Ch-Name - Current Electricity

3.1) Here $\varepsilon = 12V$, $r = 0.4\,\Omega$

The current drawn from the battery will be maximum when the external resistance in the circuit is 0 i.e $R = 0$

$$I_{max} = \frac{\varepsilon}{r} = \frac{12}{0.4} = 30A$$

3.2) As, $I = \frac{\varepsilon}{R+r}$

$$R + r = \frac{\varepsilon}{I} \Rightarrow R = \frac{\varepsilon}{I} - r = \frac{10}{0.5} - 3 = 20 - 3 = 17\,\Omega$$

Terminal voltage $\Rightarrow V = IR$

$$= 0.5 \times 17 = 8.5\,V$$

3.3 i) $R_s = R_1 + R_2 + R_3 = 6\,\Omega$

ii) current in circuit, $I = \varepsilon / R = 12/6 = 2A$

∴ potential drop across different resistors are

$V_1 = IR_1 = 2 \times 1 = 2V$

$V_2 = IR_2 = 2 \times 2 = 4V$

$V_3 = IR_3 = 2 \times 3 = 6V$

3.4 i) $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{2} + \frac{1}{4} + \frac{1}{5} = \frac{19}{20}$

$R_p = \frac{20}{19}\,\Omega$

ii) currents drawn through different resistors are

$I_1 = \frac{\varepsilon}{R_1} = \frac{20}{2} = 10A$  $I_2 = \frac{\varepsilon}{R_2} = \frac{20}{4} = 5A$

$I_3 = \frac{\varepsilon}{R_3} = \frac{20}{5} = 4A$

Total current drawn from battery $= I = I_1 + I_2 + I_3 = 10+5+4$
$= 19A$

5) Here $R_1 = 100\,\Omega$, $R_2 = 117\,\Omega$, $t_1 = 27^\circ C$

$\alpha = 1.7 \times 10^{-4}\,C^{-1}$

As

$$\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)} \qquad \therefore t_2 - t_1 = \frac{R_2 - R_1}{R_1 \alpha} = \frac{117 - 100}{100 \times 1.7 \times 10^{-4}}$$

$t_2 = 1000 + t_1 = 1000 + 27 = 1027^\circ C$

6) Here $l = 15\,m$, $A = 6.0 \times 10^{-7}\,m^2$, $R = 5\,\Omega$

Resistivity = $\rho = \frac{RA}{l} = \frac{5 \times 6 \times 10^{-7}}{15} = 2 \times 10^{-7}\,\Omega m$

7) Here $R_1 = 2.1\,\Omega$, $t_1 = 27.5^\circ C$, $R_2 = 2.7\,\Omega$, $t_2 = 100^\circ C$

Temp. coefficient of resistivity of silver

$$\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)}$$

$$= \frac{2.7 - 2.1}{2.1(100 - 27.5)} = \frac{0.6}{2.1 \times 72.5} = 0.00394^\circ C^{-1}$$

8) Here $V = 230\,V$, $I_1 = 3.2\,A$

$I_2 = 2.8\,A$, $\alpha = 1.7 \times 10^{-4}\,{}^\circ C^{-1}$

Resistance at room temperature

$$R_1 = \frac{V}{I_1} = \frac{230}{3.2} = 71.875\,\Omega$$

Resistance at steady temp.

$$R_2 = \frac{V}{I_2} = \frac{230}{2.8} = 82.143\,\Omega$$

Now, $\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)}$

$$(t_2 - t_1) = \frac{R_2 - R_1}{R_1 \alpha} = \frac{10.268}{71.875 \times 1.7} = 840.35^\circ C$$

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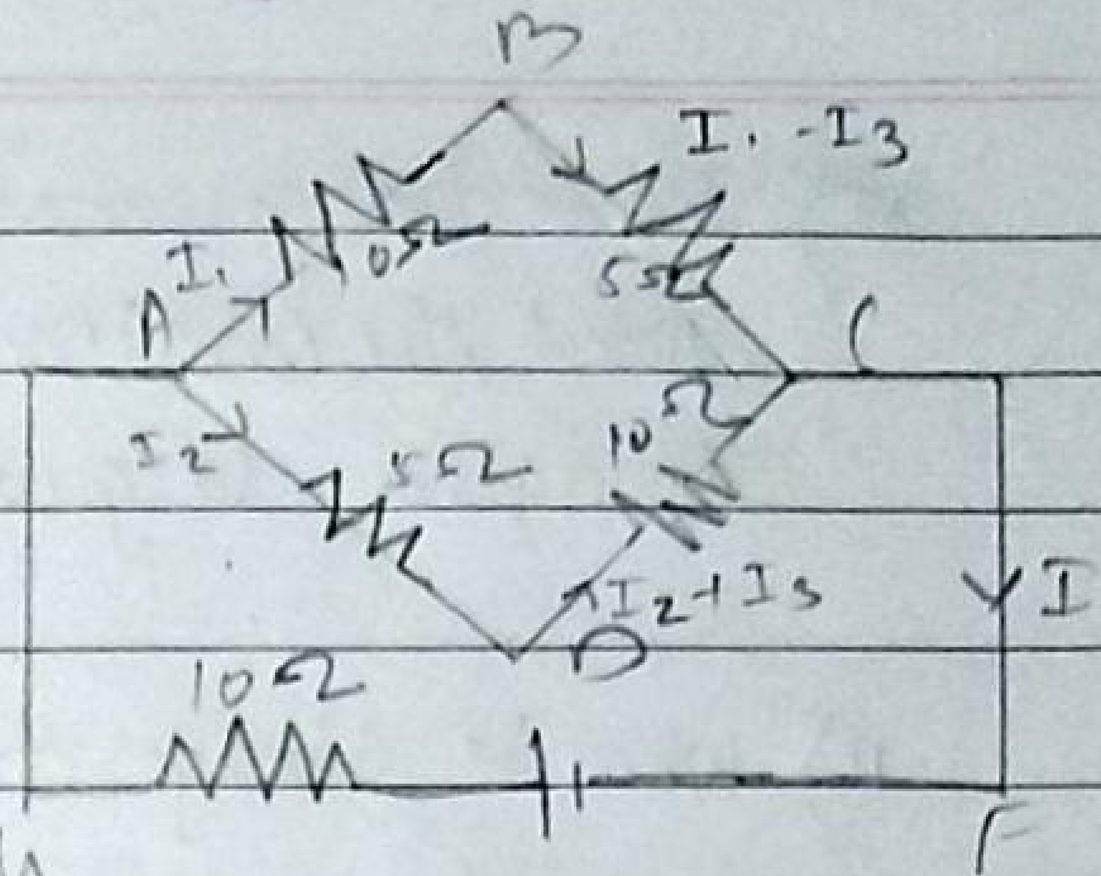
9) for loop ABDA

$10I_1 + 5I_3 - 5I_2 = 0$

for loop BCDB

$5(I_1 - I_3) - 10(I_2 + I_3) - 5I_3 = 0$

for loop ADCFGA




$5I_2 + 10(I_2 + I_3) + 10(I_1 + I_2) = 10$

$5I_1 - 10I_2 - 20I_3 = 0$

$10I_1 + 25I_2 + 10I_3 = 10$

solving eqn (1), (2) and (3) we get

$I_1 = \frac{4}{17}$ A, $I_2 = \frac{6}{17}$ A, $I_3 = -\frac{2}{17}$ A

Currents in different branches are

$I_{AB} = I_1 = 4/17$ A, $I_{BC} = I_1 - I_3 = 6/17$ A

$I_{DC} = I_2 + I_3 = 4/17$ A

$I_{AD} = I_2 = \frac{6}{17}$ A, $I_{BD} = I_3 = -2/17$ A

Total current $I = I_1 + I_2 = 10/17$ A

10) Here $l = 35.9$ cm, $R = X = 7$, $S = Y = 12.5\ \Omega$

As $S = \frac{100 - l}{l} \times R$ $\therefore 12.5 = \frac{100 - 39.5}{39.5} \times R$

$R = \frac{12.5 \times 39.5}{60.5} = 8.16\ \Omega$

Connection are made by thick copper strips to minimise the resistance of connection which are not accounted for in the above formula

ii) when x and y are interchanged

$R = Y = 12.5\ \Omega$ $S = X = 8.16\ \Omega$, $l = ?$

$S = \frac{100 - l}{l} \times R$ $\therefore 8.16 = \frac{100 - l}{l} \times 12.5$

$8.16 l = 1250 - 12.5 l$ $l = \frac{1250}{20.66} = 60.5\ \Omega$ from the end A

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iii) When the galvanometer and cell are interchanged at the balance point, the condition of balanced bridge are still satisfied and So again the galvanometer

11) When the storage battery of 8.0 V and internal resistance is charged with a dc supply of 120 V dc supply using a

11) $\varepsilon' = 120 - 8 = 112\,V$

Current in the circuit during charging

$I = \frac{\varepsilon'}{R + r} = \frac{112}{15.5 + 0.5} = 7A$

The terminal voltage of battery during charging

$V = \varepsilon + I r = 8.0 + 7 \times 0.5 = 11.5\,V$

12) As $\frac{\varepsilon_2}{\varepsilon_1} = \frac{l_2}{l_1}$

$\varepsilon_2 = \frac{l_2}{l_1} \times \varepsilon_1 = \frac{63 \times 1.25}{35} = 2.25$

13) Here $n = 8.5 \times 10^{28}\,m^{-3}$, $l = 3\,m$

As $2 \times 10^{-6}\,m^2$ $e = 1.6 \times 10^{-19}\,C$ $I = 3.0A$

Drift speed

$v_d = \frac{I}{enA} = \frac{3}{1.6 \times 10^{-19} \times 8.5 \times 10^{28} \times 2 \times 10^{-6}}$

$= \frac{3}{16 \times 85 \times 2 \times 10}\,m/s = 1.1 \times 10^{-4}\,m/s$

Required time

$t = \frac{l}{v_d} = \frac{3}{1.1 \times 10^{-4}}\,s = 2.73 \times 10^{4} \simeq 7.57h$

14) Surface charge density $\sigma = 10^{9} cm^{-2}$

Radius of earth $= R = 6.37 \times 10^{6} m$

Current $= I = 1800 A$

Total charge of the globe

$q =$ Surface area $\times \sigma = 4\pi R^2 \sigma$

$= 4 \cdot 3.14 \times (6.37 \times 10^6)^2 \times 10^{-9} = 509.65 \times 10^{3} C$

Required time

$t = \frac{q}{I} = \frac{509.65 \times 10^3}{1800} = 283.13 s \simeq 283 s$

15) Here $\varepsilon = 2V$, $r = 0.015 \Omega$, $R = 8.5 \Omega$, $n = 6$

When the cells joined in series the current is

$I = \frac{n\varepsilon}{R + nr} = \frac{6 \times 2}{8.5 + 6 \times 0.015} = \frac{12}{8.59} A \simeq 1.4 A$

Terminal voltage

$V = IR = 1.4 \times 8.5 = 11.9 V$

b) Here $\varepsilon = 1.9V$, $r = 380 \Omega$

$I_{max} = \frac{1.9}{380} = 0.005 A$

This secondary cell cannot drive the starting motor of car because that requires a large current of about 100 A for few second.

16) Given,

$\rho_{Al} = 2.63 \times 10^{-8} \Omega m$, $\rho_{Cu} = 1.72 \times 10^{-8} \Omega m$

relative density of Al $= 2.7$ and that of Cu $= 8.9$

Mass $=$ volume $\times$ density $= Ald$

$= \frac{\rho l}{R} \cdot ld = \frac{\rho d l^2}{R}$ $\quad \left[ \because R = \rho \frac{l}{A} \right]$

As the two wires are of equal length and have the same resistance, their mass ratio will be

$\frac{m_{Cu}}{m_{Al}} = \frac{\rho_{Cu} \, d_{Cu}}{\rho_{Al} \, d_{Al}} = \frac{1.72 \times 10^{-8} \times 8.9}{2.63 \times 10^{-8} \times 2.7} = 2.155 \simeq 2.2$

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18) a) only current is constant because it is given to be steady. Other quantities : current density, electric field and drift speed vary inversely with area of cross section.

b) NO ohm's law is not universally applicable for all conducting elements. Examples of non-~~attohoic~~ ohmic elements are vacuum diode, thyristor, gas discharge tube, electrolytic soln etc.

c) The maxm. current that can be drawn from a voltage supply is given by

$$I_{max} = \frac{\mathcal{E}}{r}$$

clearly $I_{max}$ will be large if r is small

d) If the internal resistance is not very large ; then the current will exceed the safety limits in case the circuit is short circuited accidentally.

19 a) Alloys of metal usually have greater resistivity than that of their constituents

b) Alloys usually ~~having~~ much lower temperature coefficient of resistance than pure metal

c) The resistivity of alloy ~~oo~~ manganin is nearly independent of rapidly with increase of temp.

d) The resistivity of a typical insulator is greater than ~~that~~ of a metal ~~with increase of temperature~~ by a factor of order of $10^{22}$

20 a) For maximum effective resistance, all the n resistors must be connected in series.

∴ maximum effective resistance

$$R_s = nR$$

For minimum resistance, n resistors should be in parallel connected

$\frac{1}{R_P} = \frac{nR}{R/n} = \frac{n^2}{1} = n^2 : 1$

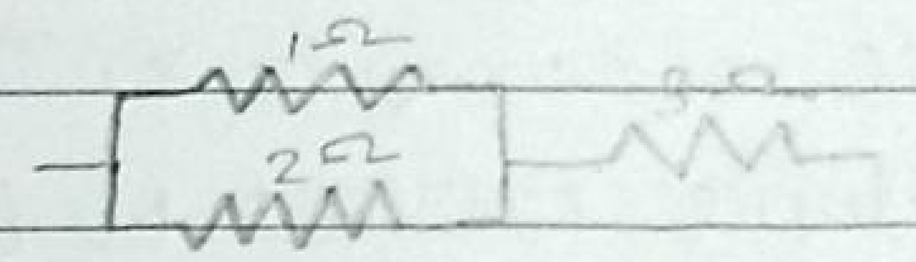
b) Here, $R_1 = 1\Omega$, $R_2 = 2\Omega$, $R_3 = 3\Omega$

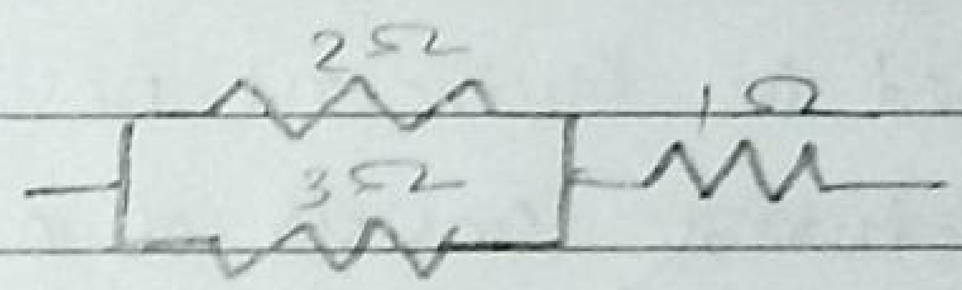
i) when parallel combination of $1\Omega$ and $2\Omega$ resistors are connected in series with $3\Omega$ resistors

$R = R_P + R_3 = \frac{R_1 R_2}{R_1 + R_2} + R_3 = \frac{1\times 2}{1+2} + 3 = \frac{11}{3}\Omega$

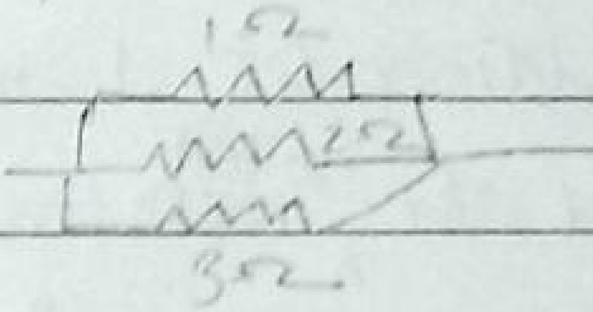
ii) when parallel combination of $2\Omega$ and $3\Omega$ resistors is connected in series with $1\Omega$ resistors the equivalent resistance is

$R = \frac{R_2 R_3}{R_2 + R_3} + R_1 = \frac{2\times 3}{2+3} + 1 = \frac{6}{5} + 1 = \frac{11}{5}\Omega$

a) 


b) 


c) 


d) 


iii) when three resistances are connected in series the equivalent resistance is

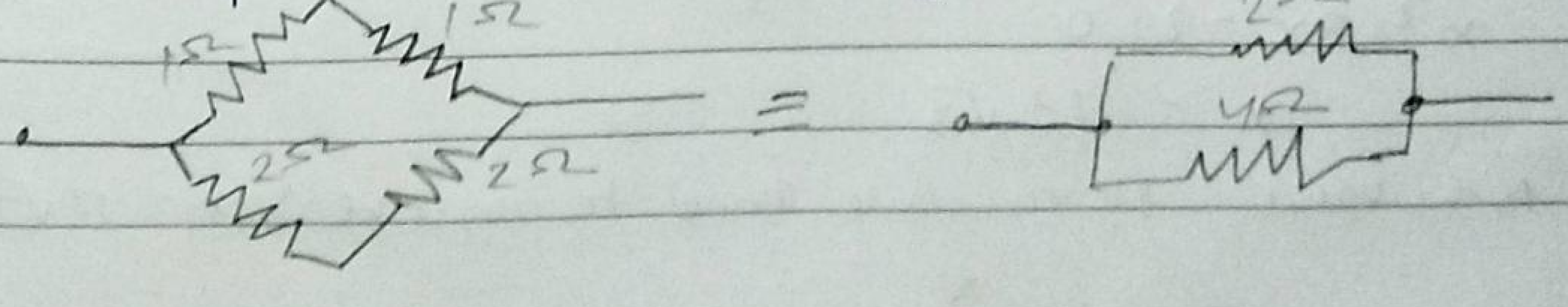
$R = R_1 + R_2 + R_3 = (1+2+3)\Omega = 6\Omega$

iv) when all resistances are connected in parallel

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{1} + \frac{1}{2} + \frac{1}{3} = \frac{11}{6}$

Equivalent resistance $= \frac{6}{11}\Omega$

c) The network shown in fig is a series combination of four identical units. One such unit is shown in figure and it is equivalent to parallel combination of resistances of $2\Omega$ and $4\Omega$ as shown in fig



Resistance R of one such unit is given by

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

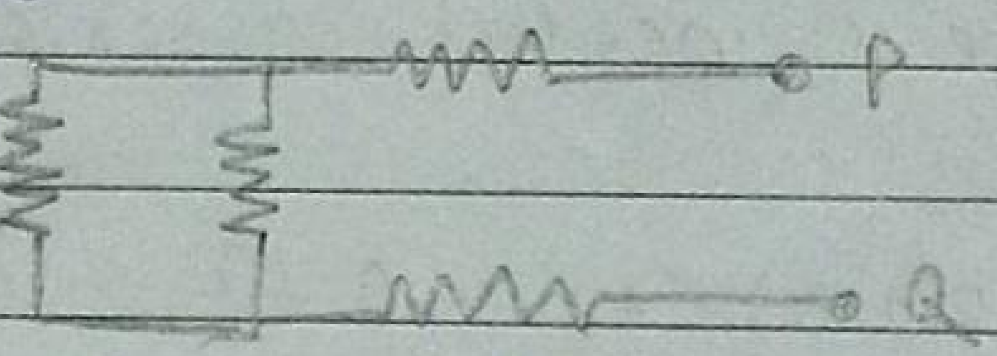
$R = \frac{4}{3}\ \Omega$

Resistance of total network = $4 \times \frac{4}{3} = 16/3\ \Omega$

ii) The network shown in fig is a series combination of 5 resistors each of resistance R

$\therefore$ equivalent resistance = $\cancel{4 \times \frac{4}{3}} = \cancel{\frac{16}{3}}$ 5R

21) Let the equivalent resistance of infinite network be $x$. This network consists of infinite units of three resistors of 1Ω, 1Ω and 1Ω. Addition of 1 more ~~resistors~~ such unit across will not affect the total resistance. The network obtained by adding one more unit would appear

22) 


Resistance between A and B

= Resistence equivalent to parallel combination of $x$ and 1Ω

= $\frac{x \cdot 1}{x+1} = \frac{x}{x+1}$

Resistance between P and Q = $1 + \frac{x}{x+1} + 1 = 2 + \frac{x}{x+1}$

This must be equal to original resistance $x$

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

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

$x = 1 \pm \sqrt{3}$

As the value of resistance cannot be negative so $x = 1+\sqrt{3} = 2.732$

Current $I = \frac{\text{emf}}{\text{total resistance}} = \frac{\mathcal{E}}{x+r} = \frac{12}{2.732+0.5} = 3.713A$

22 a) $\mathcal{E} = 1.02V$, $l_1 = 67.3cm$, $\mathcal{E}_2 = \mathcal{E} = ?$, $l_2 = 82.3cm$

Formula for the comparison of emf by ~~potential~~ Potentiometer is

$\frac{\mathcal{E}_2}{\mathcal{E}_1} = \frac{l_2}{l_1}$ $\therefore \frac{\mathcal{E}_2}{1.02} = 1.25V$

b) High resistance of 600 ~~k~~ k$\Omega$ protects the galvanometer for position faraway from balance point

c) No balance point is not affected by high resistance because no current flows through standard cell at balance point.

d) Yes, the balance point is affected by the internal resistance affects the current through the potentiometer wire, so changes ~~the potentiom~~ the potential gradient and hence affects the ~~current through~~ balance point.

e) No, the arrangement will not work. If $\mathcal{E}$ is greater than emf of the driver cell of potentiometer there will be no balance point on wire AB.

23) Here, $R = 10\Omega$, $l_1 = 58.3cm$, $x = ?$, $l_2 = 68.5cm$

Let $\mathcal{E}_1$ and $\mathcal{E}_2$ be potential drops across $R$ and $x$ respectively and $I$ be the current in potentiometer wire

Then $\frac{\mathcal{E}_2}{\mathcal{E}_1} = \frac{Ix}{IR} = \frac{x}{R}$

But $\frac{\mathcal{E}_2}{\mathcal{E}_1} = \frac{l_2}{l_1}$ $\therefore \frac{x}{R} = \frac{l_2}{l_1}$

$x = \frac{l_2}{l_1} R = \frac{68.5}{58.3} \times 10 = 11.75\Omega$

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24) Here, $l_1 = 76.3cm$, $l_2 = 64.8cm$, $R = 9.5\Omega$

The formula for internal resistance of a cell by potentiometer method

$$r = R\left(\frac{l_1 - l_2}{l_2}\right) = 9.5\left(\frac{76.3 - 64.8}{64.8}\right) = \frac{9.5 \times 11.5}{64.8} \simeq 1.7\Omega$$