

NCERT Solutions for Class-XII Physics

Chapter-3

NCERT Physics Class 12

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

1. Emf of the battery, $E = 12\text{ V}$

Internal resistance of the battery, $r = 0.4\Omega$

Maximum current drawn from the battery = I

According to Ohm's law,

$$E = Ir$$

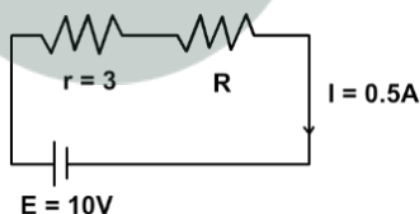
$$I = \frac{E}{r}$$

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

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

2. A battery of emf 10 V and internal resistance 3Ω is connected to a resistor. If the current in the circuit is 0.5 A, what is the resistance of the resistor? What is the terminal voltage of the battery when the circuit is closed?

2. The diagram is given as:



Given: Electromotive force (E) of battery = 10 volt.

Internal Resistance r of the battery = 3Ω

Current in the Circuit (I) = 0.5 A

Let the resistance of the required resistor is $R\Omega$.

Let the Terminal voltage of the register be V .

As per Ω 's law,

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

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

$$\Rightarrow R + r = \frac{10}{0.5}$$

$$\Rightarrow R + r = 20 \Omega$$

$$\therefore r = 3 \Omega$$

Resistance of Resistor is 17Ω .

Also, as per Ohm's law,

$$\Rightarrow V = IR$$

$$\Rightarrow V = 0.5 \text{ A} \times 17 \Omega = 8.5 \text{ V}$$

$$\Rightarrow V = 8.5 \text{ V}$$

$\therefore$ Terminal voltage of the register is 8.5 V .

3. (a) Three resistors 1Ω , 2Ω and 3Ω 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.

3. (a) Three resistors of resistance 1Ω , 2Ω and 3Ω are combined in series. Total resistance of the combination is given by the algebraic sum of individual resistances. Total resistance = $1 + 2 + 3 = 6 \Omega$

(b) Current flowing through the circuit = I

Emf of the battery, $E = 12 \text{ V}$

Total resistance of the circuit, $R = 6 \Omega$

The relation for current using Ohm's law is,

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

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

Potential drop across 1Ω resistor = V_1

From Ohm's law, the value of V_1 can be obtained as $V_1 = 2 \times 1 = 2 \text{ V}$...

(i)

Potential drop across 2Ω resistor = V_2

Again, from Ohm's law, the value of V_2 can be obtained as $V_2 = 2 \times 2 = 4 \text{ V}$... (ii)

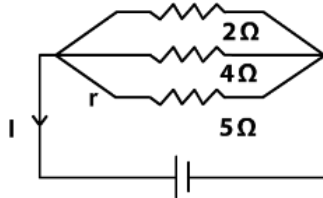
Potential drop across 3Ω resistor = V_3

Again, from Ohm's law, the value of V_3 can be obtained as $V_3 = 2 \times 3 = 6 \text{ V}$... (iii)

Therefore, the potential drop across 1Ω , 2Ω and 3Ω resistors are 2 V , 4 V and 6 V respectively.

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

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



$$E = 20V$$

4.

(a) Since three resistors are connected in parallel, hence total resistance (R) of the combination is given by

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

$$\Rightarrow \frac{1}{R} = \frac{1}{2} + \frac{1}{4} + \frac{1}{5} = \frac{19}{20}$$

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

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

Hence, Total Resistance is 1.05Ω .

(b) Given, EMF of the battery $E = 20$ Volt

$$\text{Current flowing through } 2 \Omega \text{ resistor is given by } I_1 = \frac{E}{R_1} = \frac{20V}{2\Omega} = 10 \text{ A}$$

$$\text{Current flowing through } 4 \Omega \text{ resistor is given by } I_2 = \frac{E}{R_2} = \frac{20V}{4\Omega} = 5 \text{ A}$$

$$\text{Current flowing through } 5 \Omega \text{ resistor is given by } I_3 = \frac{E}{R_3} = \frac{20V}{5\Omega} = 4 \text{ A}$$

Current flowing through 2Ω resistor is 10 Ampere; 4Ω resistor is 5 Ampere and through 5Ω resistor is 4 Ampere respectively.

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

5. Room temperature, $T = 27^\circ\text{C}$

Resistance of the heating element at T , $R = 100 \Omega$

Let T_1 is the increased temperature of the filament.

Resistance of the heating element at T_1 , $R_1 = 117 \Omega$

Temperature co-efficient of the material of the filament,

$$\alpha = 1.70 \times 10^{-4} \text{ } ^\circ\text{C}^{-1}$$

α is given by the relation,

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

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

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

$$T_1 - 27 = 1000$$

$$T_1 = 1027^\circ\text{C}$$

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

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

6. Given, the length of wire $l = 15$ metre

Area of cross section of wire $a = 6.0 \times 10^{-7}$ metre square

Resistance of material of wire, $R = 5 \Omega$

Resistivity of material of wire $= \rho$

$$R = \frac{\rho l}{a}$$

$$\Rightarrow \rho = \frac{Ra}{l}$$

$$\Rightarrow \rho = \frac{5\Omega \times 6 \times 10^{-7} \text{ m}^2}{15 \text{ m}}$$

$$\Rightarrow \rho = 2 \times 10^{-7} \Omega - \text{m}$$

Hence Resistivity of material of wire is 2×10^{-7} metre.

7. A silver wire has a resistance of 2.1Ω at 27.5°C , and a resistance of 2.7Ω at 100°C . Determine the temperature coefficient of resistivity of silver.

7. Temperature, $T_1 = 27.5^\circ\text{C}$

Resistance of the silver wire at T_1 , $R_1 = 2.1 \Omega$

Temperature, $T_2 = 100^\circ\text{C}$

Resistance of the silver wire at T_2 , $R_2 = 2.7 \Omega$

Temperature coefficient of silver $= \alpha$

It is related with temperature and resistance as

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

$$= \frac{2.7 - 2.1}{2.1(100 - 27.5)} = 0.0039^\circ\text{C}^{-1}$$

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

8. A heating element using nichrome connected to a 230 V supply draws an initial current of 3.2 A which settles after a few 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 averaged over the temperature range involved is $1.70 \times 10^{-4}\text{C}^{-1}$.

8. Given Supply Voltage = 230 Volt

And it draws current $I_1 = 3.2$ Ampere

Resistance is given by $R_1 = V/I$

$$R_1 = 230\text{V}/3.2\text{A}$$

$$R_1 = 71.87 \Omega$$

Steady value of current $I_2 = 2.8$ Ampere

Resistance R_2 is given by $R_2 = 230\text{V}/2.8\text{A}$

$$R_2 = 82.14 \Omega$$

Temperature coefficient of nichrome wire $\alpha = 1.70 \times 10^{-4}$ per $^\circ\text{C}$

Initial temperature of nichrome $T_1 = 27^\circ\text{C}$

Steady Temperature attained by nichrome = T_2

The formula is: $R_2 = R_1[1 + \alpha(T_2 - T_1)]$

$$\Rightarrow R_2 - R_1 = R_1\alpha(T_2 - T_1)$$

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

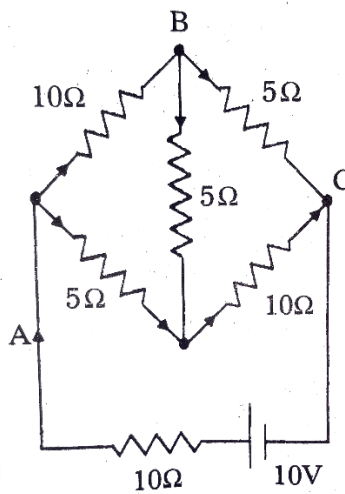
$$\Rightarrow T_2 - 27^\circ\text{C} = \frac{82.14\Omega - 71.87\Omega}{1.70 \times 10^{-4} \times 71.87\Omega}$$

$$\Rightarrow T_2 - 27^\circ\text{C} = 840.5^\circ\text{C}$$

$$\Rightarrow T_2 = 840.5^\circ\text{C} + 27^\circ\text{C} = 867.5^\circ\text{C}$$

Hence Steady Temperature attained by nichrome = 867.5°C .

9. Determine the current in each branch of the network shown in figure:



9. Current flowing through various branches of the circuit is represented in the given figure.

I_1 = Current flowing through the outer circuit

I_2 = Current flowing through branch AB

I_3 = Current flowing through branch AD

$I_2 - I_4$ = Current flowing through branch BC

$I_3 + I_4$ = Current flowing through branch CD

I_4 = Current flowing through branch BD

For the closed circuit ABDA, potential is zero i.e.,

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

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

$$I_3 = 2I_2 + I_4 \quad \dots (1)$$

For the closed circuit BCDB, potential is zero i.e.,

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

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

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

$$I_2 = 2I_3 + 4I_4 \quad \dots (2)$$

For the closed circuit ABCFEA, potential is zero i.e.,

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

$$3I_2 + 2I_2 - I_4 = 2 \quad \dots (3)$$

From equation (1) and (2), we obtain

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

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

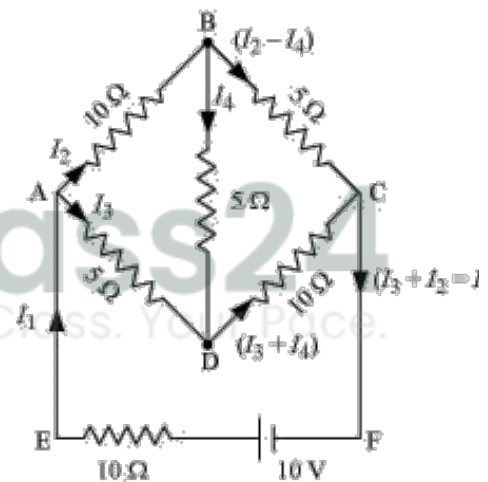
$$-3I_3 = 9I_4$$

$$-3I_4 = +I_3 \quad \dots (4)$$

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

$$I_3 = 2I_2 + I_4$$

$$-4I_4 = 2I_2$$



$$I_2 = -2I_4 \quad \dots (5)$$

It is evident from the given figure that,

$$I_1 = I_3 + I_2 \quad \dots (6)$$

Putting equation (6) in equation (1), we obtain

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

$$5I_2 + 2I_3 - I_4 = 2 \quad \dots (7)$$

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

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

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

$$17I_4 = -2$$

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

Equation (4) reduces to

$$I_3 = -3I_4 = -3\left(-\frac{2}{17}\right) = \frac{6}{17} \text{ A}$$

$$I_2 = -2I_4 = -2\left(-\frac{2}{17}\right) = \frac{4}{17} \text{ A}$$

$$I_2 - I_4 = \frac{4}{17} - \left(-\frac{2}{17}\right) = \frac{6}{17} \text{ A}$$

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

$$I_1 = I_3 + I_2 = \frac{6}{17} + \frac{4}{17} = \frac{10}{17} \text{ A}$$

Therefore, the current in branch in $AB = I_2 = \frac{4}{17} \text{ A}$

The current in branch in $BC = I_2 - I_4 = \frac{6}{17} \text{ A}$

In branch $CD = I_3 + I_4 = \frac{4}{17} \text{ A}$

In branch $AD = I_3 = \frac{6}{17} \text{ A}$

In branch $BD = I_4 = -\frac{2}{17} \text{ A}$

Total current = $I_1 = \frac{10}{17} \text{ A}$

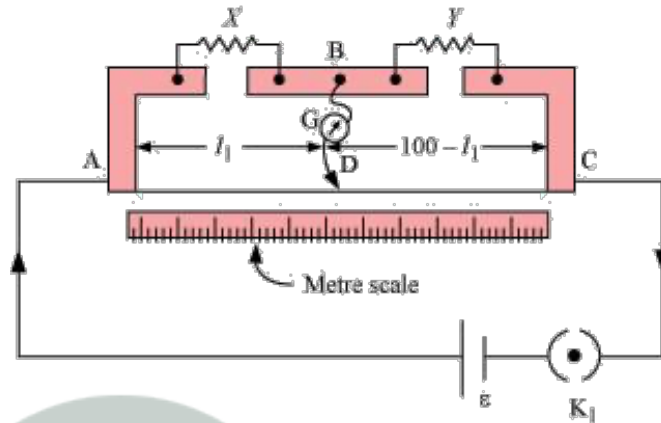
- 10.** (a) In a metre bridge [Fig. 3.27], the balance point is found to be at 39.5 cm from the end A, when the resistor Y is of 12.5Ω . Determine the resistance of X. Why are the

connections between resistors in a Wheatstone or meter bridge made of thick copper strips?

(b) Determine the balance point of the bridge above if X and Y are interchanged.

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

10. (a) The diagram is shown below:



Balance Point from end A, $l_1 = 39.5$ centimeter

Resistance of resistor Y = 12.5Ω

Balance condition is given by,

$$\frac{X}{Y} = \frac{100 - l_1}{l_1}$$

$$X = \frac{(100 \text{ cm} - 39.5 \text{ cm}) \times 12.5 \Omega}{39.5 \text{ cm}}$$

$$\Rightarrow X = 8.2 \Omega$$

(b) When X and Y gets interchanged then l_1 and $100 - l_1$ gets interchanged.

Now the balance point of bridge will be $100 - l_1$ from A

$$100 - l_1 = 100 - 39.5 = 60.5 \text{ cm}$$

Hence the balance point is 60.5 cm from A.

(c) When the galvanometer and cell are interchanged at balance point of bridge then no current would flow through galvanometer because of no deflection.

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

11. Emf of the storage battery, $E = 8.0 \text{ V}$

Internal resistance of the battery, $r = 0.5 \Omega$

DC supply voltage, $V = 120 \text{ V}$

Resistance of the resistor, $R = 15.5 \Omega$

Effective voltage in the circuit = V^1

R is connected to the storage battery in series. Hence, it can be written as $V^1 = V - E$

$$V^1 = 120 - 8 = 112 \text{ V}$$

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

$$I = \frac{V^1}{R + r}$$
$$= \frac{112}{15.5 + 5} = \frac{112}{16} = 7 \text{ A}$$

Voltage across resistor R given by the product, $IR = 7 \times 15.5 = 108.5 \text{ V}$

DC supply voltage = Terminal voltage of battery + Voltage drop across R

$$\text{Terminal voltage of battery} = 120 - 108.5 = 11.5 \text{ V}$$

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

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

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?

12. Given EMF of the cell $E_1 = 1.25 \text{ Volt}$

Balance point of the potentiometer l_1 is given 35 cm.

Since the cell is replaced by another cell of EMF E_2 .

New balance point of potentiometer l_2 is 63 cm.

Since balance condition is given by $\frac{E_1}{E_2} = \frac{l_1}{l_2}$

$$\Rightarrow E_2 = E_1 \times \frac{l_2}{l_1}$$

$$E_2 = 1.25 \text{ V} \times (63 \text{ m} / 35 \text{ m})$$

$$E_2 = 2.25 \text{ Volt.}$$

13. The number density of free electrons in a copper conductor estimated in Example 3.1 is $8.5 \times 10^{28} \text{ m}^{-3}$. 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 cross-section of the wire is $2.0 \times 10^{-6} \text{ m}^2$ and it is carrying a current of 3.0 A.

13. Number density of free electrons in a copper conductor, $n = 8.5 \times 10^{28} \text{ m}^{-3}$ Length of the copper wire, $l = 3.0 \text{ m}$

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

Current carried by the wire, $I = 3.0 \text{ A}$, which is given by the relation, $I = nAeV_d$

Where, e = Electric charge = $1.6 \times 10^{-19} \text{ C}$

$$V_d = \text{Drift velocity} = \frac{\text{Length of the wire}(l)}{\text{Time taken to cover } l(t)}$$

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

$$t = \frac{nAel}{I}$$

$$= \frac{3 \times 8.5 \times 10^{28} \times 2 \times 10^{-6} \times 1.6 \times 10^{-19}}{3.0}$$

$$= 2.7 \times 10^4 \text{ s}$$

Therefore, the time taken by an electron to drift from one end of the wire to the other is $2.7 \times 10^4 \text{ s}$.



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