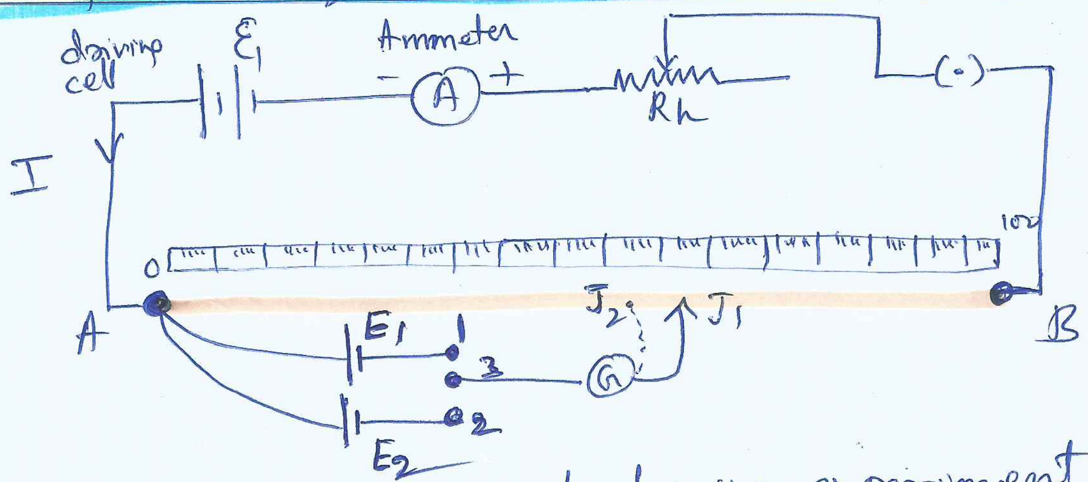
potentiometer	voltmeter
1. It measures the emf of a cell very accurately	1. It measures the emf of a cell approximately.
2. While measuring emf, it does not draw any current from the source of known emf	2. While measuring emf, it draws some current from the source of emf.
3. While measuring emf, the resistance of the potentiometer becomes infinite.	3. While measuring emf, the resistance of voltmeter is high but finite.
4. Its sensitivity is high	4. Its sensitivity is low.
5. It is based on null deflection method.	5. It is based on deflection method.
6. It can be used for various purposes eg. measuring internal resistance of a cell.	6. It can be used only to measure emf or potential difference.

PTO → uses of potentiometer

Uses of potentiometer

1. To find emf of cell → See page 52.

2. Comparison of the emf's of two cells



- Keep current I constant during experiment.
- Comparison of emfs of E_1 and E_2 = ?
- plug 1 and 3, so that E_1 comes into circuit, measure null point - say l_1 from A.
- plug 2 & 3, so that E_2 comes into circuit, measure null point - say l_2 from A
- $E_1 = k l_1$ where k = potential gradient along the wire.
- $E_2 = k l_2$

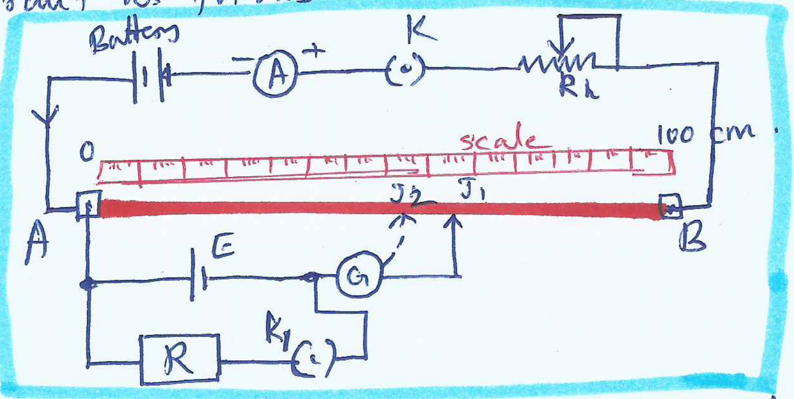
$$\therefore \boxed{\frac{E_1}{E_2} = \frac{l_1}{l_2}} \longrightarrow (1)$$

From this, the ratio E_1/E_2 can be calculated. Since the measurements l_1 and l_2 are taken in the condition of no current, the internal resistances of the sources of emf do not enter the picture.

In practice, one is chosen as standard cell whose emf is known to a high degree of accuracy, then the emf of the cell can be determined using eqn. (1).

(3) Measurement of Internal Resistance (r) of a cell

Set up the circuit as follows



- Firstly close key K and adjust R_h to get a steady const. current in the circuit.

→ case (i) : K_1 = open ; Find null point l_1 $\therefore$ $\epsilon = K l_1$ → (1)

→ case (ii) : K_2 = closed ; Find null point l_2. In this case, since current is drawn from the cell, its terminal p.d. is balanced (not emf ϵ) $\therefore$ $V = K l_2$ → (2)

- From (1) and (2), $\dfrac{\epsilon}{V} = \dfrac{K l_1}{K l_2} = \dfrac{l_1}{l_2}$; [where l_1 = open circuit null point, l_2 = closed circuit with R in loop.]

$$\therefore \boxed{\frac{\epsilon}{V} = \frac{l_1}{l_2}} \rightarrow (3)$$

- we know that $V = \epsilon - Ir$ $\Rightarrow$ $\epsilon - V = Ir$

$\therefore r = \dfrac{\epsilon - V}{I}$ Since when I is present, the p.d. measured across R will be V (not emf ϵ)

$\therefore I = V/R$

$$\therefore r = \frac{\epsilon - V}{V/R} = \left(\frac{\epsilon - V}{V}\right) R \qquad \therefore \boxed{r = \left[\frac{\epsilon}{V} - 1\right] R} \rightarrow (4)$$

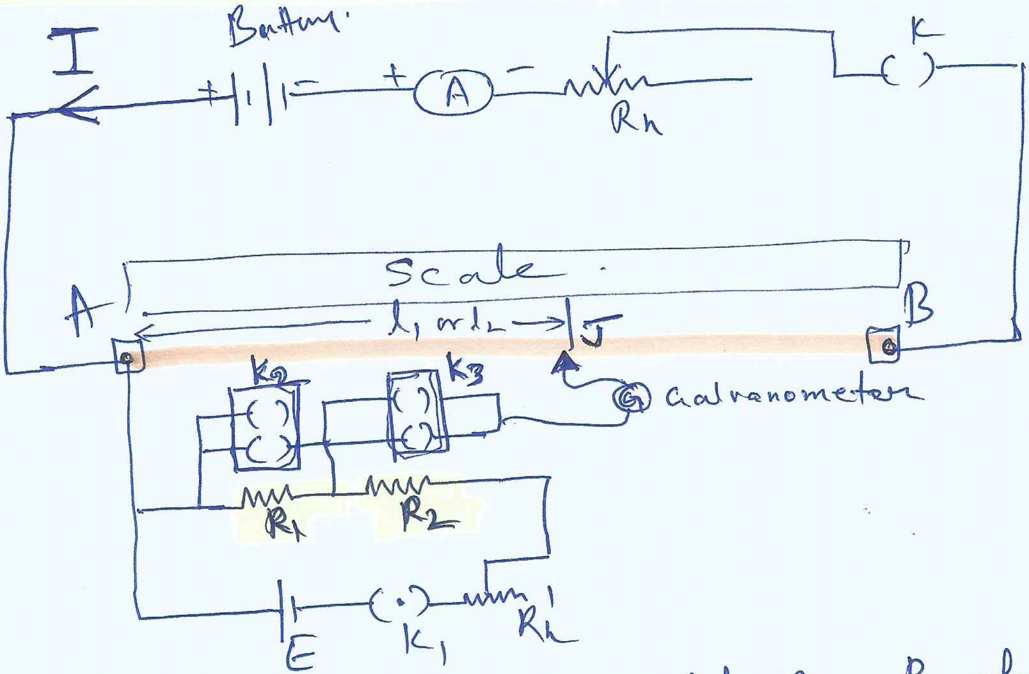
using (3) in (4), we get

$$\boxed{r = \left(\frac{l_1}{l_2} - 1\right) R} \rightarrow (5)$$

- Several values of l_2 are noted for different values of R. The internal resistance r is calculated for each l_2 and finally the mean r is taken as final value.

 (not in NCERT syllabus)

4 Potentiometer use : Comparison of Resistances



- Set up circuit as shown. Adjust R_h for steady constant current I.
- Two Resistances R_1 and R_2 to be compared are connected in series with another rheostat R_h' and a cell E, which sends a steady current through R_1 and R_2.
- First R_1 is connected to main circuit by keys K_2 and K_3 and measure l_1 using null-point.
- Secondly R_2 is connected to main circuit by using keys K_2 and K_3 and measure l_2 using null-point.

$$IR_1 = Kl_1$$
$$\therefore \quad IR_2 = Kl_2$$

$$\boxed{\frac{R_1}{R_2} = \frac{l_1}{l_2}}$$

From this ratio of resistors can be ~~calculated~~ calculated.

If one of the resistances ~~is a st~~ has a standard value, the other can be determined by above equation.

End.

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problems

NCERT (ch 3) → problem 3.24

Given Battery voltage = 2 V
$l_1 = 76.3$ cm
$l_2 = 64.8$ cm , $R = 9.5\ \Omega$

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

$= 9.5\left(\frac{76.3}{64.8} - 1\right)$

$= 9.5\left(\frac{76.3 - 64.8}{64.8}\right)$

$= \frac{9.5 \times 11.5}{64.8}$

$\boxed{r = 1.7\ \Omega.}$

NCERT (ch3) : problem 3.23

~~Given~~ Formula $\frac{R}{X} = \frac{l_1}{l_2}$

Given $R = 10\ \Omega$, $X = ?$, $l_1 = 58.3$ cm , $l_2 = 68.5$ cm

$\therefore X = \frac{l_2}{l_1} \cdot R = \frac{68.5}{58.3} \times 10 = \frac{685}{58.3} \simeq \underline{11.8\ \Omega}$

Ans.

What might you do if you failed to find a balance point with the given cell of emf ~~ε~~ ε.

→ Ans: Reduce main current I by inserting a suitable series resistance with driving battery.

NCERT : ch: 3 : problem # 3.22

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

Given $\varepsilon_1 = 1.02\,V$, $l_1 = 67.3$ cm, $l_2 = 82.3$ cm

(a) $\varepsilon_2 = \frac{l_2}{l_1} * \varepsilon_1 = \frac{82.3}{67.3} \times 1.02 = \boxed{1.25\,V}$

(b) purpose of 600 k Ω is the reduce current in G when balance point is far away.

(c) No, since there is no current in G at ~~null~~ null point.

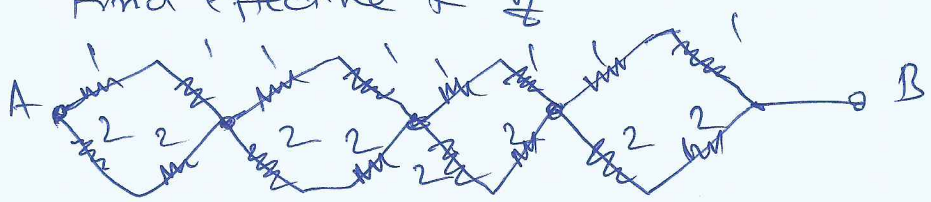
(d) No, since @ null point G = 0, independent of r of the driver cell.

(e) If ε > emf. of driver cell, ~~there is no~~ we will not get null point on wire AB.

(f) Reduce current R in main circuit by using suitable resistance so that the null point will be somewhere in the middle of wire AB (accuracy is more, % of error is less)

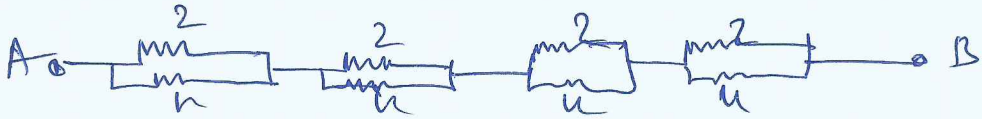
NCERT : Ch3 : problem 3.20

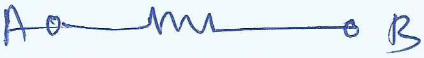
Find effective R



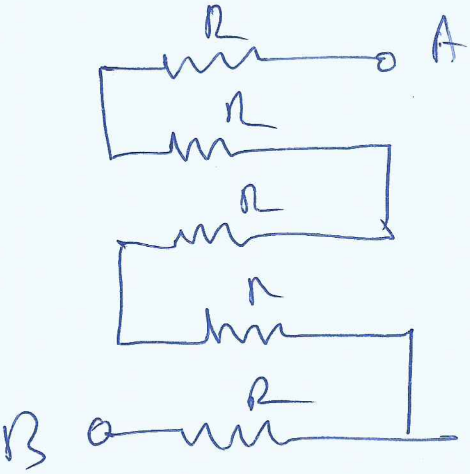
$$\frac{1}{R'} = \frac{1}{2} + \frac{1}{4} = \frac{2+1}{4} = \frac{3}{4}$$

$$R' = 4/3$$





$$= \frac{4}{3} \times 4 = \frac{16}{3}\,\Omega.$$

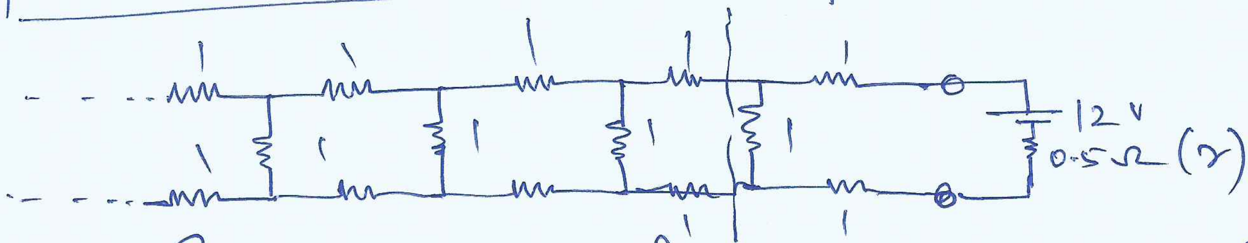


Since all are in series

$R_{AB} = \cancel{5R}$

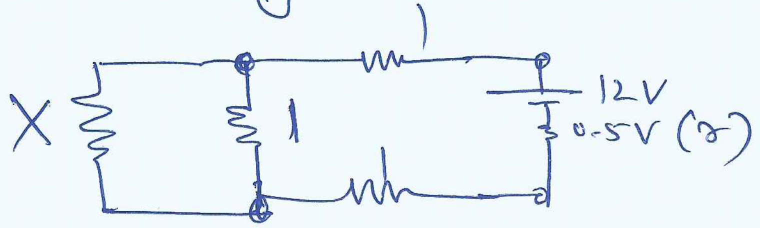
$= 5R$

NCERT : ch:3 problem 3.21



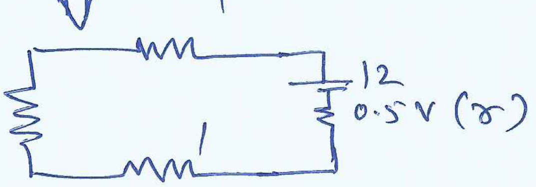
Since it is an infinite ~~loo~~ network of R

⇓



⇓

$R' = X \parallel 1 = \frac{x}{x+1}$



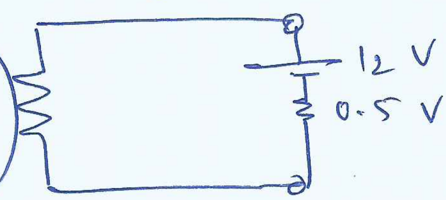
$X \parallel 1$

$\frac{1}{R'} = \frac{1}{X} + \frac{1}{1} = \frac{1+x}{X}$

$R' = \frac{X}{x+1}$

⇓

$\left(2 + \frac{x}{x+1}\right)$



$$\boxed{2 + \left(\frac{x}{x+1}\right) = x}$$

(Since this is infinite network, total net resistance $= x$

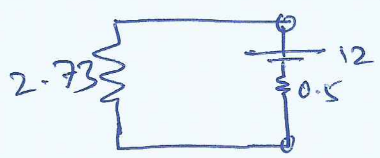
$2(x+1) + x = x^2 + x$

$2x + 2 + \cancel{x} = x^2 + \cancel{x}$

$x^2 - 2x - 2 = 0$

$x = \frac{2 \pm \sqrt{\cancel{4 \times 8}\, 4+8}}{2} = \frac{2 \pm 2\sqrt{3}}{2} = 1 \pm \sqrt{3}$

Value of R cannot be negative, hence $R = 1+\sqrt{3} = 2.73\ \Omega$

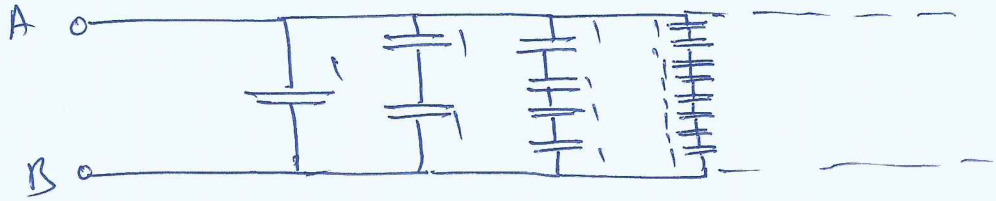


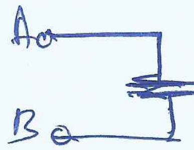
$I = \frac{12}{2.73 + 0.5} = \frac{12}{3.23}$

$= \underline{3.72\ A.}$

problem

In the figure shown below, ~~capaciton~~ capacitance of each capacitor = 1 μF. find effective C bet^n A and B



Resultant C =  $C = 1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \cdots$

This is an infinite series and the sum of an infinite geometric progression

$S_\infty = \frac{a}{1-r}$ where a = first term
r = common ratio bet^n two consequtive terms

Here in fig, $a = 1$

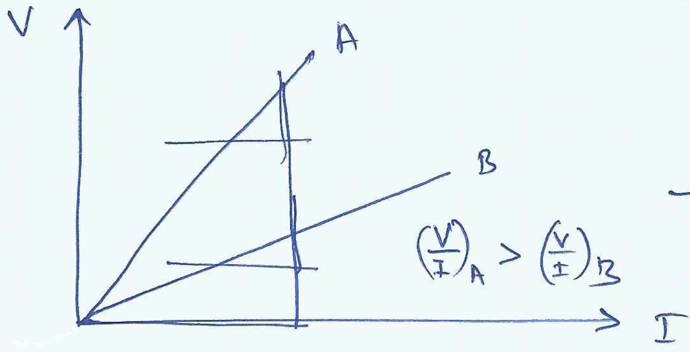
$r = \frac{1/2}{1/1} = \frac{1}{2}$ $\left(\frac{1/16}{1/8} = \frac{8}{16} = \frac{1}{2} \right)$

$\therefore \quad C = \frac{1}{1 - \frac{1}{2}} = \frac{1}{1/2} = \boxed{2 \mu F}$

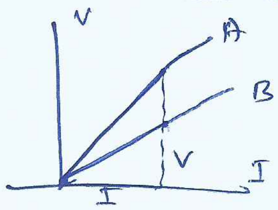
---

problem :

which graph is having high Resistence



$\left(\frac{V}{I}\right)_A > \left(\frac{V}{I}\right)_B$

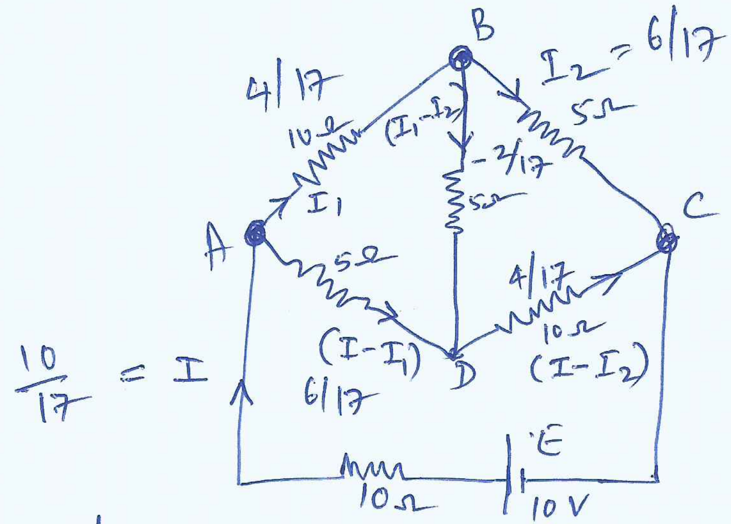


$R = \frac{V}{I}$ = Slope of curve

$R_A > R_B$

NCERT ch 3 problem # 3.9

Determine current in each branch of the following network.



Let 3 currents I, I_1, I_2 be the ones that should be evaluated. (3-variable eq^{n})

Consider 3 loops : ① EABCE ② ABDA ③ BCDB

① EABCE: $-10 + 10I + 10I_1 + 5I_2 = 0$

$2I + 2I_1 + I_2 = 2 \longrightarrow (1)$

② ABDA: $10I_1 + 5(I_1 - I_2) - 5(I - I_1) = 0$

$10I_1 + 5I_1 - 5I_2 - 5I + 5I_1 = 0$

$2I_1 + I_1 - I_2 - I + I_1 = 0$

$-I + 4I_1 - I_2 = 0 \longrightarrow (2)$

③ BCDB: $5I_2 - 10(I - I_2) - 5(I_1 - I_2) = 0$

$5I_2 - 10I + 10I_2 - 5I_1 + 5I_2 = 0$

$I_2 - 2I + 2I_2 - I_1 + I_2 = 0$

$-2I - I_1 + 4I_2 = 0 \longrightarrow (3)$

Using ① ② & ③ eliminate one common variable.

$2I + 2I_1 + I_2 = 2$

$-I + 4I_1 - I_2 = 0$

add: $I + 6I_1 = 2$

eliminate I_2

$-2I - I_1 + 4I_2 = 0$

$-4I + 16I_1 - \cancel{4I_2} = 0$

$-2I - I_1 + \cancel{4I_2} = 0$

$-6I + 15I_1 = 0$

$\cancel{6I} + 36I_1 = 12$

$-\cancel{6I} + 15I_1 = 0$

$51 I_1 = 12$

$I_1 = \frac{12}{51} = \frac{4}{17}$ $\quad \boxed{I_1 = \frac{4}{17}}$

$\therefore I = 2 - 6 \times \frac{4}{17} = 2 - \frac{24}{17}$

$= \frac{34 - 24}{17} = \frac{10}{17}$

$\boxed{I = \frac{10}{17}}$

$I_2 = -I + 4I_1$

$= -\frac{10}{17} + \frac{16}{17} = \frac{6}{17}$

$\boxed{I_2 = \frac{6}{17}}$

$I - I_1 = \frac{10}{17} - \frac{4}{17}$

$= \frac{6}{17}$

$I_1 - I_2$

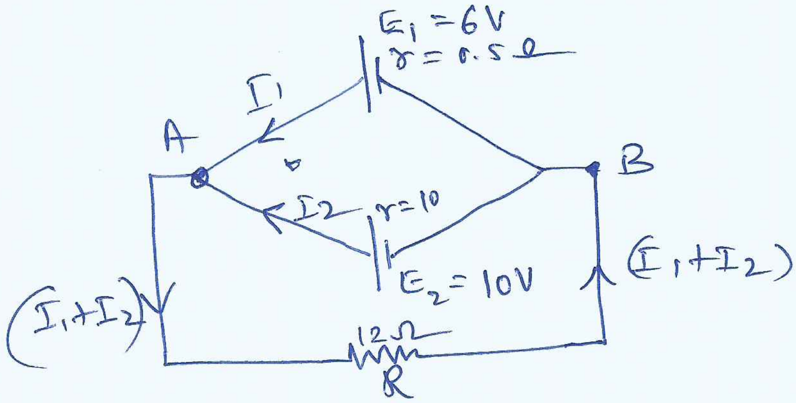
$\frac{4}{17} - \frac{6}{17} = -\frac{2}{17}$

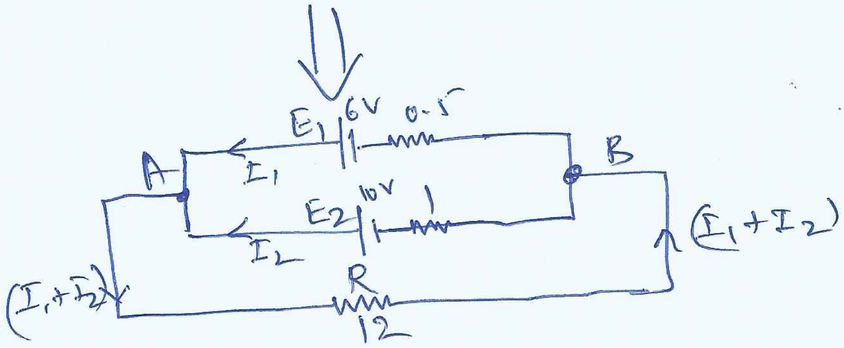
$I - I_2 = \frac{10}{17} - \frac{6}{17}$

$= 4/17$

Problem

Find I_1 and I_2 in the following circuit





Take loop: $ARBE_1A$: $12(I_1+I_2) + 0.5\,I_1 - 6 = 0$

~~Take loop~~: $\boxed{12.5\,I_1 + 12\,I_2 = 6} \longrightarrow (1)$

Take loop $ARBE_2A$: $12(I_1+I_2) + I_2 - 10 = 0$

$= \boxed{12\,I_1 + 13\,I_2 = 10} \longrightarrow (2)$

Solving above 2 variable equations, we get

$I_1 = -2.27\ A$ → Negative sign shows that I_1 actually flows in a direction opposite to what is shown in the figure.

$I_2 = 2.86\ A$