

THEME

3

Energy and Sustainability of Life



- What is electricity and magnetism?
- What is force?
- How is force measured?
- What is the main source of energy on Earth?
- How do liquids react with heat?
- Why do different music instruments produce different sound?



Electricity and Magnetism

How can wind be used to generate electricity?

Which energy is needed for vehicles to move?

What causes the formation of lightning?

Why does the compass always show the north-south direction?

Let's understand:

- Electricity
- The flow of electric current in a series circuit and a parallel circuit
- Magnetism

SCIENCE BLOG

The Electric Eel

The electric eel or scientifically known as *Electrophorus electricus* is a type of freshwater fish found in South America. The length of its body can exceed 8 feet.

This fish has around 6 000 special cells known as electrocytes. These cells are their secret weapon that enables the electric eel to discharge electricity up to 800 volts!

Electricity that is discharged is used to protect the fish from its predators and to catch smaller fishes. This fish's eyesight is limited because of its dark and muddy habitat. This causes the fish to use the transmission of electric charges as a guide for direction.

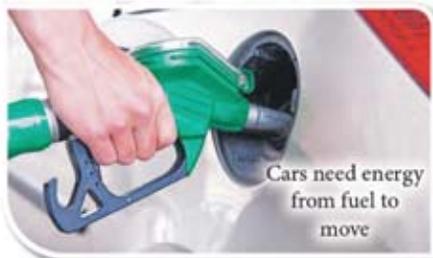
Keywords

- ▶ Electric current
- ▶ Electric charge
- ▶ Electrostatic
- ▶ Ohm's Law
- ▶ Parallel circuit
- ▶ Series circuit
- ▶ Resistors
- ▶ Magnetic field
- ▶ Magnet
- ▶ Electromagnet

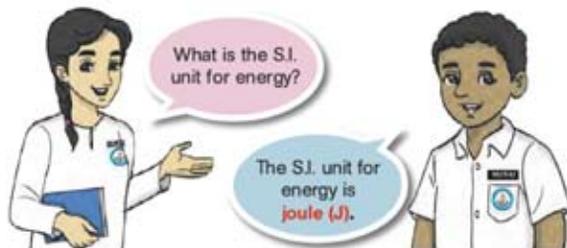
Do you still remember the topic on electricity that you have learned during primary school? Various home appliances such as the washing machine, television, computer and others use electricity to function.

Energy

All living things need energy. A moving vehicle, a lighted bulb, and a sleeping cat use energy. What does energy mean? **Energy** means the ability to do **work**. Can you state a few daily activities that use energy?



Photograph 7.1 Various uses and needs of energy



Forms of Energy

Energy cannot be created nor destroyed but it can exist in **various forms**. Photograph 7.2 shows various forms of energy that exist around us. Can you give another example for each of the following types of energy?



Sound energy



Kinetic energy



Electrical energy



Gravitational potential energy



Elastic potential energy



Light energy



Nuclear energy



Heat energy



Chemical energy

Photograph 7.2 Various forms of energy

Sources of Energy

You have learned various forms of energy that exist. What are the sources used to generate energy? Figure 7.1 shows various sources of energy that exist around us.

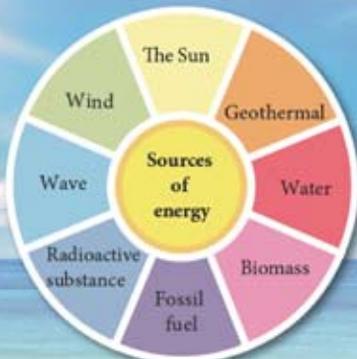


Figure 7.1 Various sources of energy

Brain Teaser

Does nuclear energy produce radioactive wastes?

Activity 7.1

21
Century

Aim : To discuss energy.

Instruction

1. Work in groups.
2. Discuss:
 - (a) the importance of energy in our daily lives
 - (b) forms of energy
 - (c) sources of energy
3. Use various sources to gather these information.
4. Present your discussion in the form of a multimedia presentation.

Electrostatic Charges

Have you ever felt an electric shock when you touched a door knob? Why does this happen? It happens as a result of the transfer of electric charges between our body and the door knob that has static electric charges. These static charges are known as **electrostatic charges**. Let us carry out Activity 7.2 to show the existence of electrostatic charges on different types of materials.

Activity 7.2

Aim: To test the existence of electrostatic charges on certain materials.

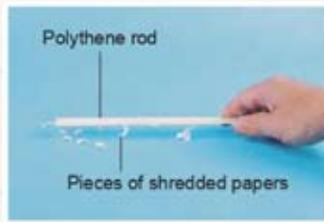
Note: Make sure that all the apparatus are dry.

Materials: Balloon, pieces of shredded paper and stream of running tap water

Apparatus: Polythene rod, cellulose acetate strip and woollen cloth

Instruction

1. Rub a polythene rod with a woollen cloth.
2. Hold the rod close to pieces of shredded paper (Photograph 7.3) and record your observation.
3. Repeat step 1.
4. Hold the rod close to a small stream of running tap water and record your observation.
5. Repeat steps 1 to 4 using a cellulose acetate strip and a balloon to replace the polythene rod.



Photograph 7.3

Questions

1. Give an inference for your observation.
2. What other methods can be used to test the existence of electrostatic charges on the balloon? Explain the steps taken.



Info

Tap Water and Electrostatic Charges
<https://www.thoughtco.com/bend-water-with-static-electricity-604268>

Based on your observation in Activity 7.2, how are the electrostatic charges between the objects produced? Electric charges consist of positive charges (proton) and negative charges (electron). The attraction and repulsion between the electric charges shown in Figure 7.2 are known as **electrostatic forces**.

When two different types of objects are rubbed together, only the electrons are transferred from one object to the other, whereas the protons do not move. The object that gains electrons will be negatively charged. The object that loses electrons will be positively charged. The object that has equal number of protons and electrons is known as neutral.

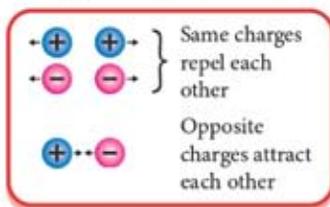


Figure 7.2 Properties of electric charges

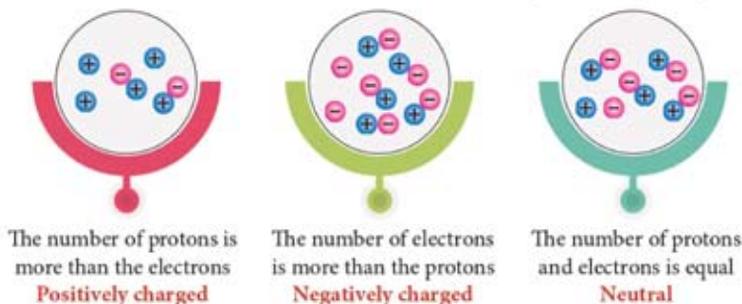


Figure 7.3 The number of electrons on objects

Look at Figure 7.4 to understand the effect of electrostatic charges on a plastic comb that has been rubbed with a piece of woollen cloth.

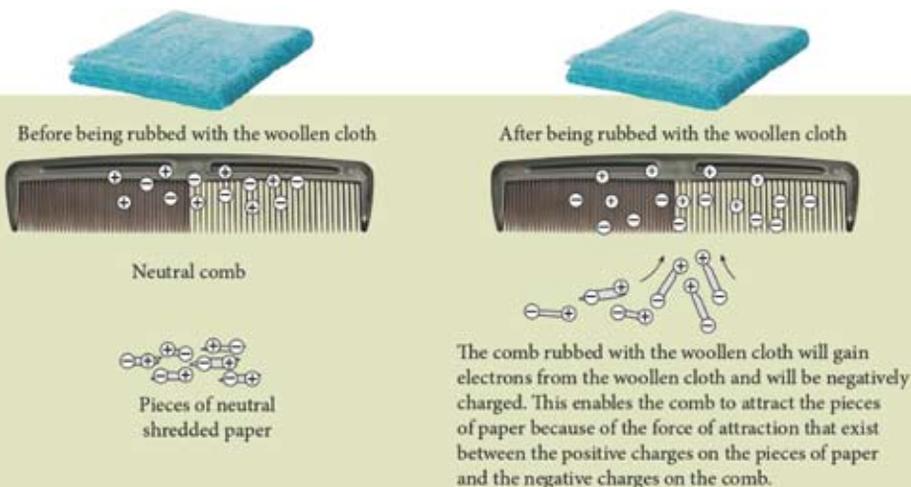
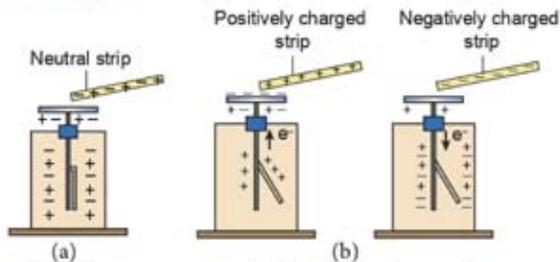


Figure 7.4 Effect of production of electrostatic charges

Electroscope

An electroscope is a device used to detect the **existence of electric charges** on an object.



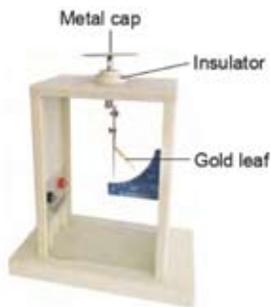
(a) The gold leaf does not diverge because the positive and negative charges are attracted to one another.

(b) The gold leaf diverges because the same charges repel each other.

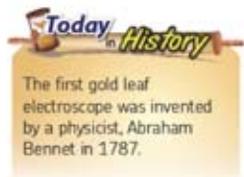
Figure 7.5 How the electroscope works



The further the divergence of the gold leaf, the higher the quantity of electrostatic charges accumulated.



Photograph 7.4 An electroscope



Examples of Electrostatic in Our Daily Life

The occurrence of lightning is one of the phenomena that is related to electrostatic charges. The friction between clouds and air causes the clouds to be charged with electric charges. Lightning is a result of the force of attraction that exists between the positive charges on the ground and the negative charges in the clouds.

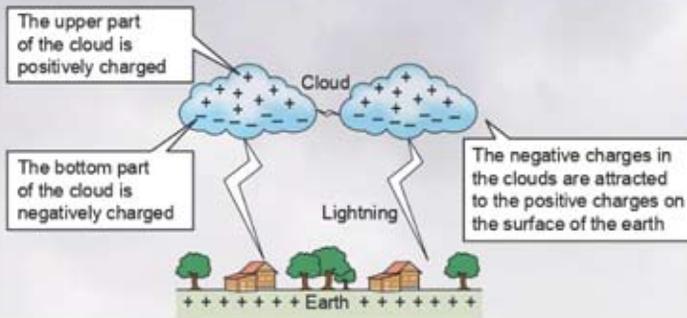


Figure 7.6 Lightning



Lightning conductor



The lightning conductor is installed at buildings to provide a path for the electric charges to flow into the ground. This method protects the building from being struck by lightning.

Simulation of lightning can be carried out in the school laboratory by using a Van de Graaff generator or Wimhurst machine. Carry out Activity 7.3 to observe the simulation of lightning.



Wimhurst machine is a device for generating high voltages.

Activity 7.3

21st Century

Aim: To carry out a simulation of lightning formation by using the Van de Graaff generator.

Apparatus: Van de Graaff generator

Instruction

1. Switch on the Van de Graaff generator.
2. After a few minutes, move the metal sphere closer to the dome and record your observation.

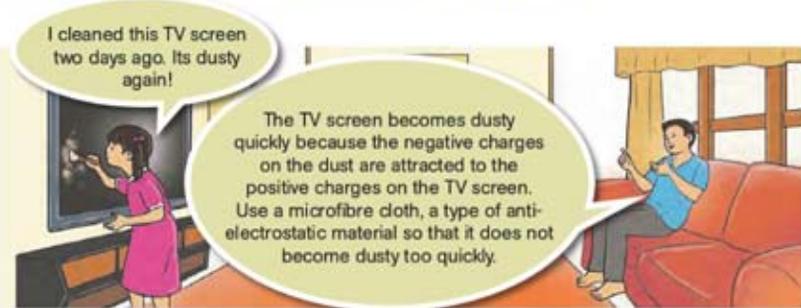
Questions

1. What is your observation in this activity?
2. What will happen if the metal cap of an electroscope is brought closer to the dome of the Van de Graaff generator?



Photograph 7.5

Solving Daily Life Problems Involving Electrostatic



Activity 7.4

STEM

21st Century

Aim: To gather information and solve daily life problems involving electrostatic.

Instruction

1. Work in groups.
2. Gather information on the following problems that involves electrostatic. Discuss how to solve them.
 - (a) The choice of fabric to be worn in hot weather
 - (b) Safe shelters during a thunderstorm (use Faraday's cage concept)
3. Share your findings with the class.

Electric Current

Electrical appliances require electric charges to operate. Energy that is needed for the electric charges to flow can be generated from sources such as electrical generators, dry cells and solar cells. What is the relationship between electric charges and electric current?



Photograph 7.6 Dry cells

Activity 7.5

Aim: To study the relationship between electric charges and electric current.

Apparatus: Van de Graaff generator, galvanometer and connecting wire

Instruction

1. Set up the apparatus as shown in Figure 7.7.
2. Switch on the Van de Graaff generator and observe the pointer on the galvanometer.



Figure 7.7



A galvanometer is used to detect very small electric currents.

Questions

1. What happens to the galvanometer's pointer? Explain.
2. How do you show the existence of electric charges on the dome of the generator?
3. State the meaning of electric current.

The deflection of the galvanometer's pointer indicates the flow of the electric current. Electric current can be defined as the **rate of flow of electric charges** through a conductor.

Measuring the Quantity of Electricity

The flow of electric current can be measured by using an **ammeter**. You have learned in Form One that the S.I. unit for electric current is **ampere (A)**. The voltage is the potential difference between two points that can be measured in **volt (V)** by using a **voltmeter**.



Photograph 7.7 Voltmeter

Activity 7.6

Aim: To measure the current and voltage by using a suitable measuring apparatus.

Apparatus: Ammeter, voltmeter, connecting wire, switch, dry cell, crocodile clip, bulb and dry cell holder

A Measuring current using an ammeter

Instruction

1. Connect the circuit as shown in Photograph 7.8 using one dry cell.
2. Turn on the switch and record the reading of the ammeter. Observe the brightness of the bulb.
3. Record your observations.
4. Repeat steps 1 to 3 using two dry cells.



Photograph 7.8

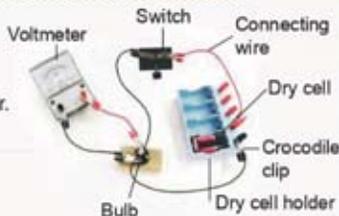
B Measuring the voltage using a voltmeter



The voltmeter must be connected parallel to the bulb in order to measure the voltage.

Instruction

1. Connect the circuit as shown in Photograph 7.9 using one dry cell.
2. Turn on the switch and record the reading of the voltmeter. Observe the brightness of the bulb.
3. Record your observations.
4. Repeat steps 1 to 3 using two dry cells.



Photograph 7.9

Observation

Activity	Number of dry cells	Reading of ammeter / A	Reading of voltmeter / V	Brightness of bulb
A	1			
	2			
B	1			
	2			

Questions

1. What is the relationship between the electrical current and the increase in the number of dry cells?
2. What is the relationship between the voltage and the increase in the number of dry cells?
3. Give an inference for the brightness of bulb in Activity A.
4. What is the relationship between the voltage, electric current and the brightness of the bulb?



Multimeter can be used to measure current and voltage.

The Relationship between Current, Voltage and Resistance

The ability of a conductor to limit or resist the flow of electric current is known as **resistance**. The unit for measuring resistance is **ohm (Ω)**. A fixed resistor has resistance that cannot be adjusted whereas a variable resistor or rheostat has resistance that can be adjusted. Current, voltage and resistance are three electrical quantities that are closely related to one another in a circuit. The changes in magnitude of one of the electrical quantities will have an effect in the magnitude of the other quantities.

Let us carry out Experiment 7.1 to study the relationship between current, voltage and resistance.

Experiment 7.1

Aim: To study the effects of changes in resistance and voltage on electric current.

A **The effect of changes in resistance on electric current**

Problem statement: What is the effect of changes in resistance on electric current?

Hypothesis: The higher the resistance, the smaller the current flow.

Variables:

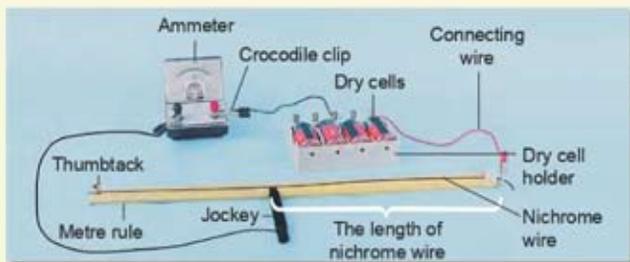
- Constant variable: Number of dry cells
- Manipulated variable: The length of the nichrome wire
- Responding variable: Reading of the ammeter

Material: Nichrome wire (60 cm)

Apparatus: Ammeter, metre rule, dry cell holder, dry cell, thumbtack, crocodile clip, jockey and connecting wire

Procedure:

- Fix a nichrome wire to both ends of a metre rule.
- Set up the apparatus as shown in Photograph 7.10.
- Place the jockey where the length of the nichrome wire is 20 cm. Record the reading of the ammeter.
- Repeat step 3 by increasing the length of the nichrome wire to 30 cm, 40 cm, 50 cm and 60 cm.
- Record the ammeter readings in a table for each length of the nichrome wire used.
- Plot a graph of current against the length of nichrome wire.



Photograph 7.10



Observation:

Length of nichrome wire (cm)	Reading of ammeter (A)
20	
30	

Conclusion:

Is the hypothesis accepted? Give your reasons.

Questions

1. What is the relationship between the length of the nichrome wire and resistance?
2. What is the relationship between the length of the nichrome wire and the current that flows in the circuit?
3. What is the relationship between resistance and electric current?

B The effect of changes in voltage on electric current

Problem statement: What is the effect of changes in voltage on current?

Hypothesis: The higher the voltage, the larger the current flow

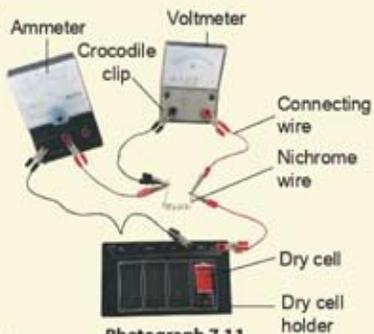
Variables:

- (a) Constant variable : Nichrome wire of 10 cm length
- (b) Manipulated variable : Number of dry cells
- (c) Responding variable : Reading of the ammeter

Apparatus: Ammeter, voltmeter, connecting wire, nichrome wire of 10 cm length, dry cell and crocodile clip

Procedure:

1. Set up the circuit as shown in Photograph 7.11 using one dry cell.
2. Record the reading on the ammeter and voltmeter.
3. Record your observations in a table.
4. Repeat steps 1 to 3 using two, three and four dry cells.
5. Plot a graph of current against voltage.



Photograph 7.11

Observation:

Number of dry cells	1	2	3	4
Reading of ammeter (A)				
Reading of voltmeter (V)				

Conclusion:

Is the hypothesis accepted? Give your reasons.

Questions

1. What is the relationship between the number of dry cells and the reading of voltmeter?
2. What is the relationship between voltage and electric current?

Experiment 7.1 shows that the amount of current flowing through the circuit decreases as the resistance increases. Besides, we can also observe that when a higher voltage flows through the circuit, the amount of current flowing through the circuit also increases.

The relationship between the current, I , the voltage, V and the resistance, R is known as the **Ohm's Law**. The relationship among these three electrical quantities can be written as:

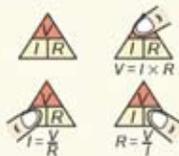
$$V = IR$$



Ohm's Law states that the electric current that flows through a conductor is directly proportional to the voltage across two ends of the conductor, provided the temperature and other physical situations remain unchanged.



Ohm's Law Triangle can be used to memorise the Ohm's Law. Put your finger over the quantity that you are looking for. Then, multiply or divide the other two quantities that are given.



Formative Practice 7.1

1. State the forms of energy that exists in each of the following situations.

- Boiling water
- A chicken running
- Compressed spring

2. As the clouds move, a lot of electric charges are accumulated by the clouds.

Based on the statement above, explain the occurrence of lightning.

3. What is the resistance of a car light bulb that conducts 0.025 A current when connected to a 12 V car accumulator? Is the current in the bulb steady?

7.2

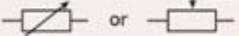
Flow of Electric Current in a Series Circuit and Parallel Circuit

Electric current requires a complete path which enables it to flow. This path is known as an **electric circuit**.

Electrical Circuit Components

A complete electric circuit is made up of various **electrical components** which are represented by symbols. These symbols are used to draw circuit diagrams.

Table 7.1 Electrical components and their symbols

Electrical component	Symbol	Electrical component	Symbol
Switch		Bulb	
Dry cell		Resistor	
Voltmeter		Fuse	
Galvanometer		Variable resistor	
Ammeter			

Series Circuit and Parallel Circuit



An electric circuit can be connected in series or parallel. A **series circuit** is made up of electrical components that are connected one after another where the current flows through in a single path (Figure 7.8). A **parallel circuit** is separated into several different paths of electrical circuit and each parallel path has electrical components (Figure 7.9).

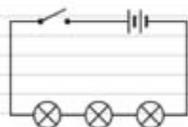


Figure 7.8 Series circuit

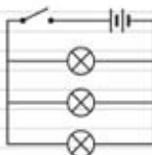


Figure 7.9 Parallel circuit

Current, Voltage and Resistance in a Series Circuit

Is the current that flows through each electrical component in a series circuit the same? Carry out Activity 7.7 to study the current, voltage and resistance in a series circuit.

Activity 7.7

Aim: To study current, voltage and resistance in a series circuit.

Apparatus: Dry cell holder, connecting wire, bulb (1.5 V), dry cell, switch, ammeter and voltmeter

Instruction

1. Set up a series circuit as shown in Figure 7.10 (a).
2. Turn on the switch and measure the current that flows through bulb *M*. Measure the current that flows through bulb *N* by placing the ammeter between *M* and *N* as shown in Figure 7.10 (b).
3. Measure the current that flows through bulb *M* and *N* by setting up the circuit as shown in Figure 7.10 (c).
4. Set up the voltmeter across bulb *M*, followed by bulb *N* as shown in Figure 7.10 (d) to measure the voltage reading across the bulb.
5. Set up the voltmeter as shown in Figure 7.10 (e) to measure the voltage across two bulbs.
6. Calculate the resistance for each bulb separately and also for both the bulbs using Ohm's Law.
7. Record all the readings in a table.

Questions

1. What is your conclusion on the current flow through the series circuit?
2. What will happen to the bulbs in the series circuit if one of the bulbs is removed?

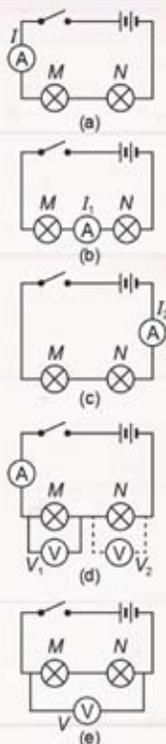


Figure 7.10

After carrying out Activity 7.7, you will notice that the current that flows through each bulb is the same but the voltage is the sum of the voltages across each bulb. Effective resistance, R is the total resistance across the components. We can conclude that:

$$\text{Current, } I = I_1 = I_2$$

$$\text{Voltage, } V = V_1 + V_2$$

$$\text{Resistance, } R = R_1 + R_2$$

Table 7.2 Advantages and disadvantages of a series circuit

Advantages	Disadvantages
<ul style="list-style-type: none"> • Every component in the circuit receives the same amount of current. • Every component is controlled by the same switch. • Increase in voltage supplies more electric current. 	<ul style="list-style-type: none"> • When one of the electrical appliances is damaged, other electrical appliances cease to function. • Adding more electrical appliances increases resistance and decreases the flow of the current. • Each electrical appliance cannot be switched off individually.

Current, Voltage and Resistance in a Parallel Circuit

Current, voltage and resistance in a parallel circuit is different from a series circuit. Carry out Activity 7.8 to investigate the current, voltage and resistance in a parallel circuit.



Activity 7.8

Aim: To study current, voltage and resistance in a parallel circuit.

Apparatus: Dry cell holder, connecting wire, switch, bulb (1.5 V), dry cell, ammeter and voltmeter

Instruction

1. Set up a parallel circuit as shown in Figure 7.11 (a).
2. Turn on the switch and measure the current that flows through bulb *M*. Measure the current that flows through bulb *N* by changing the position of the ammeter.
3. Measure the electric current that flows through both the bulbs, *M* and *N* by setting up a circuit as shown in Figure 7.11 (b).
4. Fix the voltmeter across bulb *M* followed by bulb *N* as shown in Figure 7.11 (c) to measure the voltage across the bulbs.
5. Fix the voltmeter as shown in Figure 7.11 (d) to measure the voltage across two bulbs.
6. Calculate the resistance for each bulb separately and for both the bulbs using Ohm's Law.
7. Record all the readings in a table.

Questions

1. Is the value of voltage different for bulb *M* and *N*?
2. List out the advantages and disadvantages of a parallel circuit.

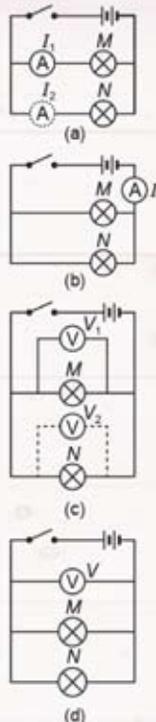


Figure 7.11

Voltage, V that flows across each resistor in a parallel circuit is the same as the voltage that flows across the dry cell. However, the current, I that flows in a parallel circuit is actually the total amount of current that flows through each resistor. Therefore, the current and the voltage can be concluded as:

$$\text{Current, } I = I_1 + I_2$$

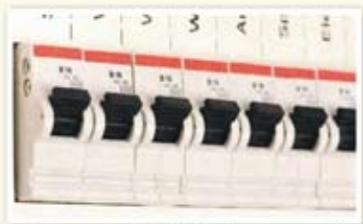
$$\text{Voltage, } V = V_1 = V_2$$

Effective resistance, R can be calculated using the following formula: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

Table 7.3 Advantages and disadvantages of a parallel circuit

Advantages	Disadvantages
<ul style="list-style-type: none"> • Every electrical appliance can be switched on or off separately. • The increase in the number of electrical appliances does not affect the function of other appliances in the same circuit. 	<ul style="list-style-type: none"> • The voltage for every electrical appliance cannot be adjusted because the voltage is the same as the source of voltage.

The electrical wiring system in our homes is connected in **parallel**. For example, all the lights at home are connected in parallel to ensure every light gets the same voltage from its main power supply. The current that flows from the main power supply to the circuit is controlled by a distribution panel (Photograph 7.12).



Photograph 7.12 Distribution panel

Numerical Problems Related to Current, Voltage and Resistance in Series Circuit and Parallel Circuit

1. Two resistors, R_1 and R_2 are connected in series in a circuit as shown in Figure 7.12. Calculate:
- the effective resistance, R
 - the current, I in the circuit
 - the voltage, V_1 and V_2

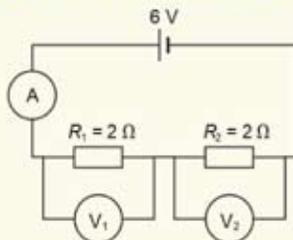


Figure 7.12

Solution:

- (a) Effective resistance, R

$$\begin{aligned} R &= R_1 + R_2 \\ R &= 2 \Omega + 2 \Omega \\ R &= 4 \Omega \end{aligned}$$

- (b) Current, I

$$\begin{aligned} I &= \frac{V}{R} \\ &= \frac{6 \text{ V}}{4 \Omega} \\ &= 1.5 \text{ A} \end{aligned}$$

$$\begin{aligned} \text{(c) } V_1 &= IR_1 \\ &= 1.5 \text{ A} \times 2 \Omega \\ &= 3 \text{ V} \\ V_2 &= IR_2 \\ &= 1.5 \text{ A} \times 2 \Omega \\ &= 3 \text{ V} \end{aligned}$$

2. Two resistors, R_1 and R_2 are connected in parallel in a circuit as shown in Figure 7.13. Calculate:
- the effective resistance, R
 - the voltage, V
 - the current, I in the circuit

Solution:

- (a) Effective resistance,
- R

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

$$\frac{1}{R} = \frac{1}{2\ \Omega} + \frac{1}{2\ \Omega}$$

$$\frac{1}{R} = 1\ \Omega$$

$$R = 1\ \Omega$$

- (b) Voltage,
- V

Voltage across each resistor in a parallel circuit is the same, that is 6 V.

- (c) Current,
- I

$$I_1 = \frac{V_1}{R_1} \quad I_2 = \frac{V_2}{R_2}$$

$$= \frac{6\ \text{V}}{2\ \Omega} \quad = \frac{6\ \text{V}}{2\ \Omega}$$

$$= 3\ \text{A} \quad = 3\ \text{A}$$

$$I = I_1 + I_2$$

$$= 3\ \text{A} + 3\ \text{A}$$

$$= 6\ \text{A}$$

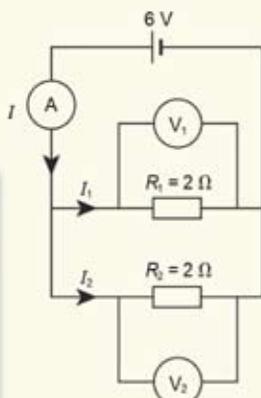
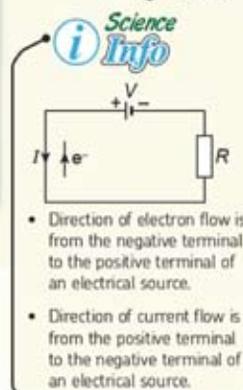


Figure 7.13



- Direction of electron flow is from the negative terminal to the positive terminal of an electrical source.
- Direction of current flow is from the positive terminal to the negative terminal of an electrical source.

Formative Practice 7.2

- Draw a parallel circuit using three bulbs, a dry cell, a switch and several connecting wires.
- Based on Figure 1, calculate:
 - the effective resistance
 - the current in the circuit
 - the voltage across each resistor
- Based on Figure 2, calculate:
 - the effective resistance
 - the voltage
 - the current flowing through each resistor

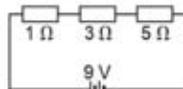


Figure 1

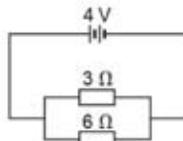
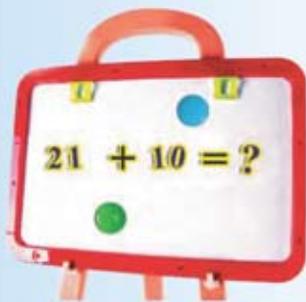


Figure 2

Do you know what causes button magnets to stick to a whiteboard? These button magnets have pieces of magnet attached to them to enable them to stick on a whiteboard surface (Photograph 7.13). Magnets exist naturally in the form of **lodestones**. However, man-made magnets, made of materials such as iron, steel, cobalt and nickel, are widely used in our everyday life.



Photograph 7.13 Button magnets on whiteboard

Properties of a Magnet

You might have already known one of the properties of a magnet, that it only attracts magnetic materials. Do magnets have other properties? Let us learn its properties (Figure 7.14).

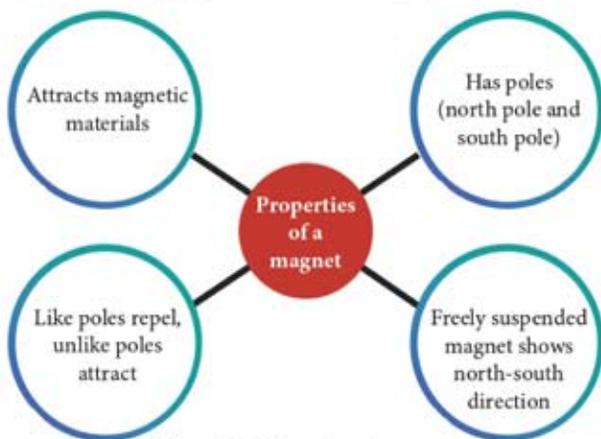


Figure 7.14 Properties of a magnet

Magnetic Field

Photograph 7.14 shows only steel balls that are closer to the magnet are attracted by the magnet. The area around the magnet with magnetic force is known as **magnetic field**.



Photograph 7.14 Magnet and steel balls

Activity 7.9

Aim: To study the pattern of a magnetic field.

Materials: Iron filings and a piece of thin card

Apparatus: Bar magnet, horseshoe magnet, magnadur magnet, compass and drawing paper

Instruction

1. Sprinkle some iron filings evenly on a thin piece of card. (Photograph 7.15).
2. Place the card on a piece of bar magnet (Photograph 7.16) and tap the card gently until a pattern is formed.
3. Draw the pattern that is formed.
4. Arrange four compasses and a bar magnet on the piece of drawing paper as shown in Figure 7.15.
5. Mark the direction of the compass needle on the pattern that you have already drawn in step 3.
6. Repeat steps 1 to 5 by replacing the bar magnet with a horseshoe magnet and magnadur magnet.

Questions

1. Which part of the magnet can you see the most magnetic field lines?
2. What is the direction of the magnetic field lines?
3. What is the relationship between the magnetic field lines and the strength of the magnetic field?



Photograph 7.15



Photograph 7.16



Figure 7.15

You have observed different patterns of magnetic field produced by the magnetic field lines. These magnetic field lines have several characteristics.

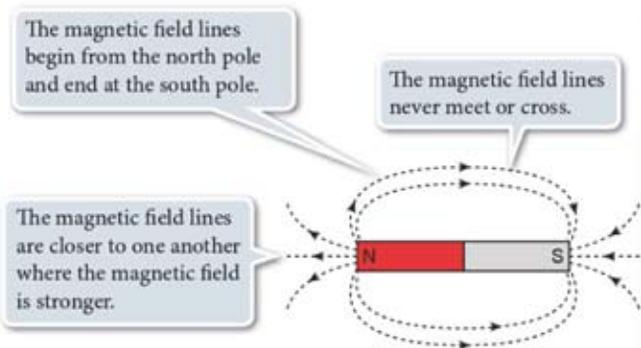


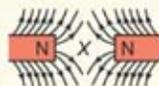
Figure 7.16 Characteristics of magnetic field lines

Brain Teaser

Does a magnet broken into two pieces still have two poles?

Science Info

A magnetic field between two like poles will produce a neutral region (X) which is free from the effect of any magnetic force.



Electromagnet

You have studied electric current in 7.1. Do you know that electric current has magnetic effects? An **electromagnet** is a type of magnet that has temporary magnetic effect when electric current flows through it. The electric bell is an object that uses electromagnet (Photograph 7.17).



Photograph 7.17
Electric bell



Activity 7.10

Aim: To study the pattern and direction of the magnetic field produced by the electric current that flows through different conductors.

Materials: Straight wire, coiled wire, thin cardboard, solenoid and iron filings

Apparatus: Compass, retort stand with clamp, power supply (D.C. 3 V), connecting wire and crocodile clip

Instruction

1. Set up the apparatus as shown in Figure 7.17.
2. Sprinkle some iron filings evenly on the white cardboard. Start the power supply and tap the cardboard gently until a magnetic field pattern is formed.
3. Stop the power supply and sketch the magnetic field pattern that has been formed.
4. Place four compasses around the straight wire as shown in Figure 7.18.
5. Restart the power supply and observe the direction of the needle of the compasses.
6. Stop the power supply. Mark the direction of the current flow and the direction of the magnetic field in the pattern you have drawn in step 3.
7. Reverse the direction of the current flow and observe the pattern and the direction of the magnetic field again.
8. Repeat steps 1 to 7 by replacing the straight wire with coiled wire and solenoid.

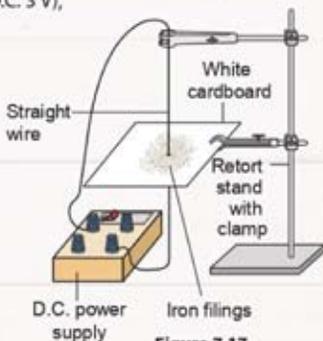


Figure 7.17

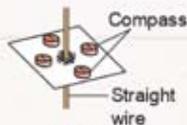


Figure 7.18

Questions

1. What is the purpose of using the iron filings and compass in this activity?
2. Are the magnetic field patterns for all three conductors similar?
3. What can you observe in the magnetic field when the direction of the electric current is reversed?

The **pattern of the magnetic field** depends on the **shape of the conductor** used. For example, the magnetic field lines produced by a straight wire and a coiled wire are concentric circles. Magnetic field lines are closer where the magnetic field is stronger. The strength of the magnetic field reduces as it moves away from the centre of the conductor. The pattern of the magnetic field produced is not affected by the direction of the current that flows through the conductor.

The **direction of the magnetic field** is determined by the direction of the electric current. The **right-hand grip rule** determines the direction of the magnetic field of the current flow in a straight wire (Figure 7.19).

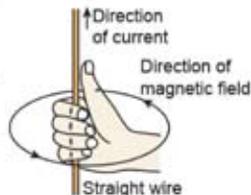


Figure 7.19 Right-hand grip rule

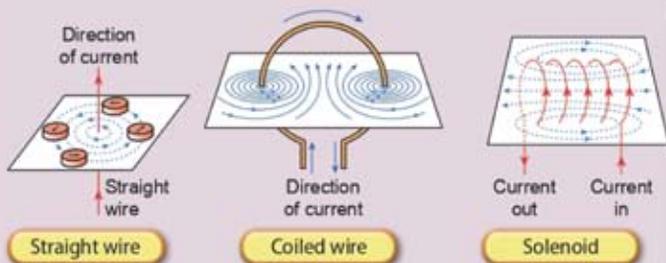


Figure 7.20 Pattern and direction of magnetic fields produced by conductors



Solenoid polarity can be determined by observing the direction of the current flow. The current that flows in the anti-clockwise direction is the north pole, whereas the current that flows clockwise is the south pole.



Experiment 7.2

Aim: To study the factors that influence the strength of the magnetic field.

A **The relationship between the current that flows and strength of the magnetic field**

Problem statement: Does the current flow affect the strength of the magnetic field?

Hypothesis: The larger the current that flows through a conductor, the stronger the magnetic field.

Variable:

- Constant variable : The number of turns of the coil
- Manipulated variable: Current
- Responding variable : Number of pins attracted

Materials: Pin, iron rod and copper wire

Apparatus: D.C. power supply, ammeter, rheostat, Petri dish and retort stand with clamp

Procedure:

- Set up the apparatus as shown in Figure 7.21 with 10 coils of copper wire around the iron rod.
- Turn on the power supply and adjust the rheostat to obtain 0.5 A of current.
- Replace the Petri dish containing pins with an empty Petri dish.
- Turn off the power supply to let all the pins to fall back into the empty Petri dish.
- Count the number of pins attracted by the iron rod.
- Repeat steps 1 to 5 using 1.0 A, 1.5 A, 2.0 A and 2.5 A of current. Record your observations.

Conclusion:

Is the hypothesis accepted? Give your reasons.

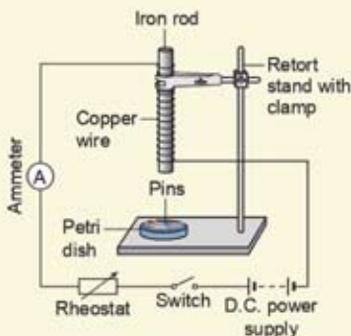


Figure 7.21

B The relationship between the number of turns of a coil and the strength of the magnetic field

Problem statement: Does the number of turns of a coil affect the magnetic field?

Hypothesis: The more the number of turns of a coil, the stronger the magnetic field.

Variables:

- Constant variable: Current
- Manipulated variable: Number of coils
- Responding variable: Number of pins attracted

Procedure:

- Set up the apparatus as shown in Figure 7.21 with 10 coils of copper wire coiled around an iron rod.
- Turn on the power supply.
- Replace the Petri dish containing pins with an empty Petri dish.
- Turn off the power supply so that all the pins drop back into the empty Petri dish.
- Count the number of pins attracted by the iron rod.
- Repeat steps 1 to 5 using 20, 30, 40 and 50 turns of copper wire on the iron rod.
- Record your observations.

Conclusion:

Is the hypothesis accepted? Give your reasons.

Application of Magnets and Electromagnets in Daily Life

The needle of a compass uses a magnet to show the direction of the poles.



Credit cards and debit cards have an electromagnetic strip that stores information.



The magnetic lock on doors uses an electromagnet to lock the doors automatically.



Photograph 7.18 Uses of magnets and electromagnets in daily life

Formative Practice 7.3

- What is a magnetic field?
- Figure 1 shows an iron nail coiled with insulated copper wire connected to a dry cell of 1.5 V.
 - What happens when the switch is turned on?
 - Mark the direction of the current flow in the copper wire around the iron nail.
 - State the poles of the magnetic field at P and Q.
 - What happens to the strength of the magnetic field if another dry cell of 1.5 V is added?
- State **True** or **False** for the following statements.
 - If an object is attracted to magnet, the object is a magnetic material.
 - A straight wire produces magnetic field lines in the shape of concentric circles.

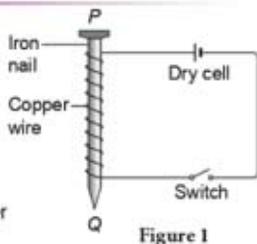
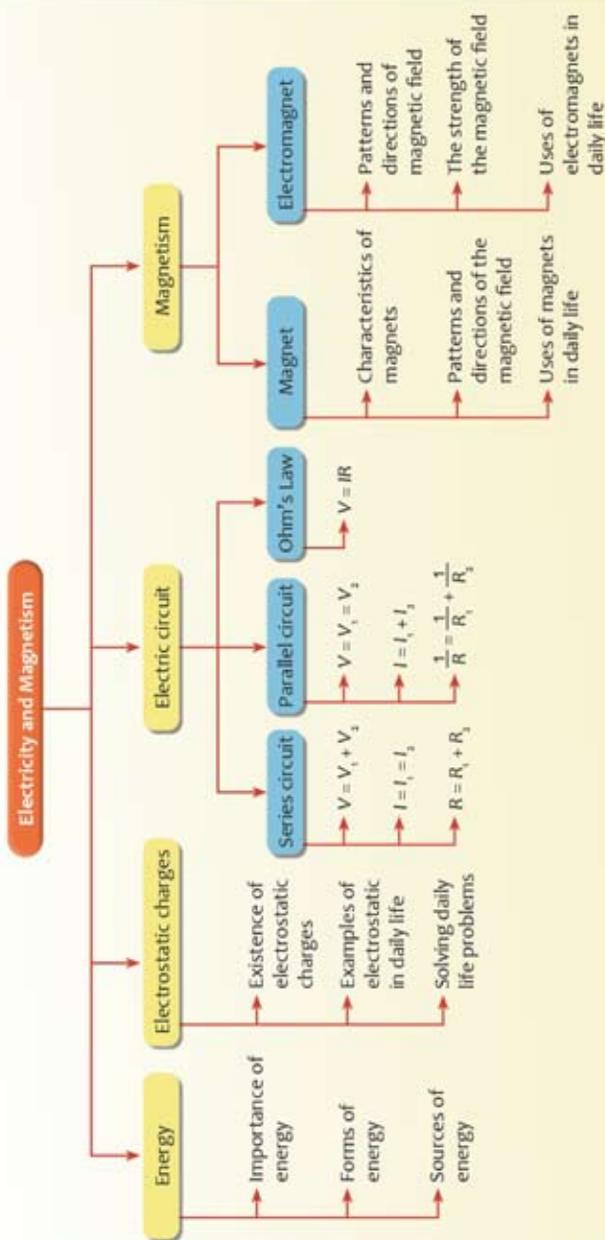


Figure 1

Summary



Interactive Quiz 7



SELF-REFLECTION

After learning this chapter, you are able to:

7.1 Electricity

- Describe and communicate about energy.
- Explain and communicate the existence of electrostatic charges.
- Explain with examples electrostatic in daily life.
- Draw a conclusion that the flow of charges produces electric current.
- Characterise current, voltage and resistance, and their units.
- Draw a conclusion on the relationship between current, voltage and resistance.

7.2 The Flow of Electric Current in a Series Circuit and Parallel Circuit

- Elaborate and communicate about the flow of electric current in series circuit and parallel circuit.

7.3 Magnetism

- Draw a conclusion about the characteristics of a magnet.
- Describe and communicate about electromagnets.
- Carry out an experiment and communicate the uses of magnets and electromagnets in daily life.

Summative Practice 7

1. Tick (✓) the correct statement about electrostatic charges.
 - (a) Earthing causes positive charges to flow from the object to the ground.
 - (b) Similar types of electric charges attract one another.
 - (c) An electroscope is used to determine the presence of electrostatic charges.
2. Imran's office floor is covered with a nylon carpet.
 - (a) What is the effect of electrostatic charges on Imran if he touches an iron chair? Explain your answer. 
 - (b) Suggest a method to overcome the effect of the electrostatic charges mentioned in 2 (a). 
3.
 - (a) Why doesn't a Van de Graaff generator function properly in damp weather? 
 - (b) Why is the shock from the Van de Graaff generator not as dangerous as the electric shock from a domestic power supply? 

