NCERT SOLUTIONS
CLASS-XII PHYSICS
CHAPTER-3 CURRENT AND ELECTRICITY

Question 3.1:

The car has a storage battery with an emf of 12 V. 0.4Ω is the internal resistance of the battery, what is the maximum current that can be drawn from the battery?

Answer 3.1:

Given that Emf of the battery, E = 12 V

Battery has an Internal resistance of R = 0.4 Ω

The Maximum current drawn from the battery is given by = I

According to Ohm's law,

E = IR

$I = \frac{E}{R}$ 0.4

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

The maximum current drawn from the given battery is 30 A.

Question 3.2:

A battery has an emf of 10 V and internal resistance is observed to be 3 Ω and is connected to a resistor. If the current flowing in the circuit is 0.5 A, calculate the resistance of the resistor? Also, calculate the terminal voltage of the battery when the circuit is closed.

Answer 3.2:

Given Data :

Given that Emf of the battery, E = 10 V

Battery has an Internal resistance of R = 3 Ω

Current flowing in the circuit, I = 0.5 A

Let the Resistance of the resistor be = R

$I = \frac{E}{R+r}$ The relation for current using Ohm's law is,

Terminal voltage of the resistor = V

According to Ohm's law,

V = IR

V = 0.5 × 17

V = 8.5 V

Therefore, the resistance of the resistor calculated is 17 Ω and the terminal voltage is found to be

8.5 V.

Question 3.3

a) A series combination of three resistors with the following resistance r_1 = 1 Ω , r_2 = 2 Ω and r_3 = 3 Ω is made. Calculate the total resistance of the combination.

b) Calculate the potential drop across each resistor given above, when this combination is connected to a battery of emf 12 V with negligible internal resistance.

Answer 3.3 :

1. a) Resistors r_1 = 1 Ω , r_2 = 2 Ω and r_3 = 3 Ω are combined in series

Total resistance of the above series combination can be calculated by the algebraic sum of individual resistances

Therefore, total resistance is given by :

R = 1 Ω + 2 Ω + 3 Ω = 6 Ω

Thus calculated R = 6 Ω

b) I is the current flowing the given circuit

Also,

Given that emf of the battery , E = 12 V

Total resistance of the circuit (calculated above) = R = 6 Ω

Using Ohm's law , relation for current can be obtained

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

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

Therefore, the current calculated is 2 A

Let the Potential drop across 1 Ω resistor = V_1

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

V_1 = 2 x 1 = 2 V

Let the Potential drop across 2 Ω resistor = V_2

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

V_2 = 2 x 2 = 4 V

Let the Potential drop across 3 Ω resistor = V_3

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

V_3 = 2 x 3 = 6 V

Therefore, the potential drops across the given resistors r_1 = 1 Ω , r_2 = 2 Ω and r_3 = 3 Ω are calculated to be

V_1 = 2 x 1 = 2 V

V_1 = 2 x 1 = 4 V

V_1 = 2 x 1 = 6 V

Question 3.4 :

a) A parallel combination of three resistors with the following resistance r_1 = 2 Ω , r_2 = 4 Ω and r_3 = 5 Ω is made. Calculate the total resistance of the combination.

b) Calculate the current drawn from the battery when the above combination of resistors is given is connected to a battery of emf 20 V with negligible internal resistance.

Answer 3.4 :

A) Resistors r_1 = 1 Ω , r_2 = 2 Ω and r_3 = 3 Ω are combined in parallel

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

$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$ $\frac{1}{R} = \frac{1}{2} + \frac{1}{4} + \frac{1}{5}$ $\frac{1}{R} = \frac{10+5+4}{20}$ $\frac{1}{R} = \frac{19}{20}$

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

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

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

Let the current flowing through resistor R_1 be I_1

I_1 is given by :

$I_1 = \frac{V}{R_1}$ $I_1 = \frac{20}{2}$ $I_1 = 10A$

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 :

$I_3 = \frac{V}{R_1}$ $I_3 = \frac{20}{5}$ $I_3 = 4A$

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

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

therefore the current flowing through each resistors is calculated to be :

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

and the total current is calculated to be, I = 19 A

Question 3.5 :

Resistance of a heating element is observed to be 100 Ω at a room temperature of (27 ° C) . Calculate the resistance of this element if the resistance is 117 Ω, given that the temperature coefficient of the material used for the element is 1.70 x 10^{-4} C^{-1}

Answer 3.5 :

Given that the room temperature , T = 27 ° C

The heating element has a resistance of , R = 100 Ω

Let the increased temperature of the filament be T_1

At T_1 , the resistance of the heating element is R_1 = 117 Ω

Temperature coefficient of the material used for the element is 1.70 x 10^{-4} C^{-1}

α = 1.70 x 10^{-4} C^{-1}

α is given by the relation ,

$\alpha = \frac{R_1 - R}{R(T_1 - T)} \; T_1 - T = \frac{R_1 - R}{R\alpha} \; T_1 - 27 = \frac{117 - 100}{100(1.7x10_{-4})} \; T_1 - 27 = 1000$

T_1 = 1027 ° C

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

Question 3.6 :

The length of a wire is 15 m and uniform cross – section is 6.0 x 10^{-7} m^2. Negligibly small current is passed through it with a resistance of 5.0 Ω. Calculate the resistivity of the material at the temperature at which the experiment is conducted.

Answer 3.6 :

Given that the length of the wire , L = 15 m

Area of cross – section is given as , a = ***6.0 x 10^{-7} m^2***

Let the resistance of the material of the wire be , R , ie. , R = 5.0 Ω

Resistivity of the material is given as ρ

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

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

Question 3.7 :

A silver wire is observed to have a resistance of 2.1 Ω at a temperature of 27.5 ° C and a resistance of 2.7 Ω at a temperature of 100 ° C. Calculate the temperature coefficient of resistivity of silver.

Answer 3.7 :

Given :

Given that temperature T_1 = 27.5 ° C

Resistance R_1 at temperature T_1 is given as :

R_1 = 2.1 Ω (at T_1)

Given that temperature T_2 = 100 ° C

Resistance R_2 at temperature T_2 is given as :

R_2 = 2.7 Ω (at T_2)

Temperature coefficient of resistivity of silver = α

$R_2 - R_1$ $\quad$ $2.7 - 2.1$ $\quad$ $0.0039^{\circ} C^{-1}$

$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$ $\alpha = \frac{2.7 - 2.1}{2.1(100 - 27.5)} = 0.0039\ C^{-1}$

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

Question 3.8 :

A heating element made up of nichrome is connected to a 230 V supply draws an initial current of 3.2 A which after a few seconds, settles to a steady value of 2.8 A. calculate the steady temperature of the heating element at a room temperature of 27.0 ° C. The temperature coefficient of nichrome (material used to make the above heating device) averaged over the temperature range involved is 1.70 x 10^{-4} ° C^{-1}

Answer 3.8 :

Given that the supply voltage , V = 230 V

Initial current drawn is observed to be , I_1 = 3.2 A

Let the initial resistance be R_1 , which can be found by the relation :

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

$R_1 = \frac{230}{3.2}$ = 71.87 Ω

Value of current at steady state , I_2 = 2.8 A

Value of resistance at steady state = R_2

R_2 can be calculated by the following equation :

$R_2 = \frac{230}{2.8}$ $R_2 = 82.14\Omega$

The temperature coefficient of nichrome (material used to make the above heating device) averaged over the temperature range involved is 1.70 x 10^{-4} ° C^{-1}

Value of initial temperature of nichrome , T_1 = 27.0 ° C

Value of steady state temperature reached by nichrome = T_2

This temperature T_2 can be obtained by the following formula :

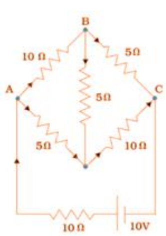
$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$ $T_2 - 27 = \frac{82.14 - 71.87}{71.87x(1.7x10_{-4})}$ $T_2 - 27 = 840.5$

T_2 = 840.5 + 27 = 867.5 ° C

Hence, the steady temperature of the heating element is 867.5 ° C

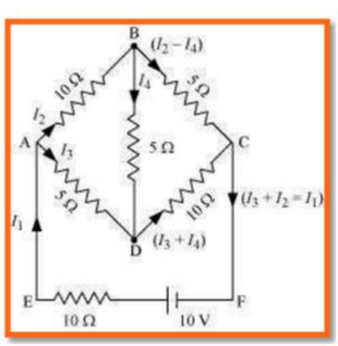
Question 3.9 :

Calculate the current in each branch of the network shown in the figure shown below :



Answer 3.9 :

The current flowing through various branches of the network is shown in 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 $I_2 - I_4$ be the current flowing through branch BC

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

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

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

$2 I_2 + I_4 - I_3 = 0$

$I_3 = 2 I_2 + I_4$ . . . . eq (1)

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

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

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

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

$I_2 = 2 I_3 - 4 I_4$ . . . . eq (2)

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

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

$10 = 15 I_2 + 10 I_1 - 5 I_4$

$3 I_2 + 2 I_2 - I_4 = 2$ . . . . eq (3)

From equation (1) and (2) , we have :

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

$I_3 = 4 I_3 + 8 I_4 + I_4$

$- 3 I_3 = 9 I_4$

$- 3 I_4 = + I_3$ . . . . eq (4)

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

$I_3 = 2 I_2 + I_4$

$- 4 I_4 = 2 I_2$

$I_2 = - 2 I_4$ . . . . eq (5)

From the above equation , we infer that :

$I_1 = I_3 + I_2$ . . . . eq (6)

Putting equation (4) in equation (1) , we obtain

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

$5 I_2 + 2 I_3 - I_4 = 2$ . . . . eq (7)

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

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

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

$17 I_4 = - 2$

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

Equation (4) reduces to

$I_3 = - 3 (I_4)$

$I_3 =-3 \left(\frac{-2}{17}\right) = \frac{6}{17} A$

$I_2 = - 2 (I_4)$

$I_2 =-2 \left(\frac{-2}{17}\right) = \frac{4}{17} A \; I_2 - I_4 = \frac{4}{17} - \frac{-2}{17} = \frac{6}{17} A \; I_3 + I_4 = \frac{6}{17} - \frac{-2}{17} = \frac{4}{17} A \; I_1 = I_3 + I_2 \; I_1 = \frac{6}{17} + \frac{4}{17} = \frac{10}{17} A$

Therefore, current in 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 $= \frac{4}{17} + \frac{6}{17} + \frac{-4}{17} + \frac{6}{17} + \frac{-2}{17} = \frac{10}{17} A$

Question 3. 10 :

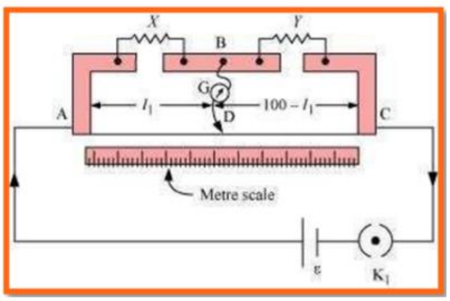
A) In the metre bridge shown below in the figure, 39.5 cm is found to be the balance point from the end A with N resistor having a value of 12.5 Ω. Calculate the value of the resistor M. Also, state the reason behind making the connections between the resistors in a Wheatstone bridge or meter bridge of thick copper strips.

B) Calculate the new balance point of the bridge above if M and N are interchanged.

C) Would the galvanometer show any deflection if the cell and galvanometer are interchanged at the balance point of the Wheatstone bridge?

Answer 3. 10 :

A meter bridge with resistors M and N are shown in the figure.



Meter Bridge

(a) Let L_1 be the balance point from end A ,

Given that , L_1 = 39.5 cm

Given that resistance of the resistor N = 12.5 Ω

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

$\frac{M}{N} = \frac{100-L_1}{L_1}$ $M = \frac{100-39.5}{39.5} \times 12.5 = 8.2\Omega$

Thus calculated the resistance of the resistor M , M = 8.2Ω

Question 3.11 :

A storage battery has an emf of 8.0 V and an internal resistance of 0.5 Ω is allowed by charged by a 120 V, DC supply using a series resistor of 15.5 Ω. What is the terminal voltage of the battery during charging? What is the purpose of having a series resistor in the charging circuit?

Answer 3.11 :

Given :

Emf of the given storage battery, E = 8.0 V

Given that the Internal resistance of the battery, r = 0.5 Ω

DC supply voltage, V = 120 V

Resistance of the resistor, R = 15.5 Ω

Effective voltage in the circuit = V^1

R is connected to the storage battery in series.

Hence, it can be written as

$V^1 = V - E$

$V^1 = 120 - 8 = 112$ V

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 resistor R given by the product,

I x R = 7 × 15.5 = 108.5 V

We know that ,

DC supply voltage = Terminal voltage + voltage drop across R

Terminal voltage of battery = 120 – 108.5 = 11.5 V

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

The current will become extremely high in its absence. This is extremely dangerous.

Question 3.12 :

In a potentiometer arrangement, a cell of emf 1.25 V gives a 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?

Answer 3.12 :

Emf of the cell, E_1 = 1.25 V

Balance point of the potentiometer, l_1 = 35 cm

The cell is replaced by another cell of emf E_2.

New balance point of the potentiometer, l_2 = 63 cm

The balance condition is given by the relation ,

$\frac{E_1}{E_2} = \frac{l_1}{l_2}$ $E_2 = E_1 \times \frac{l_2}{l_1}$ $E_2 = 1.25 \times \frac{63}{35} = 2.25V$

Question 3.13 :

A copper conductor has a number density of free electrons estimated in Example 3.1 of

8.5×10^{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 of the cross-section of the wire is 2.0×10^{-6} m^2 and it is

carrying a current of 3.0 A.

Answer 3.13 :

Given that Number density of free electrons in a copper conductor , n = 8.5×10^{28} m^{-3}

Let the Length of the copper wire be l

Given , l = 3.0 m

Let the area of cross – section of the wire be A = 2.0×10^{-6} m^2

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

I = n A e V_d

Where,

e = electric charge = 1.6×10^{-19} C

$V_d = Driftvelocity = \frac{Lengthofthewire(l)}{timetakentocoverl(t)}$ $I = nAe\frac{l}{t}$ $t = \frac{n \times A \times e \times l}{I}$ $t = \frac{3 \times 8.5 \times 10^{28} \times 2 \times 10^{-6} x 1.6 \times 10^{-19}}{3.0}$ $t = 2.7 \times 10^4 sec$