Current electricity

19.1 Static electricity and current electricity

Electricity is a very important form of energy to us. In the modern world, many instruments are manufactured in a way that they could be operated using electricity. House hold equipment such as Electric bulbs, electric irons and electric fans are some of the examples. Electricity basically has two forms, static electricity and current electricity.

You have learnt in grades 7 and 9 that static electricity consists of charges that are deposited on the surfaces of insulators and that they do not flow. Now let us investigate the behavior of static electricity.

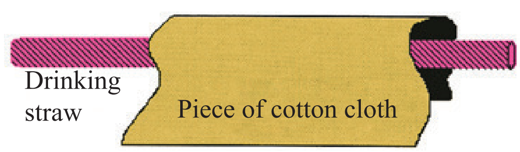


Figure 19.1 – Rubbing a straw with a piece of cotton cloth

Rub a drinking straw well with a cotton material (Figure 19.1) and bring it close to tiny bits of paper as shown in Figure 19.2. You will observe that the bits of paper get attracted to the straw rubbed with the piece of cotton cloth. Also bring another straw that was not rubbed with a cotton cloth close to tiny pieces of paper. You will notice that the bits of paper would not be attracted to the straw.

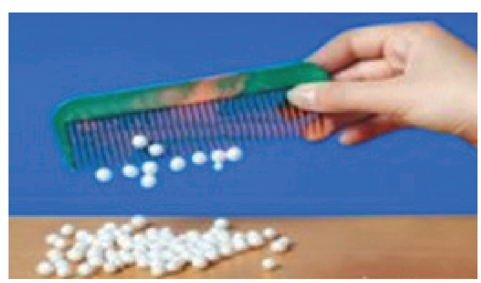


Figure 19.2 – Tiny pieces of rigifoam attracted to a comb charged by rubbing

Rub a plastic rod, pen or a comb against your hair and bring it near tiny bits of paper or tiny pieces of rigifoam. You will observe that these tiny pieces being attracted to the items rubbed with hair. Figure 19.2 shows little bits of rigifoam being attracted to a rubbed comb. Try the above with a plastic rod that was not rubbed with hair. You will observe that the rigifoam pieces do not get attracted to it.

When some objects are rubbed, they acquire a force to attract little pieces of paper, dust and other light materials. Such objects acquire this attractive power through the static electric charges generated by rubbing.

You have observed that objects such as a drinking straw or a comb attract tiny bits of paper only after rubbing them and if the objects are not rubbed, they cannot attract bits of paper.

How are static electric charges that give certain objects an attractive power generated? All materials are composed of atoms. Atoms consist of tiny particles known as electrons, protons and neutrons. Protons are 'positively' charged particles while electrons are 'negatively' charged particles. Neutrons do not have a charge. They are neutral.

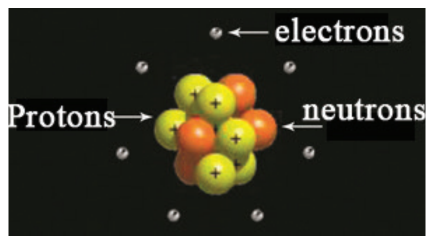


Figure 19.3 – Subatomic particles in an atom

Protons and neutrons are found in the centre of an atom known as the nucleus (Figure 19.3). Electrons are found rotating around the nucleus. Only electrons can be removed from an atom easily. If electrons are removed from the atoms on the surface of an object after rubbing it with a piece of cloth, positive charges are generated on the surface of the object. That is, the surface is positively (+) charged. If the object receives electrons from the piece of cloth after being rubbed with the cloth, then the surface of the object acquires a negative charge. That is, the surface gets negatively (–) charged.

Charges that are found stationary on an object in this manner are known as electrostatic charges.
When such accumulated electrostatic charges begin to move, they give rise to an electric current.

In order to find out how to generate an electric current from electrostatic charges let us engage in Activity 1.

Activity 19.1

Items required: A piece of a PVC tube, a piece of polythene, a neon bulb, conducting wires, a stand

- Arrange the set-up by connecting the conducting wires to the neon bulb as shown in Figure 19.4. Connect one terminal of the neon bulb to the earth

- Charge the PVC rod by rubbing with polythene.
- Touch the terminal of the neon bulb with the charged rod.
- Repeat the above steps several times and observe the lighting of the neon bulb.

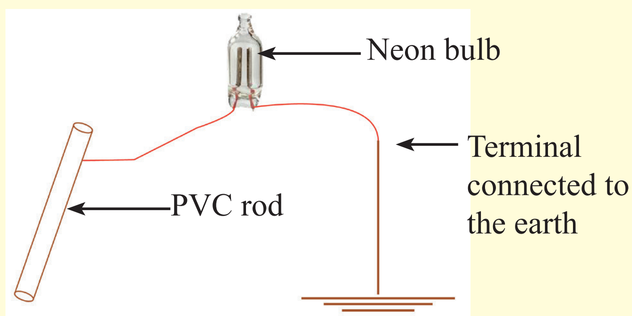


Figure 19.4 – Lighting up of the neon bulb when the electrostatic charges generated by rubbing the PVC rod flow through the bulb.

Electrostatic charges are stored on the surface of the PVC rod rubbed by polythene. When it touches the conducting wires, the stored static charges begin to flow out via the conducting wires. When these charges flow through the neon bulb, it lights up. When static electric charges begin to flow in this manner, it is known as an electric current.

A current of electric charges flowing through a conductor is known as an electric current.

19.2 Electricity flowing through conductors

• Conductors

Materials that allow a current of electrons to pass easily through it are known as conductors. All metals conduct electricity easily. All metals such as copper, aluminum and iron are electric conductors. The electrons in the outermost shell of metallic atoms can be easily detached from the atom. A large number of such detached electrons from the outermost shell of metal atoms are in random motion in the regions between metal atoms as shown in Figure 19.5. These electrons are known as free electrons

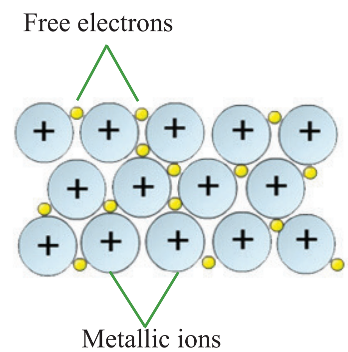


Figure 19.5 – Free existence of electrons in the outermost shell of metallic atoms

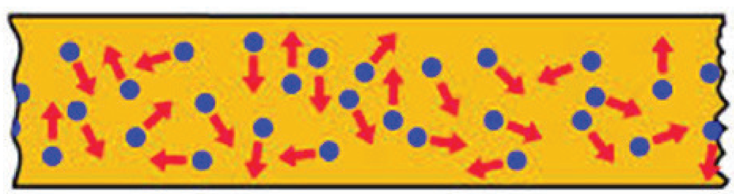


Figure 19.6 – Free electrons in a metal

The reason for electricity to flow easily through metals is the existence of free electrons. Let us consider the process that takes place when the ends of such a metallic conductor is connected to a dry cell as shown in Figure 19.7.

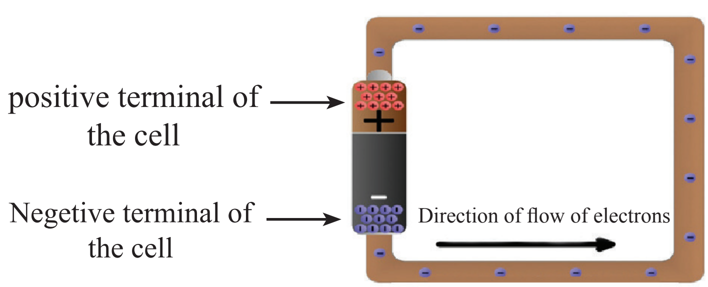


Figure 19.7 - Flow of electrons through a conductor

The negative terminal of a cell has the ability to repel electrons. Its positive terminal has the ability to attract electrons. Therefore, whenever the positive and negative terminals of a cell are connected by a conductor, electrons begin to flow from the negative terminal of the cell to the positive terminal via the conductor. This flow of electrons is possible because of the presence of free electrons in metals. That is, the free electrons that are in random motion in a metal begin to move from the negative terminal of the cell to the positive terminal along the same direction as a result of connecting the electric cell.

The actual flow of electrons takes place from the negative to the positive terminals of the cell via the conductor. However, conventionally the direction of the electric current is considered to be in the opposite direction to that of the electron flow. That is, when an electron current flows from the negative to the positive terminal, a conventional electric current is said to flow from the positive to the negative terminal. The directions of the electric current flow and the electron flow are illustrated in Figures 19.8 and 19.9.

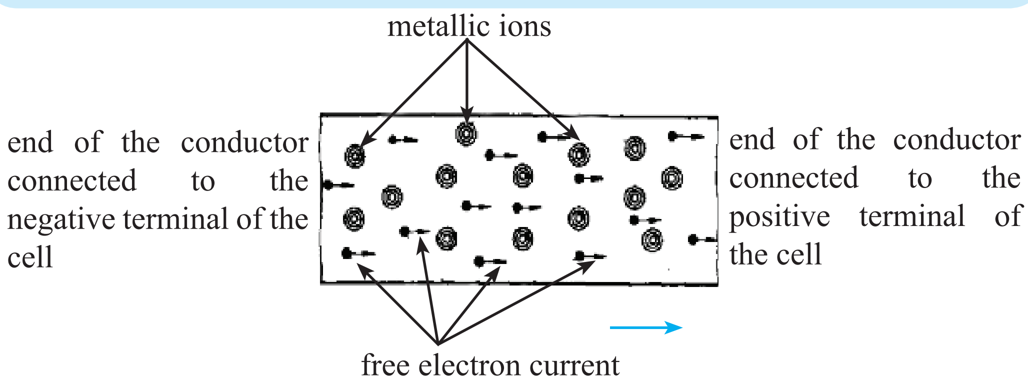


Figure 19.8 – Flow of electric current through a conductor

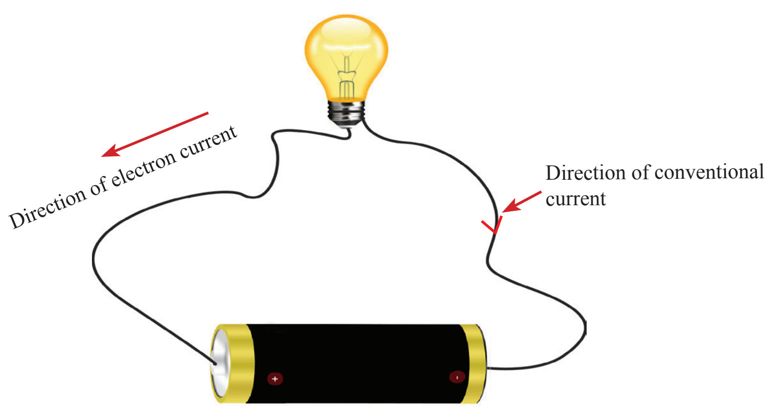


Figure 19.9 – Directions of the conventional electric current and the free electron current

The SI unit used to measure the electric current is known as the Ampere (A) and the instrument used to measure electric current is known as the ammeter

(a) (b)

Figure 19.10 - (a) An ammeter (b) Digital multimeter as an ammeter

If we need to measure the current flowing through a conductor, it is necessary to connect the ammeter to the circuit in such a way that the entire current passing through the conductor passes through the ammeter as well.

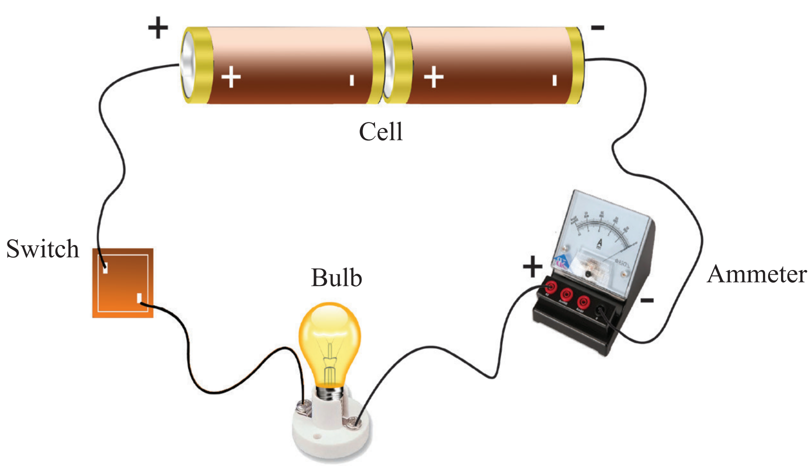
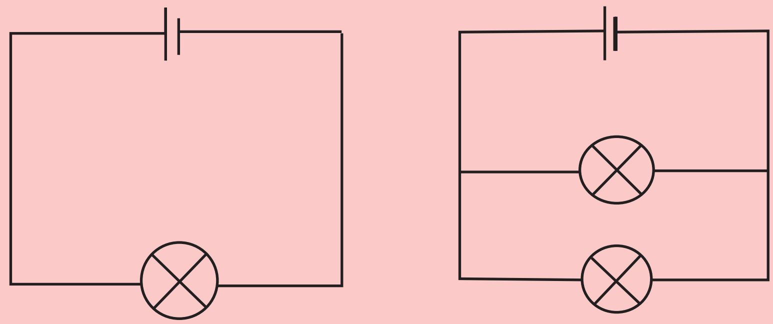


Figure 19.11 - Connecting an ammeter to a circuit

Exercise 19.1

Mark the currents flowing through the circuits given below by arrow heads.



19.3 Potential difference and the electromotive force

It is a well-known fact that the speed of water flow through pipe lines is larger for water tanks positioned at higher locations. The reason for the higher flow speeds with higher positions of the tank is the larger pressure difference between the water tank and the place where the water is utilized.

The current flowing in an electric circuit is analogous to the water flow from a water tank. Here, the source of electricity acts like the water tank and the pressure difference between the two ends of a water carrying tube corresponds to the electric pressure difference arising due to the electrons being pushed by the negative terminal of the source of electricity through the conductor.

This electric pressure difference is known as the potential difference. The unit used to measure the potential difference is the Volt (V). The force by which the negative terminal of the electric source releases electrons to the external circuit is known as the electromotive force. (EMF)

The electromotive force of a cell is equal to the potential difference between the terminals of the cell when electricity is **not drawn from the cell**.

When an electric current is drawn from a cell, the current also passes through the cell itself. The cell too has an electric resistance. Then a potential difference arises across the resistance of the cell. When this potential difference is subtracted from the electromotive force of the cell, the potential difference that provides an electric current to the external circuit can be obtained.

Since the potential difference between two points in a circuit is measured in Volts, it is also known as the voltage.

Figure 19.12 - A voltmeter

The instrument used to measure the voltage is the voltmeter. In order to measure the potential difference between two points in a circuit, the two terminals of the voltmeter should be connected across the two points as shown in the figure 19.13.

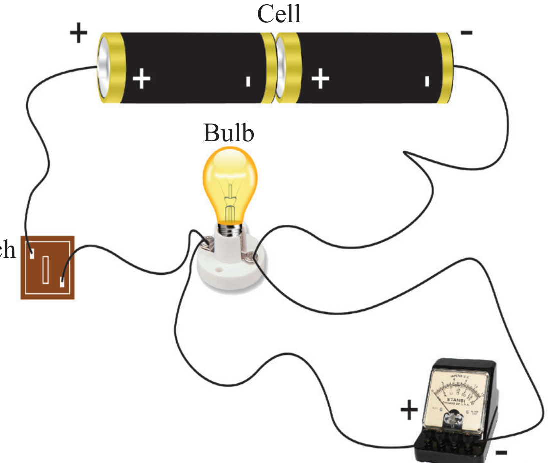


Figure 19.13 - Connecting a voltmeter to a circuit

In order to verify that there should be a potential difference between the terminals of a cell for a current to flow, let us engage in the following activity.

Activity 19.2

Items required: two dry cells, conducting wires, a voltmeter, an ammeter, a bulb

- As shown in Figure 19.14 (a), there are three different ways to connect the two dry cells to the bulb. In all three ways, the voltmeter is used to measure the voltage across the bulb. The ammeter is connected to the circuit to measure the current passing through the bulb. Figure 19.14 (b) shows the circuit diagrams corresponding to the above three possible connections.
- Connect the circuits as shown in each of the three circuit diagrams of Figure 19.14 (a) and observe the lighting of the bulb.
- Record the potential difference across the bulb and the current passing through it for each circuit.

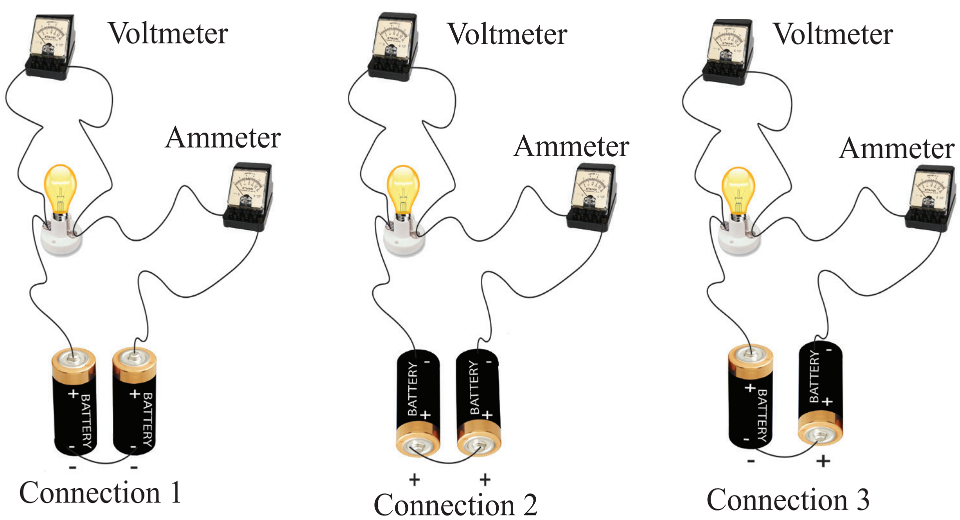


Figure 19.14 (a) Circuit connections for Activity 19.2

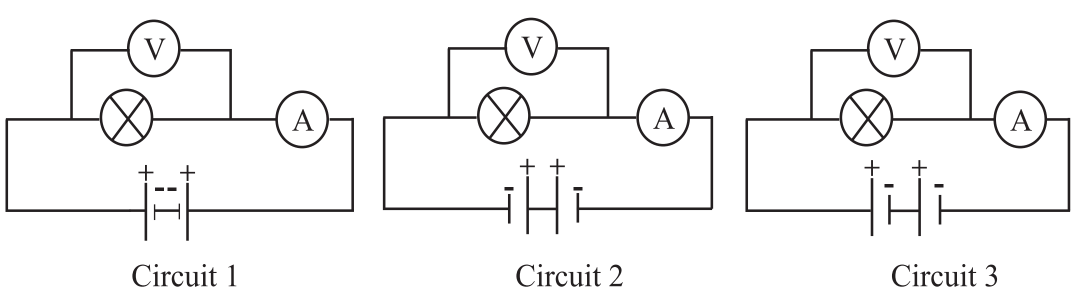


Figure 19.14 (b) Circuit diagrams for each of the connections of 19.14 (a)

- Tabulate your results in the table given below.

Connection	Current	Potential difference	Bulb lights up/does not light up
1			
2			
3			

In the first instance, the positive terminals of the two cells are connected to the two terminals of the bulb. Therefore there is no potential difference across the bulb. As there is no potential difference, there won't be a current flow through the bulb. This will be evident from your observations.

In the second connection, the negative terminals of the two cells are connected to the terminals of the bulb. Here also there does not exist a potential difference across the battery and there won't be a current flow through the bulb.

In the third connection, the positive terminal of one cell and the negative terminal of other cell are connected to the terminals of the bulb. Here, there will be a potential difference across the bulb and a current flow through the bulb only in the third connection.

From this activity we can conclude that in order for a current to flow through a conductor, it is necessary for a potential difference to exist across it.

19.4 Relationship between the current flowing through a conductor and the potential difference across the conductor

When a potential difference is applied across a conductor, a current flows through it. Let us now investigate whether there is a relationship between the current passing through a conductor and the potential difference across the conductor.

Activity 19. 3

Items required: a nichrome wire coil, a voltmeter, an ammeter, a rheostat, two dry cells, connecting wires, a switch

- The voltmeter is used to measure the voltage affecting the conductor (nichrome coil).
- The ammeter is used to measure the current passing through the conductor (nichrome coil).

Figure 19.15 - Rheostat

- The rheostat (Figure 19.15) is used to vary the current and the potential difference across the nichrome coil.

  The circuit symbol used for the rheostat is

- Connect the circuit shown in Figure 19.16 using the items above.

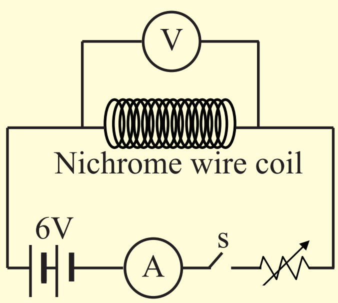


Figure 19.16 - Circuit diagram for the activity

- Close the switch (s) and quickly obtain the readings of the voltmeter and the ammeter and turn off the switch. The reason for quickly turning off the switch is to prevent the temperature of the nichrome coil from rising. It is essential to maintain a constant temperature throughout the activity.
- After sometime adjust the rheostat, close the switch and take another set of readings.
- Repeat the above steps to take at least five sets of readings.

By changing the current through the circuit using the rheostat, obtain readings for the potential difference across the nichrome coil and the current and tabulate the results in the table given below.

	Voltage difference (*V*)	Current (A)	V/A
1			
2			
3			
4			
5			

Find the ratio Voltage (*V*)/Current (*I*) for each data set. You will observe a constant value for the above ratio if the temperature of the coil was maintained at a constant value.

This relationship was first discovered by the German scientist George Simon Ohm. This law is known as Ohm's law.

Ohm's Law

When the temperature of a conductor remains constant, the current (*I*) passing through the conductor is directly proportional to the potential difference (*V*) across it.

That is, at constant temperature, $I \propto V$
Therefore, V/I= constant
This constant is known as the electrical resistance of the conductor.
The unit for measuring the resistance is the Ohm (Ω).
That is, $\frac{V}{I} = R$ Where *R* is the resistance of the conductor,

Figure 19.17 – George Simon Ohm

The unit for measuring the resistance is the Ohm (Ω).

If a current of one Ampere (1A) passes through a conductor for a potential difference of one Volt (1V) across it, then its resistance is defined to be one Ohm (1Ω).

Ohm's law can be expressed in the form of an equation as $V=IR$, where V is the potential difference, *I* is the current and *R* is the resistance.

The instrument used to measure the resistance is known as the **Ohm meter**.

If a graph is plotted using your data, with the voltage difference in the y axis and the current in **x** axis it will take the form shown by Figure 19.18 .

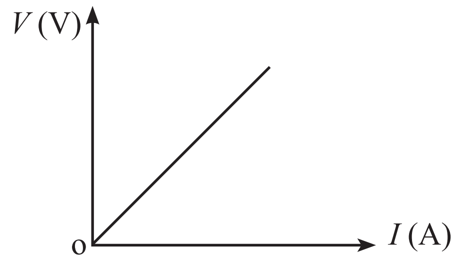


Figure 19.18 - The way that current varies with the potential difference

Example 1

A current of 1.5 A is flowing through a bulb which has a resistance of 6Ω . Find the potential difference across the bulb.

By applying V = IR for the bulb

$$V = 1.5 \times 6$$

Voltage difference across the bulb = 9 V

Exercise 19.2

1. When a bulb is connected to a 12 V power supply, a current of 0.5 A flows. What is the resistance of the filament of the bulb of that instance?
2. A nichrome wire coil has a resistance of 10 Ω. When it is connected to a power supply, a current of 0.6 A flows. What is the potential difference between the terminals of the power supply?
3. The resistance of a nichrome wire coil is 6 Ω. When it is connected to a power supply of 3 V,what is the current flowing through it?

19.5 Factors affecting the resistance of a conductor

The resistance of a segment of a conductor depends on the following factors.

(i) Area of cross section of the segment of conductor
(ii) Length of the segment of conductor
(iii) Material composition of the conductor

Let us do Activity 4 in order to investigate the influence of each of the above factors on resistance.

Activity 19.4

Items required: three segments of nichrome wire of length 1 m having different cross-sectional areas, a copper wire segment and several segments of iron wires with the same length as the nichrome wires and having a cross-sectional area equal to the nichrome wire with the lowest cross-sectional area, two dry cells, an ammeter, a switch, a board of wood with a length of about 1 m and a breadth of about 20 cm.

Connect the circuit shown in Figure 19.19 using the items above.
Connect the terminal X to the end of each conductor and record the current passing through each conductor.

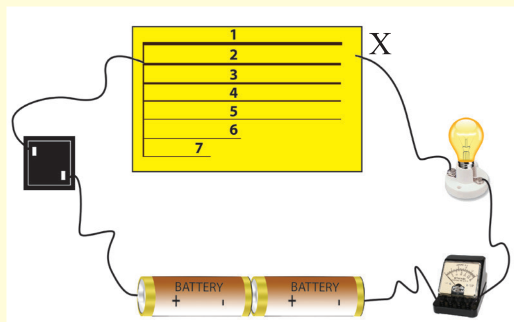


Figure 19.19 - Circuit for studying the factors that affect the resistance of a conductor

In the above figure, the numbers indicate the following segments:

1 – nichrome wire with the largest cross-sectional area
2 – nichrome wire with the medium cross-sectional area
3 – nichrome wire with the smallest cross-sectional area
4 – thin copper wire
5 – thin iron wire
6 and 7 – iron wires with unequal lengths

(wires used in 4,5,6 and 7 above should have equal cross-sectional areas)

Conductor	Ammeter reading (current) A
1	
2	
3	
4	
5	
6	
7	

(a) What conclusion can you draw from the readings obtained for the wires 1, 2 and 3?
(b) What can you conclude from the readings for the wires 3, 4 and 5?
(c) What can you say from the readings for the wires 5, 6 and 7?

According to Activity 4, it will be clear that the current flowing in each of the above instances are different. The reason for this is the differences in the resistances in each instance. According to this activity, three main factors that affect the resistance of a conductor can be stated.

That is,
(i) Area of cross-section of the conductor
(ii) Length of the conductor
(iii) Material of the conductor.

How each of them affects the resistance is mentioned below.

- The resistance decreases when the cross-sectional area is increased.
- The resistance increases when the length is increased.
- For wires having the same length and cross-sectional areas but made of different metals, the currents flowing for the same potential difference are different. The reason for this is the difference in the factor known as the "**resistivity**" which depends on the material.

19.6 Resistors

In order to control the water flow through a tube, a tap can be used. What is done here is the use of an obstacle to control the water flow. The electric current flowing through a conductor can also be controlled in a similar manner. You may have already understood what could be done in the case of a conductor. By increasing the resistance of a circuit, the current flow through the circuit can be decreased. In order to change the resistance of a circuit, many circuit components with various resistances that could be connected to the circuit have been found. They are known as resistors.

Figure 19.20 – Controlling the water flow through a pipeline

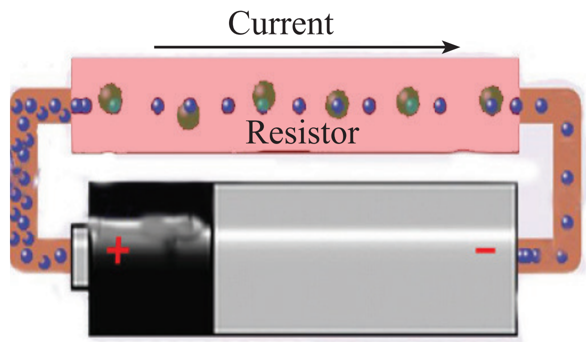


Figure 19.21 – Controlling the current flow through a conductor using a resistor

Let us do Activity 19.5 in order to understand the action of resistors.

Activity 19.5

Items required: A small torch bulb, a switch, resistors having resistances 5 Ω, 10 Ω, 20 Ω, connecting wires, two dry cells, an ammeter

- Connect the circuit shown in Figure 19.22.

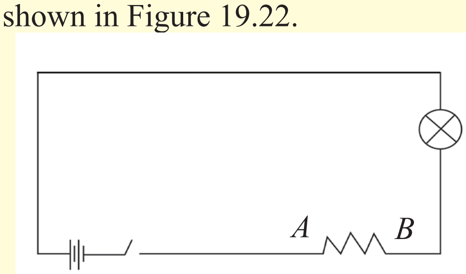


Figure 19.22 – Circuit diagram for Activity 5

- Observe the brightness of the bulb by connecting each of the resistors between *A* and *B*. Record your observations in the table given below.

Resistor value	Brightness of the bulb
5 Ω	
10 Ω	
20 Ω	

In this activity you will observe that the brightness of the bulb decreases as the resistor value increases.

It will be clear that the current through a circuit decreases with the increase of resistance.

Types of resistors

Various types of resistors with various values for the resistances have been invented. Let us consider a few such varieties.

1. Fixed value resistors
2. Variable resistors
3. Light dependent resistors

• Fixed value resistors

By depositing thin films of carbon on insulators or by winding a material with a high resistance materials like nichrome, resistors having various values for the resistance are fabricated. Their resistances cannot be changed.

Eg. : fixed value resistors with resistances 10 Ω, 100 Ω, 1.2k Ω

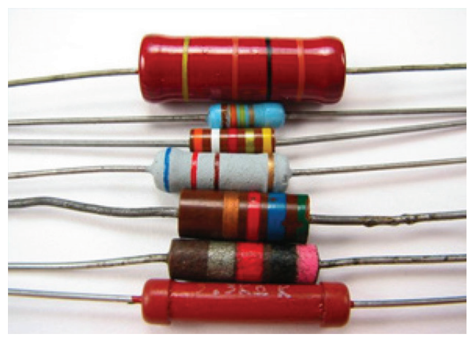


Figure 19.23 – Some different fixed value resistors

In Figure 19.23, a few different resistors are shown while Figure 19.24 shows the circuit symbols used for fixed value resistors.

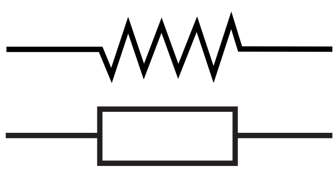


Figure 19.24 – Symbols used for resistors

• Resistor colour code

Often, the value of a resistor is indicated in coded form by colour bands marked on its body. The coding system of marking the resistor value using colored bands is known as the colour code method.

Figure 19.25 – Resistor values marked on the body of resistors using the color code method

(i) Resistors with four color bands

In this method, four color bands are marked on the resistor as shown in Figure 19.25. Three of them are marked close together while the fourth one is marked slightly away from them.When the three closely spaced bands are placed to the left, the first two bands from the left indicate respectively the first and second digit of the value of the resistor.

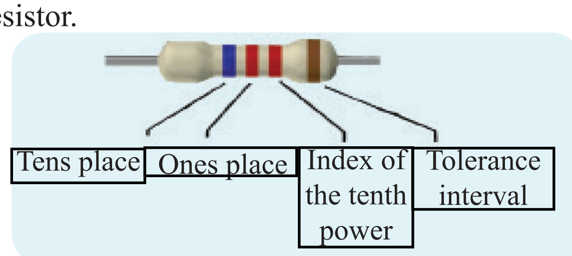


Figure 19.27 - Resistor with four colour bands

The value assigned to each color is given in Table 19.1. In order to find the coded value of resistor, the number given by the first two color bands should be multiplied by a power of ten. The power which ten should be raised to (index of the tenth power) is given by the value of the third band. The index of this value is given in column 1 of Table 19.1. In addition to this, the indices corresponding to gold and silver are -1 and -2 respectively. That is, in order to represent the resistor values for decimal valued resistances, gold and silver bands are used. The fourth band marked apart from the other three indicates the range that the resistor value can vary (tolerance interval). Table 19.2 shows the values assigned to the tolerance color codes.

Table 19.1 – Resistor color codes

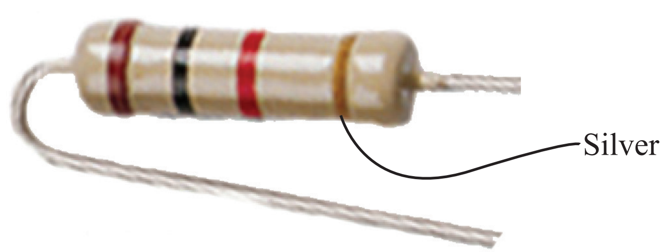
Number	Colour		Number to be multiplied by According the color of the third or fourth band
0	Black		$10^0 = 1$
1	Brown		$10^1 = 10$
2	Red		$10^2 = 100$
3	Orange		$10^3 = 1000$
4	Tellow		$10^4 = 10000$
5	Green		$10^5 = 100000$
6	Blue		$10^6 = 1000000$
7	Purple		$10^7 = 10000000$
8	Gray		$10^8 = 100000000$
9	White		$10^9 = 1000000000$
-1	Gold		$10^{-1} = 0.1$
-2	Silver		$10^{-2} = 0.01$

Table 19.2 – Color codes to resistor tolerance

Color	brown	red	gold	silver	No fourth color band
Tolerance value	± 1%	± 2%	± 5%	± 10%	± 20%

Example 1

The figure below shows a permanent resistor purchased from the market.



(i) Find its resistance value.
(ii) What is the tolerance value of this resistor?
(iii) What is the true range of values that this resistor could have?

Solutions

		1st digit	2nd digit	
(i)	Value of resistor	brown	black	red
		1	0	10^2

$= \underline{\underline{1000\ \Omega}}$

(ii) Tolerance value of resistor $= 10\%$

(iii) Tolerance $= 10\%$

Amount of variation $= 1000 \times \frac{10}{100} = 100\ \Omega$

Range of the true value of resistor $= (1000\text{-}100)\ \Omega$ - $(1000 + 100)\ \Omega$

$= \underline{\underline{900\ \Omega - 1100\ \Omega}}$

Exercise 19.3

1. A resistor marked with orange, orange, yellow and gold colored bands is provided to you.

   (i) Find the value of the resistor.
   (ii) What is its tolerance?
   (iii) Find the range of values that the resistor could have.

● Variable resistors

Resistors fabricated so as to allow a variation in the resistance as desired are known as variable resistors. The resistor value can be varied manually or turning using a screw in an by appropriate direction. There are many types of variable resistors such as pre adjustment resistors, rheostats and volume control resistors.
Figure 19.27 (a) shows several variable resistors and Figure 19.27 (b) shows symbols used for variable resistors.

Rheostat

Pre-adjustment resistor

Volume controller (rotatable variable resistor)

Figure 19.27 (a) – Various types of variable resistors

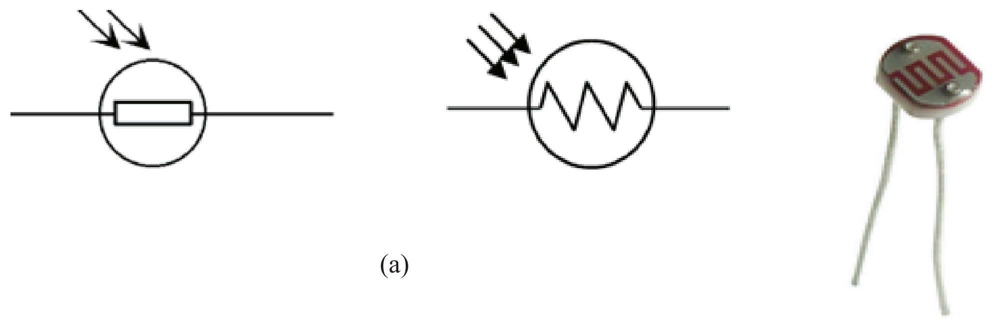
Figure 19.27 (b) – symbols used for variable resistors

Variable resistors are used to control the volume of radios, to adjust electronic circuits and to vary currents in laboratory experiments.

● Light Dependent Resistors

Light dependent resistors (LDR) are fabricated using chemicals such as cadmium sulfide. Value of the resistance depends on the intensity of light.

In the dark when the light intensity is low, these resistors have a high resistance. In the presence of light, their resistance decreases. Light dependent resistors are used in control circuits of instruments that need to operate based on the amount of light falling on them.



(a)

(b)

Figure 19.28 (a) Symbols used for light dependent resistors (b) Appearance

19.7 Combination of resistors

Resistors are used to control the current passing through a circuit as desired. When it is difficult to find a resistor with the required resistance, it is possible to use many resistors to obtain the required value. There are two basic methods of combining resistors.

1. Series combination of resistors
2. Parallel combination of resistors

Series combination of resistors

When the resistors are connected in such a way that the same current flows through each of the resistors as shown in Figure 19.29, it is known as a series combination of resistors. Figure 19.29 shows three resistors R_1, R_2 and R_3 connected in a series combination.

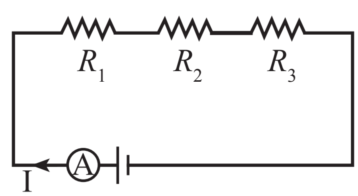


Figure 19.29 – A series combination of resistors in a circuit

If the current passing through the circuit is I, using $V=IR$,

Potential difference across the resistor $V_1 = I.\ R_1$
Potential difference across the resistor $V_2 = I.\ R_2$
Potential difference across the resistor $V_3 = I.\ R_3$

When resistors are connected in series, the sum of the potential differences across the resistors is equal to the supply voltage difference.

Therefore,

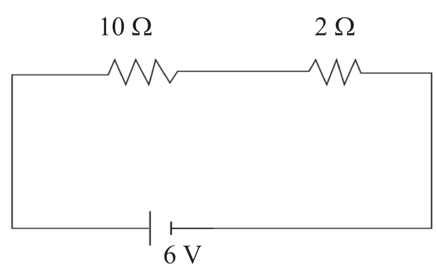
$$V = IR = I.R_1 + I.R_2 + I.R_3$$

$R = R_1 + R_2 + R_3$ where R is the equivalent resistance.

The equivalent resistance is the resistance of a single resister that could be used in place of all three resistors. In a series combination of resistors, the equivalent resistance is equal to the sum of all the resistors.

Example 1

The figure shows a 10 Ω resistor and a 2 Ω resistor connected to a 6 V power supply.



1. Find the equivalent resistance of the system.
2. What is the current passing through the circuit?

Solution

(i) Equivalent resistance $= R_1 + R_2$
$= 10\ \Omega + 2\ \Omega$
$= 12\ \Omega$

(ii) Apply $V = IR$ in order to find the current passing through the circuit.

$$V = IR$$

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

$$= \frac{6}{12}$$

$$= 0.5\ \text{A}$$

Parallel combination of resistors

A combination of resistors in which the total current is divided among the resistors as shown in Figure 19.30 is known as a parallel combination of resistors.

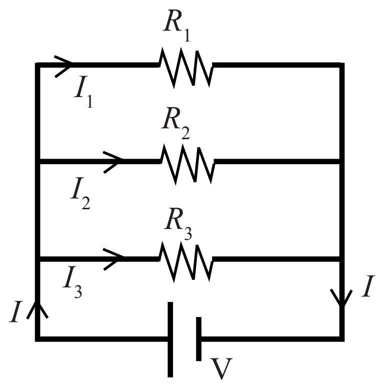


Figure 19.30 – A parallel combination of resistors in a circuit

In this circuit, the total current is divided among each of the resistors. That is, the total current in the circuit is the sum of the currents passing through each of the constituent resistors.

$$I = I_1 + I_2 + I_3$$

Substituting for I in terms of V and R according to Ohm's law,

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_1} + \frac{V}{R_1}$$

where R is the equivalent resistance. It is clear from this that the equivalent resistance of a parallel combination of resistors can be expressed by,

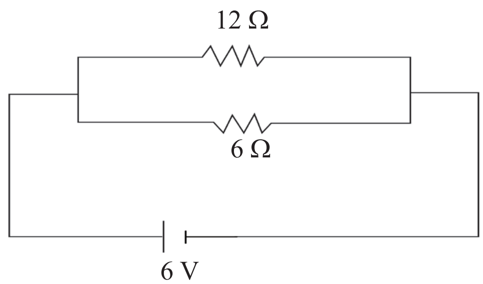
$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

The reciprocal of the equivalent resistance of a parallel combination of resistors is equal to the sum of the reciprocals of each of the constituent resistors.

Example 1

A 12 Ω resistor and a 6 Ω resistor are connected as a parallel combination in a circuit.

(i) Find the equivalent resistance of the circuit.
(ii) Find the current flowing through the circuit.
(iii) What is the current passing through each resistor?



(i)

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

$$= \frac{1}{12} + \frac{1}{6}$$

$$= \frac{1+2}{12}$$

$$\frac{1}{R} = \frac{3}{12}$$

$$R = 4\ \Omega$$

(ii) By applying V=IR for the current passing through the circuit,

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

$$= \frac{6}{4}$$

$$= 1.5\ \text{A}$$

(iii) Let us find the current passing through the 12 Ω resistor.

Since the potential difference across the 12 Ω resistor is 6 V,

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

$$= \frac{6}{12}$$

$$= 0.5\ \text{A}$$

Now let us find the current passing through the 6 Ω resistor. Since the potential difference across the 6 Ω resistor is 6 V, apply $V=IR$.

$$V = IR$$
$$I = \frac{V}{R}$$
$$= \frac{6}{6}$$
$$I = 1\text{ A}$$

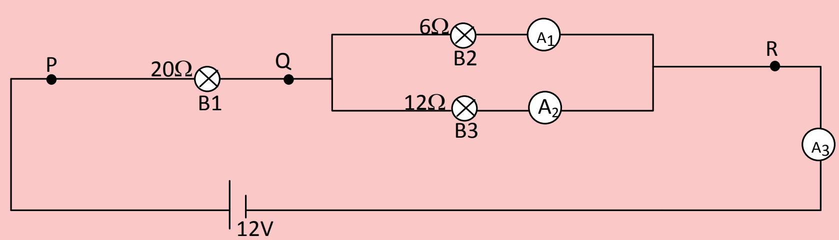
Exercise 19.4

(1) Ruvan needs a resistor of 3 Ω and another one with 40 Ω. But he could only find some resistors with resistances 20 Ω and 9 Ω.

(i) Briefly explain how you could make a combination of resistors having a resistance of 3 Ω.

(ii) Give a figure using symbols showing how you could make a combination of resistors having a resistance of 40 Ω.

(2) The figure below shows a circuit connected with three bulbs having different filament resistances. A 12 V potential difference is supplied to the two ends. The resistance of connecting wires can be neglected.



(i) What is the equivalent resistance between Q and R?

(ii) Find the equivalent resistance between P and R.

(iii) Which ammeter shows the total current passing through the circuit?

(iv) Find the total current passing through the circuit.

(v) What is the potential difference between P and Q?

(vi) Find the potential difference between Q and R.

(vii) What is the current passing through the bulb B1?

(viii) If the bulb B2 burns out, find the current passing through the circuit.

For extra knowledge

Electric Shock

Electric shock occurs when the human body becomes part of a path through which electrons can flow. A complete Circuit and a voltage difference are necessary for current to flow.

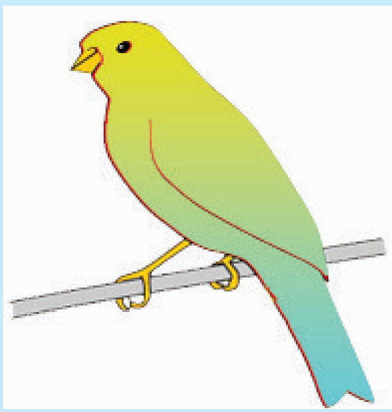


Figure 19.31

Without two contact points on the body for current to enter and exit, there is no hazard of shock. These two points should also be of different voltages. This is why birds can safely rest on high-voltage power lines without getting shocked: they make contact with the circuit but the two points they touch have the same voltage.

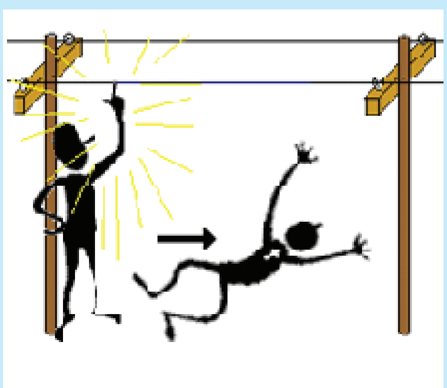


Figure 19.32

This might lend one to believe that it's impossible to be shocked by electricty by only touching a single wire. Like the birds. Unfortunately, this is not correct. Unlike birds. people are usually standing on the ground when they contact a "live" wire. One side of a power system will be intentionally connected to earth ground, and so the preson touching a single wire is actually making contact between two points in the circuit the wire earth ground.

Ohm's Law and Electrical Safety

"It's not voltage that kills, its current!" is a common phrase heard in reference to electrical safety. While there is an element of truth to this,there's more to understand about shock hazards than this simple adage.If voltage presented no danger, why do they display signs saying: DANGER -- HIGH VOLTAGE !?

The principle that " current kills" is essentially correct. However, electric current doesn't just occur on its own, there must be voltage available to motivate electrons to flow through a victim. A person's body also presents resistance to current, which must be taken into account. Taking ohm's Law for voltage, current,and resistance, and expressing it in terms of current for a given voltage and resistance, we have this equation:

$$I = \frac{V}{R} \qquad \text{Current} = \frac{\text{Voltage}}{\text{resistance}}$$

The amount of current through abody is equal to the amount of voltage applied between two points on that body, divided by the electrical resistance offered by the body between those two points. Obviously, more the voltage difference between the two points, easier the current flow through any given amount of resistance. Hence, high voltage implies high potential for a large amount of current to flow through your body, which will injure or kill you.

Conversely, the more resistance a body offers to current, slower the electron flow for any given amount of voltage. just how much voltage is dangerous depends on how much total resistance is in the circuit to oppose the flow of electrons.

Body resistance is not a fixed quantity. It varies from person to person and from time to time. There are so many variables in the human body affecting body resistance. It varies depending on how contact is made with the skin: is it from hand-to-hand, hand-to-foot, foot-to-foot, hand-to-elbow, etc.

Summary

- By rubbing certain materials on one another, electrons are exchanged between them.
- An electric current is a flow of electric charges.
- The direction of the conventional current is from the positive terminal to the negative terminal.
- The potential difference between the two terminals of a cell when a current is not passing through it is known as the electromotive force of the cell.
- Ohm's law states that the current passing through a conductor is proportional to the potential difference across it when the temperature of the conductor is constant.
- The property that obstructs the flow of current through a circuit is its electrical resistance.
- There are two main methods of connecting resistors in a circuit.

    1. Series connection
    2. Parallel connection

- A single resistance equal to the total resistance of a system of resistors is known as the equivalent resistance.

Technical Terms

Static electricity	-	ස්ථිති විද්‍යුතය	-	நிலைமின்னியல்
Current electricity	-	ධාරා විද්‍යුතය	-	ஓட்ட மின்னியல்
Electric current	-	විද්‍යුත් ධාරාව	-	மின்னோட்டம்
Resistance	-	ප්‍රතිරෝධය	-	தடை
Voltmeter	-	වෝල්ට් මීටරය	-	வோல்ற்றுமானி
Ammeter	-	ඇමීටරය	-	அம்பியர்மானி
Potential difference	-	විභව අන්තරය	-	அழுத்த வித்தியாசம்
Electromotive force	-	විද්‍යුත් ගාමක බලය	-	மின்னியக்க விசை
Equivalent resistance	-	සමක ප්‍රතිරෝධය	-	சமவலுத் தடை