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Current Electricity

NCERT exercise questions

Q3.1) The storage battery of a car has an emf of 12 V. If the interval resistance of the battery is 0.4 Ω. What is the ~~maxim~~ maximum current that can be drawn from the battery?

In the given question

The EMF of the battery is given by = 1

According to Ohm's law,

$E = IR$

Rearranging, we get

$$I = \frac{12}{0.4} = 30A$$

Therefore, the maximum current drawn from the given battery is 30A.

Q 3.2) A battery of EMF 10V and interval resistance 3 Ω is connected to a resistor. If the current in the circuit is 0.5A, what is the resistance of the resistor? What is the terminal voltage of the battery when the ~~circ~~ circuit is closed?

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A

Solution

Given :

The EMF of the battery ($E = 10V$)

The internal resistance of the battery ($R = 3\,\Omega$)

The current in the circuit ($I = 0.5A$)

Consider the resistance of the resistor to be R

The current in the circuit can be found out using ohm's laws,

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

Rewriting the above equation, we get

$$R + r = \frac{E}{I} = \frac{10}{0.5} = 20\,\Omega$$

Theraf Therefore

$$R = 20 - 3 = 17\,\Omega$$

Con Consider the Terminal voltage of the resistor to be V.

Then, according to Ohm's law,

$$V = IR$$

Substituting values in the equation, we get

$$V = 0.5 \times 17$$

$$V = 8.5V$$

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Q 3.3) (a) Three resistors 1 Ω, 2 Ω and 3 Ω are combined in series. What is the total resistance of the combination?

(b) If the combination is connected to a battery of emf 12 V and negligible internal resistance obtain the potential drop across each resistor.

Ans: (a) We know that resistors $r_1 = 1\,\Omega$, $r_2 = 2\,\Omega$ and $r_3 = 3\,\Omega$ are combined in series.

~~The total resistance $r_1 = 1\,\Omega$, $r_2 = 2\,\Omega$ and $r_3 = 3\,\Omega$ are combined in series.~~

The total resistance of the above series combination can be calculated by the algebraic sum of individual resistances as follows:

Total resistance $= 1\,\Omega + 2\,\Omega + 3\,\Omega = 6\,\Omega$
Thus ~~calcu~~ calculated Total Resistance $= 6\,\Omega$

(b) Let us consider I ~~A~~ to be the current flowing the given circuit
Also,
The emf of the battery is $E = 12\,V$

Total resistance of the circuit flowing the given ~~circ~~ circuit
~~Als~~ Also,
The emf of the battery is $E = 12\,V$

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Total resistance of the circuit (calculated above) $= R = 6\Omega$

Using Ohm's law, relation for current can be obtained as $I = \frac{E}{R}$

Substituting values in the above equation we get

$$I = \frac{12}{6} = 2A$$

Therefore, the current calculated is 2 A.

Let the Potential drop across 1Ω resistor $= V_1$

The value of V_1 can be obtained from Ohm's law as:

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

Let the Potential drop across 2Ω resistor $= V_2$

The value of V_2 can be obtained from Ohm's law as:

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

Let the Potential drop across 3Ω resistor $= V_3$

The value of V_3 can be obtained from Ohm's law as:

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

~~The~~ Therefore, the potential drops across the given resistors $r_1 = 1\Omega$, $r_2 = 2\Omega$ and $r_3 = 3\Omega$ are calculated to be

$$V_1 = 2 \times 1 = 2V$$
$$V_2 = 2 \times 1 = 4V$$
$$V_3 = 2 \times 1 = 6V$$

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Q 3.4) (a) Three resistors 2 Ω, 4 Ω and 5 Ω combined in parallel What is the total resistance of the combination?

(b) If the combination is connected to a battery of emf 20V and negligible internal resistance determine the current through each resistor, and the total current drawn from the battery.

Ans A) a) Resistors $r_1 = 2\,\Omega$, $r_2 = 4\,\Omega$ and $r_3 = 5\,\Omega$ are combined in parallel

Hence the total resistance of the above circuit can be calculated ~~a~~ by the following formula:

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

$$\frac{1}{R} = \frac{1}{2} + \frac{1}{4} + \frac{1}{5}$$

$$\frac{1}{R} = \frac{10+5+4}{20}$$

$$\frac{1}{R} = \frac{19}{20}$$

Therefore, the total resistance of the parallel combination given above is given by

$$R = \frac{20}{19}$$

B) Given that emf of the battery, $E = 20V$

Let the current flowing through resistor R_1 be I_1

I_1 is given by:

$$I_1 = \frac{V}{R_1}$$

$$I_1 = \frac{\cancel{20}^{\,10}}{\cancel{2}}$$

$$I_1 = 10A$$

Let the current flowing through resistor R_2 be I_2

I_2 is given by:

$$I_2 = \frac{V}{R_2}$$

$$I_2 = \frac{20}{4}$$

$$I_2 = 5A$$

Let the current flowing through resistor R_3 be I_3
I_3 is given by:

$$I_3 = \frac{V}{R_3}$$

$$I_3 = \frac{20}{5}$$

$$I_3 = 4A$$

Therefore, the total current can be ~~found~~ found by the following formula:

$$I = I_1 + I_2 + I_3 = 10 + 5 + 4 = 19A$$

therefore the current flowing through each resistor is calculated to be :-

$I_1 = 10A$
$I_2 = 5A$
$I_3 = 4A$

Therefore, the total current is $I = 19A$

Q 3.5) At room temperature (27.0°C) the resistance of a heating element is 100 Ω. What is the temperature of the element if the resistance is found to be 117 Ω, given that the temperature coefficient of the material of the resistor is $1.70 \times 10^{-4}\ °C^{-1}$

Given that the room temperature $T = 27°C$
The heating element has a resistance of $R = 100\ \Omega$
Let the increased temperature of the filament be T_1
at T_1, the resistance of the heating element is $R_1 = 117\Omega$
Temperature coefficient of the material for the element is $1.70 \times 10^{-4}\ C^{-1}$

$\alpha = 1.70 \times 10^{-4}\ C^{-1}$
α is given by the relation.

$$\alpha = \frac{R_1 - R}{R(T_1 - T)}$$

$$T_1 - T = \frac{R_1 - R}{R\alpha}$$

$$T_1 - 27 = \frac{117 - 100}{100(1.7 \times 10^{-4})}$$

$$T_1 - 27 = 1000$$

$T_1 = 1027°C$

Therefore, the resistance of the element is 117 Ω at $T_1 = 1027°C$

Question 3.6

Q 3.6) A negligibly small current is passed through a wire of length 15m and uniform cross-section $6.0 \times 10^{-7} m^2$, and its resistance is measured to be 5.0Ω. What is the resistivity of the materials at the temperature of the experiment

Ans 3.6) Given that the length of the wire, $L = 15m$

Area of cross-section is given as, $a = 6.0 \times 10^{-7} m^2$

Let the resistance of the material of the wire be,
$R = 5.0 \Omega$

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

$$\rho = \frac{R \times A}{L} = \frac{5 \times 6 \times 10^{-7}}{15} = 2 \times 10^{-7}$$

Therefore, the resistivity of the material is calculated to be 2×10^{-7}

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Q 3.7) A silver wire has a resistance of 2.1 Ω at 27.5°C and a resistance of 2.7 Ω at 100°C. Determine the temperature coefficient of ~~rest~~ resistivity of silver.

Ans 3.7) Given that temperature $T_1 = 27.5°C$
Resistance R_1 at temperature T_1 is given as:

$R_1 = 2.1\,\Omega$ at (T_1)

Given that Temperature T_2 is given as:

$R_1 = 2.1\,\Omega$ at (T_1)

Given that temperature $T_2 = 100°C$
Resistance R_2 at temperature T_2 is given as:

$R_2 = 2.7\,\Omega$ (at T_2)

Temperature coefficient of resistivity of silver $= \alpha$

$$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

$$\alpha = \frac{2.7 - 2.1}{2.1(100 - 27.5)}$$

$$\alpha = 0.0039°C^{-1}$$

Therefore, the temperature coefficient resistivity of silver is $0.0039°C^{-1}$

Q3.8) A heating element using nichrome connected to a 230V supply draws an initial current of 3.2 A which settles after seconds to a steady value of 2.8 A. What is the steady temperature of the heating element if the room temperature is 27.0°C? Temperature coefficient of resistance of nichrome averged over the temperture range involved is $1.70 \times 10^{-4} \, °C^{-1}$.

Ans: In the given problem

The supply voltage is $V = 230V$

The initial current drawn is $I_1 = 3.2A$

Consider the initial resistance to be R_1, which can be found by the following relation:

$$R_1 = \frac{V}{I}$$

Substituting values, we get

$$R_1 = \frac{230}{3.2} = 71.87\Omega$$

Value of current at steady state $I_2 = 2.8A$
Value of resistance at steady state $= R_2$

R_2 can be calculated by the following equation:

$$R_2 = \frac{230}{2.8} = 22.14\Omega$$

The temperature coefficient of nichrome averaged over the temperature range involved is $1.70 \times 10^{-4} \,^{\circ}C^{-1}$

Value of initial temperature of nichrome, $T_1 = 27.0^{\circ}C$
Value of steady state temperature reached by nichrome $= T_2$

This temperature T_2 can be obtained by the following formula:-

$$\alpha = \frac{R_2 - R_1}{R_1 (T_2 - T_1)}$$

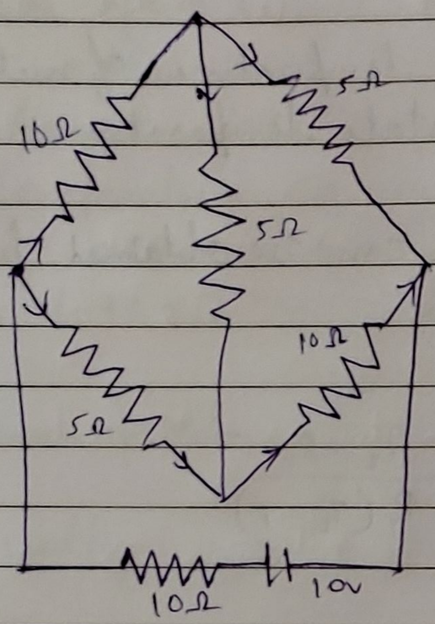
$$T_2 - 27 = \frac{82.14 - 71.87}{71.87 \times (1.7 \times 10^{-4})}$$

$$T_2 - 27 = 840.5$$

$$T_2 = 840.5 + 27 = \cancel{865}\ 867.5^{\circ}C$$

Hence, the steady temperature of the heating element is $867.5^{\circ}C$

Q3.9) Determine the current in each ~~other~~ branch of the network shown in the figure.



~~Solution~~:

Ans: The current flowing through various branches of the network is shown ~~as~~ is the figure given below:

Let I_1 be the current flowing through the outer circuit

Let I_2 be the current flowing through AB branch

Let I_3 be the current flowing through AD branch

Let ~~I~~ $I_2 - I_4$ be the current flowing through branch BC

Let $I_3 + I_4$ be the current flowing through branch DC

Let us take closed - circuit ABDA into consideration, we know that potential is zero.

i.e. $10I_2 + 5I_4 - 5I_3 = 0$

$$2I_2 + I_4 - I_3 = 0$$

$$I_3 = 2I_2 + I_4 \quad \text{--- eq (1)}$$

Let us take closed circuit BCDB into ~~consi~~ consideration, we know that potential is zero.

i.e. $5(I_2 - I_4) - 10(I_3 + I_4) - 5I_4 = 0$

$$5I_2 - 5I_4 - 10I_3 - 10I_4 - 5I_4 = 0$$

$$5I_2 - 10I_3 - 20I_4 = 0$$

$$I_2 = 2I_3 - 4I_3 \quad \text{--- eq (2)}$$

Let us take closed - circuit ABCFEA into consideration, we know that potential is zero

i.e. $-10 + 10(I_1) + 10(I_2) + 5(I_2 - I_4) = 0$

$\cancel{10 = 15I}$

$$10 = 15I_2 + 10I_2 - 5I_4$$

$$3I_2 + 2I_2 - I_4 = 2 \quad \text{--- eq (3)}$$

3) From equation 1 and 2, we have :

$$I_3 = 2(2I_3 + 4I_4) + I_4$$

$$I_3 = 4I_3 + 8I_4 + I_4$$

$$-3I_3 = 9I_4$$

$$-3I_4 = +I_3$$

4) Putting equation (4) is equation (1), we have :

$$I_3 = 2I_2 + I_4$$

$$-4I_4 = 2I_2$$

$$I_2 = -2I_4$$

5) From the above equation, we infer that :

$$I_1 = I_3 + I_2$$

6) Putting equation (4) is equation (1) we obtain

$$3I_2 + 2(I_3 + I_2) - I_4 = 2$$

$$5I_2 + 2I_3 - I_4 = 2$$

7) Putting equations (4) and (5) in equation (7), we obtain

$$5(-2I_4) + 2(-3I_4) - I_4 = 2$$

$-10I_4 - 6I_4 - I_4 = 2$

$17I_4 = -2$

$I_4 = -\frac{2}{17}$ A

Equation (4) reduces to

$I_3 = -3(I_4)$

$I_3 = -3\left(-\frac{2}{17}\right) =$

$= \frac{6}{17}$ A

$I_2 = 2(I_4)$

$I_2 = -2\left(-\frac{2}{17}\right) = \frac{4}{17}$ A

$I_2 - I_4 = \frac{4}{17} - \frac{2}{17} = \frac{6}{17}$ A

$I_3 + I_4 = \frac{6}{17} - \left(\frac{-2}{17}\right) = \frac{4}{17}$ A

Therefore, current in ~~ead~~ each branch is given as:

In branch AB = $\frac{4}{17}$ A

In branch BC = $\frac{6}{17}$ A

In branch CD = $\frac{-4}{17}$ A

In branch AD = $\frac{6}{17}$ A

In branch BD $= \frac{-2}{17}$ A

Total current $= \frac{4}{17} + \frac{6}{17} + \frac{-4}{17} + \frac{6}{17} + \frac{-2}{17} = \frac{10}{17}$ A

Q 3) a

A) In a meter bridge given below, the balance point is found to be at ~~39.5~~ 39.5cm from the end A, when the resistor S is of 12.5Ω. Determine the resistance of R. Why are the connections between resistors in a Wheatstone or meter ~~brigh~~ bridge made of thick copper strips?

B) Determine the balance point of the bridge ~~made~~ above if R and S are interchanged.

c) What happens if the galvanometer and cell ~~are~~ are interchanged at the balance point of the bridge? Would the ~~galvo~~ galvanometer show any current?

Ans a) Let L_1 be the balance point from ~~an~~ end A

Given that, $L_1 = 39.5$ cm

Given that resistance of the resistor $S = 12.5\Omega$

We know that condition for the balance is given by the equation :-

$$\frac{R}{S} = \frac{100 - L_1}{L_1}$$

$$R = \frac{100 - 39.5}{39.5} \times 12.5 = 8.2\,\Omega$$

Thus calculated the resistance of the resistor R, is

$R = 8.2\,\Omega$

b) If R and S are interchanged, then the lengths will also be interchanged.

Hence, the Length modifies to

$l = 100 - 39.5 = 60.5$ cm

(c) If the galvanometer and the cell are interchanged, the position of the balance point remains unchanged. Therefore, the galvanometer will show no current.

Q 3.11) A storage battery of emf 8.0V and internal resistance $0.5\,\Omega$ is being charged by a 120V dc supply using a series resistor of $15.5\,\Omega$. What is the terminal voltage of the battery during charging? What is the purpose of having a series resistor in the charging circuit?

Ans The EMF of the given storage battery is $E = 8.0V$

The internal resistance of the battery is given by

$r = 0.5\,\Omega$

The given DC supply voltage is $R = 15.5\,\Omega$

Effective voltage in the circuit $= V'$

R is connected to the storage battery in series.

Hence, it can be written as

$V' = V - E$

$V' = 120 - 8 = 112V$

Current flowing in the circuit = I, which is given by the relation

$$I = \frac{V'}{R+r}$$

$$I = \frac{112}{15.5+5}$$

$$I = \frac{112}{16}$$

$$I = 7A$$

We know that voltage across a a resistor R given by the product

$$I \times R = 7 \times 15.5 = 108.5V$$

DC supply voltage = Terminal voltage + voltage drop across R

Terminal voltage of battery = 120 - 108.5 = 11.5V

A series resistor, when connected in a charging circuit, ~~I~~ limits the ~~cu~~ current drawn from the external source.

~~A~~. The current will become extremely high in its absense. This is extremely dangerous.

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3.12) In a potentiometer, a cell of emf 1.25 V gives a ~~balan~~ balance point at 35.0 cm length of the wire. If the cell is replaced by another cell and the balance point shifts to 63.0 cm, what is the emf of the second cell?

Ans Emf of the cell, $E_1 = 1.25 V$

The balance point of the potentiometer, $I_1 = 35$ cm
The cell is replaced by another cell of emf E_2
New balance point of the potentiometer, $I_2 = 63$ cm
The balance ~~point~~ condition is given by the relation

$$\frac{E_1}{E_2} = \frac{I_1}{I_2}$$

$$E_2 = E_1 \times \frac{I_2}{I_1} \qquad E_2 = 1.25 \times \frac{63}{35} = 2.25 V$$

Q 3.13) The number density of frees in a copper conductor in Example 3.1 is $8.5 \times 10^{28} m^{-3}$. How long does an electron take to drift from one end of a wire 3.0 m long to its other end? The ~~area~~ area of cross-section of the wire is $2.0 \times 10^{-6} m^2$ and it is carrying of 3.0 A.

Ans Given that number density of free electrons in a copper conductor, $n = 8.5 \times 10^{28} m^{-3}$

Let the length of the copper wire be I

Given, $I = 3.0$ m

~~Let~~

~~Let the length of the copper wire be I~~

Let the area of cross-section of the wire be A $= 2.0 \times 10^{-6}\, m^2$

~~Let the length of the copper wire be I~~

~~Given~~, Value of the current carried by the wire, $I = 3.0\,A$, which is given by the equation,

$$I = nAeV_d$$

Where,

e = electric charge $= 1.6 \times 10^{-19}\, C$

v_d = Drift velocity = ~~length of the wire (l) / time taken to cover (t)~~

$$I = nAe\frac{l}{t}$$

$$t = \frac{n \times A \times e \times l}{I}$$

$$t = 3 \times 8.5 \times 10^{28} \times 2 \times 10^{-6} \times 1.6 \times 10^{-19}$$

$$t = 2.7 \times 10^{4}\ \text{sec}$$

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Q 3.14) The earth's surface has a negative surface charge density of 10^{-9} Cm^{-2}. The potential difference of 400 kV between the top of the atmosphere and the surface results (due to the low conductivity of the lower atmosphere) in a current of only 1800A over the entire globe. If there were no mechanism of sustaining atmospheric electric field, how much time (roughly) ~~was~~ would be required to neutralise the earth's surface? (This never happen in practice continual thunderstorms and lightning in different parts of the globe). (Radius of earth = 6.37×10^{6} m)

Ans: Surface charge density of the earth $\sigma = 10^{-9}$ cm^{-2}
Potential difference between ~~to top~~ the top of the atmosphere and the surface = $V = 400$ kV

Surface ~~charge~~ area of the earth, $A = 4\pi r^2$

$$= 4 \times 3.14 \times (6.37 \times 10^{6})^2 = 10^{14}\ m^2$$

Charge on the earth ~~so~~ surface, $q = \sigma A = 10^{-9} \times 5.09 \times 10^{14}$

$$= 5.09 \times 10^{5} C$$

Time taken to neutralise the earth's surface, $t = q/I$

$$\Rightarrow t = 5.09 \times 10^{5} / 1800 = 283\ s$$

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Q 3.15) (a) Six lead-acid type of secondary cells each of emf 2.0V and resistance 0.015 Ω are joined in series to provide a supply to a resistance of 8.5 Ω. What is the current drawn from the supply and its terminal voltage?

(b) A secondary cell after long has an emf ~~of~~ of 1.9V and ~~a~~ a large ~~inte~~ internal resistance of 380 Ω. What maximum current ~~a~~ can be ~~dra~~ drawn ~~fro~~ from the cell? Could the starting motor of a car?

Ans (a) ~~Emf~~ Emf of the secondary cells, $\varepsilon = 2.0V$

Number of secondary cells, $n = 6$

Total EMF, $E = n\varepsilon = 6 \times 2 = 12V$

Internal resistance of the secondary cells ~~r~~, $r = 0.015 \Omega$

Resistance to which the secondary cells are connected, R =

$R = 8.5 \Omega$

Total resistance is circuit $R_{total} = nr + R$.

$= 6 \times 0.015 + 8.5 = 8.59 \Omega$

Current drawn from the supply, $I = E/R_{total}$

$= 12/8.59$

$= 1.4A$

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

(b) Emf of the secondary cell, $\varepsilon = 1.9V$

Internal resistance, $r = 380 \Omega$

Maximum current drawn from the cell, $I = \varepsilon / r$

$= 1.9/380$

$= 0.005A.$

The current required to start a motor is 100 Amp. Here, the current produced is 0.005A, so ~~that~~ the starting motor of the car cannot be started with this current.

Q 3.16) Two wires of equal length, one of the aluminium and the other of copper have the same resistance. Which of the two wires is ~~ligt~~ lighter? Hence explain why alumininum wires are preferred for overhead power cables. ($\rho_{Al} = 2.63 \times 10^{-8}\ \Omega m$, $\rho_{Cu} = 1.72 \times 10^{-8}\ \Omega m$, Relative density of Al = 2.7, of Cu = 8.9)

Ans Length of aluminium = ~~E_1~~ l_1

Resistance of aluminium = R

~~Rest~~ Resistivity of aluminium, $\rho_{Al} = \rho_1 = 2.63 \times 10^{-8}\ \Omega m$

Relative density of aluminium $d_1 = 2.7$

Area of cross-section of the aluminium wire = A_1

length of copper = ~~E_2~~ l_2

Resistance of copper = ~~E_2~~ R_2

Resistivity of copper, $\rho_{cu} = \rho_2 = 1.72 \times 10^{-8}\ \Omega m$

Relative density of copper, $d_2 = 8.9$

Area of cross section of the copper wire $= A_2$

Therefore,

$$R_1 = \rho_1 \frac{l_1}{A_1} \quad -(1)$$

$$R_2 = \rho_2 \frac{l_2}{A_2} \quad -(2)$$

It is given that $R_1 = R_2$

$$\rho_1 \frac{l_1}{A_1} = \rho_2 \frac{l_2}{A_2}$$

$$\frac{A_1}{A_2} = \cancel{\frac{l_1}{l_2}} \frac{\rho_1}{\rho_2}$$

$$= \frac{(2.63 \times 10^{-8})}{1.72 \times 10^{-8}}$$

$$= 1.52$$

Mass of aluminium, m_1 = Volume × density

$$= A_1 l_1 \times d_1$$

Mass of ~~cop~~ copper $= m_2$ = Volume × density

$$= A_2 l_2 \times d_2$$

$$m_1/m_2 = (A_1 l_1 \times d_1 / A_2 l_2 \times d_2)$$

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Since $l_1 = l_2$

$$\cancel{\text{m}} \quad m_1 / m_2 = (A_1 d_1 / A_2 d_2)$$

$$m_1 / m_2 = (1.52) \times (2.7 / 8.9)$$

$$= (1.52) \times (0.303)$$

$$m_1 / m_2 = 0.46$$

The mass ratio of Al to Cu is 0.46. Since aluminium is ligther, it is preferred for long suspension of cables.

~~Ques~~

Q 3.17) What conclusion can you draw from the following observation ~~s~~ on a resistor made of alloy manganin?

Current A	Voltage V
0.2	3.94
0.4	7.87
0.6	11.8
0.8	15.7
1.0	19.7
2.0	39.4
3.0	59.2
4.0	78.8
5.0	98.6
6.0	118.5
7.0	138.2
8.0	158.0

Ans Ohm's law is valid to high accuracy. This means that the resistivity of the alloy manganin is nearly independent of temperature.

Q 3.18) Answer the following:

(a) A steady current flows in a metallic conductor of the non-uniform cross-section. Which of these quantities is constant along the conductor: current, current ~~de~~ density, electric field, drift speed?

b) Is Ohm's law universally applicable for all conducting elements? If not, give examples of elements that do not obey Ohm's law?

(c) A high tension (HT) supply of, say, 6 kV must have a very large internal resistance. Why?

Ans a) Current is given to be steady. Therefore, it is a constant. The current, electric field, drift speed depends on the area of cross-section inversely.

Ans b) No, examples of non-ohmic elements are vacuum ~~oxide~~ diode, semiconductor diode etc.

Ans c) Because the maximum current drawn from a source = $\mathcal{E}/r$.

~~Ans d) If the circuit is~~

Q 3.19) ~~Ghos~~ Choose the correct alternative :-

Ans (a) Alloys of metals usually have ~~greater~~ greater resistivity than that of their constituent metals.

Ans (b) Alloys usually have much lower temperature coefficients of resistance than pure metals.

Ans (c) The resistivity of the alloy manganin is nearly independent of increase of temperature

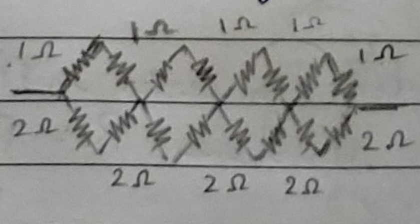
Ans (d) The resistivity of a typical insulator is greater than that of a metal by a factor of the order of 10^{22}

Q 3.20 (a) Given n resistors each of resistance R, how will you combine them to get the (i) maximum (ii) minimum effective ~~effect~~ resistance? What is the ratio of the maximum to minimum resistance?

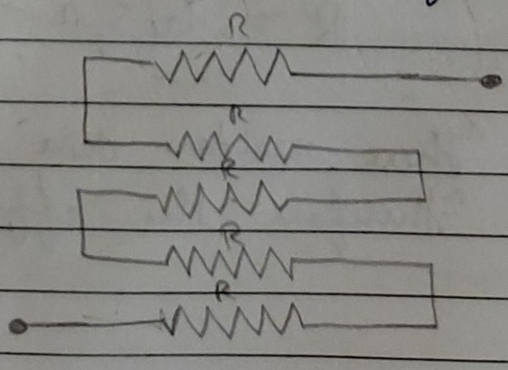
(b) Given the resistances of 1 Ω, 2 Ω, 3 Ω how will be combine them to get an equivalent resistance of

(i) (11/3) Ω
(ii) (11/5) Ω
(iii) 6 Ω
(iv) (6/11) Ω

(c) Determine the equivalent resistance of networks shown in figure



(a)

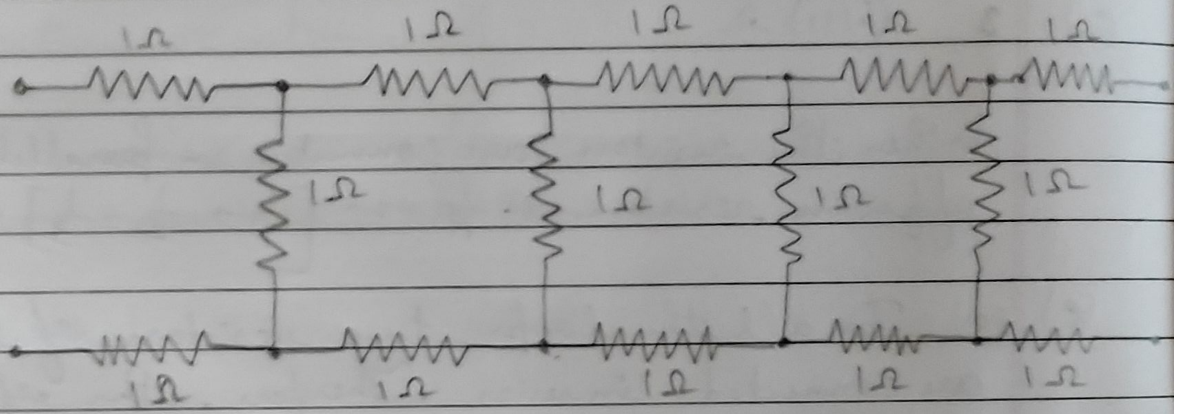


(b)

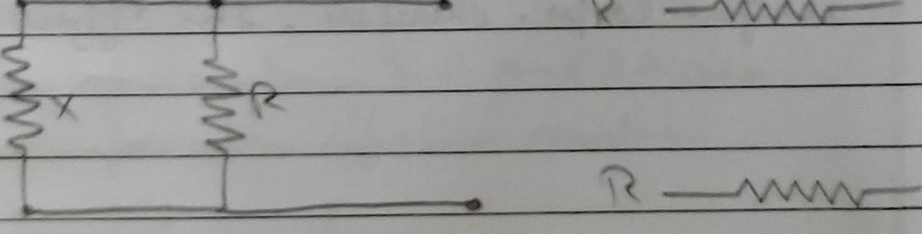
All the four resistors are connected in series. Hence the equivalent resistance R each are $(4/3) \times 4 = 16/3\ \Omega$

(c)(b) The resistors are connected in series. Therefore, the effective is $R + R + R + R + R = 5R$

Q3.21)



Ans: Let the effective resistance of the infinite network be X. Since it is an infinite network, adding three resistors of 1 Ω resistance will not change the total resistance, i.e. it will remain X. The circuit will look like this if three resistors are added.



The equivalent resistance of this network is R' = R is $R' = R +$ (equivalent resistance when X ~~and~~ and R are parallel) $+ R$

$$= R + [XR/(X+R)] + R$$

$$R' = \cancel{R}\,2R + [XR/(X+R)]$$

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As said above, since it is a infinite network, adding three resistors of 1Ω resistance will not change the total resistance

$R' = X$

$\Rightarrow 2R + [XR/(X+R)] = X$

Since $R = 1\Omega$ we get

$2 \times 1 + [X \times 1/(X+1)] = X$

$X^2 - 2X - 2 = 0$

$$X = \frac{-2 \pm \sqrt{(-2)^2 - 4 \times 1 \times (-2)}}{2}$$

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

The value of resistance cannot be negative. Therefore,

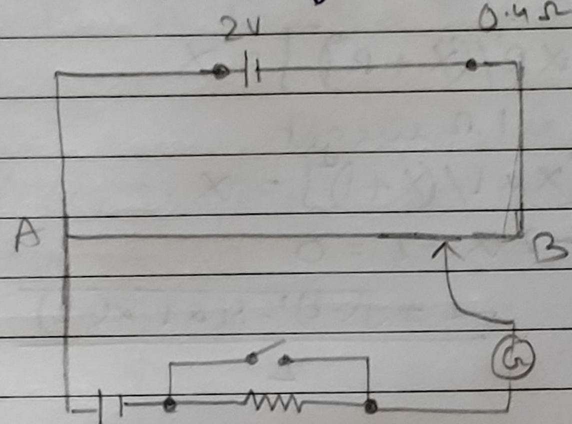
$X = 1 + \sqrt{3} = 2.732\,\Omega$

Given $E = 12V$; $r = 0.5\Omega$

If I is the current drawn by the network, then

$I = E/(X+r) = 12/(2.732 + 0.5)$
$= 3.713\,A$

Q 3.22) Figure shows a potentiometer with a cell of 2.0V and internal resistance 0.40Ω maintaining of potential drop across the resistor wire AB. A standard cell which maintains a constant emf of 1.02V (for very moderate currents upto of few mA) gives a balance point at 67.3 cm length of the wire. To ensure very low currents ~~down~~ drawn from the standard cell, a very high resistance of 600 $k\Omega$ is put in series with it, which is shorted close to the balance point. The standard cell is then replaced by a cell of unknown emf ε and the balance point found similarly, turns out to be at 82.3 cm length of the wire.



(a) What is the value ε?
(b) What purpose does the high resistance of 600 kΩ have?
(c) Is the balance point affected by this high resistance
(d) Would the method work in the above situation if the driver cell of the potentiometer had an emf of 1.0V instead of 2.0V?
(e) Would the circuit work well for determining an extremely small emf, say of the order of a few mV (such as the typical emf of a thermo-couple)? If not, how will you modify the circuit?

Ans:-(a) Constant emf of the standard cell, $E_1 = 1.02V$

The balance point on the wire, $l_1 = 67.3$ cm

The standard cell is then replaced by a cell of unknown emf ε and the balance point changes to $l = 82.3$ cm

The relation between Emf and the balancing point

$$(E_1/I_1) = (\varepsilon/I)$$

$$\varepsilon = (I \times E_1/I_1) = (82.3 \times 1.02)/67.3 = 1.247\,V$$

(b) The purpose of using high resistance of 600 kΩ is to reduce current through the ~~g~~ galvanometer when the movable contact is far from the balance point

(c) No

(d) No. If ε is greater than the emf of the driver cell of the potentiometer, there will be no balance point on the wire AB.

(e) The circuit will not be suitable because the balance point (for ε of the order of a few mV) will be very close to the end A and the percentage of error in the measurement will be very large. The circuit can be modified by putting a suitable resistor R in series with the wire AB so that the potential drop across AB is only ~~stig~~ slightly greater than the emf to be ~~mea~~ measured. Then, the balance point will be at a ~~longer~~ larger length of the wire and the percentage error will be much smaller.