Bakun hydroelectric power station in Sarawak (Energy source: Hydro energy)

Tuanku Jaafar power station in Negeri Sembilan (Energy source: Natural gas)

Sultan Azlan Shah power station in Manjung, Perak (Energy source: Coal)

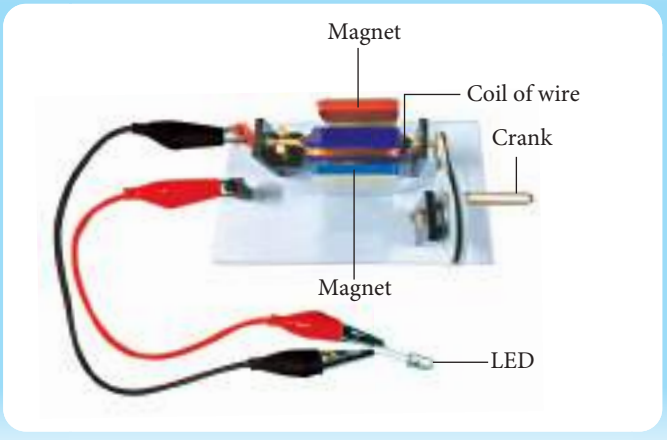
Gelugor power station in Pulau Pinang (Energy source: Diesel)

TSH Bio-Energy Sdn. Bhd. Biomass power station in Sabah (Energy source: Biomass)

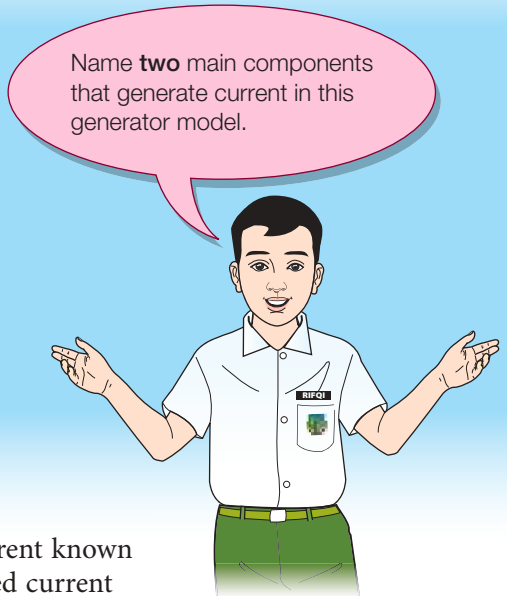
Figure 6.2 *Power stations in Malaysia that use renewable and non-renewable energy sources*

Process of Generating Electricity

A **generator** is a device used to **generate electricity**. Look at Photograph 6.1 which shows an example of a generator model.



Photograph 6.1 Generator model



When the crank of the generator model is turned, a current known as **induced current** is produced. The flow of this induced current lights up the LED.

In 1831, a scientist named Michael Faraday conducted a series of investigations on the generation of electricity using a magnetic field. Electric current is produced by:

- **Movement of the wire** which causes the magnetic field lines to be cut.

A connecting wire or solenoid is moved rapidly through the space between the magnetic poles as shown in Figures 6.3 and 6.4. An induced current is produced in the connecting wire or solenoid, and it flows through the galvanometer. The pointer in the galvanometer deflects.

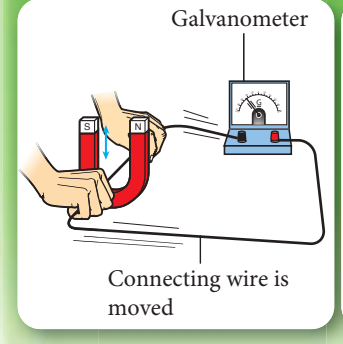


Figure 6.3

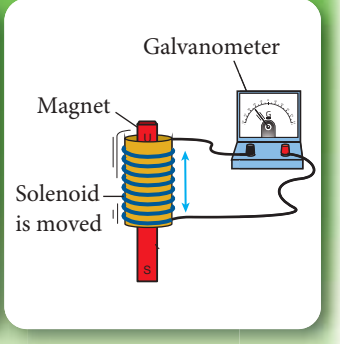


Figure 6.4

- **Movement of the magnet** which causes the magnetic field lines to be cut.

A magnet is moved as shown in Figures 6.5 and 6.6 so that the magnetic field lines are cut by the connecting wire or solenoid. An induced current is produced in the connecting wire or solenoid, and it flows through the galvanometer. The pointer in the galvanometer deflects.

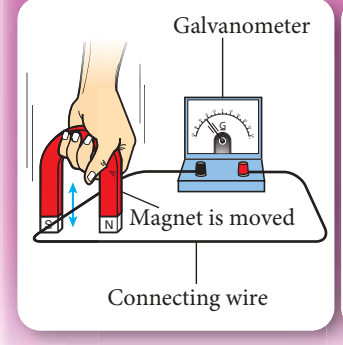


Figure 6.5

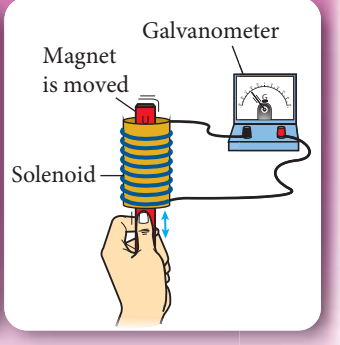


Figure 6.6

Activity 6.1

Inquiry-based activity

To study the production of electric current when magnetic field lines are cut by a copper wire

Materials

PVC insulated copper wire, connecting wire and cardboard tube with a coil of PVC insulated copper wire (coil of wire/solenoid)

Apparatus

Bar magnet, U-shaped magnet and centre-zero galvanometer

Instructions

1. Connect the PVC insulated copper wire to the centre-zero galvanometer.
2. Move the copper wire downwards between the north and south poles of a U-shaped magnet and then upwards as shown in Figure 6.3. Observe and record the deflection of the galvanometer pointer.
3. Move the U-shaped magnet upwards and then downwards as shown in Figure 6.5. Observe and record the deflection of the galvanometer pointer.
4. Connect the coil of PVC insulated copper wire to the centre-zero galvanometer.
5. Move the coil of wire as shown in Figure 6.4. Observe and record the deflection of the galvanometer pointer.
6. Move the bar magnet as shown in Figure 6.6. Observe and record the deflection of the galvanometer pointer.

Observations

Step	Deflection of galvanometer pointer
2	
3	
5	
6	

Questions

1. What is detected by the galvanometer when the galvanometer pointer deflects?
2. What happens when a magnet moves relative to a copper wire or coil of copper wire?
3. What is produced by the cutting of the magnetic field lines by a copper wire or coil of copper wire?

Activity 6.2

21st Century Skills
- ICS, ISS, STEM
- Innovation-based activity

To build a simple generator that can light up an LED using magnets and a coil of wire

Materials
PVC insulated copper wire, cellophane tape, connecting wires with crocodile clips and LED

Apparatus
Armature with axle, two magnadur magnets, wooden plank (base) and C-shaped magnet holder

Instructions
1. Work in groups.
2. Construct a simple direct current (d.c.) generator as shown in Figure 6.7.
3. Make sure the axle is stationary. Observe and record if the LED lights up.
4. Rotate the axle. Then, observe and record if the LED lights up.
5. Present your findings.

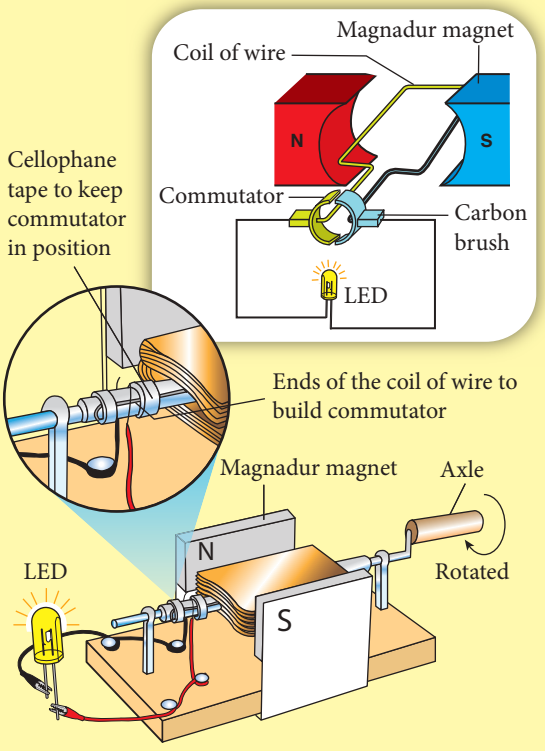


Figure 6.7 *Simple d.c. generator*

Observation

Condition of axle	Stationary	Rotating
LED		

Questions
1. Mark ' ✓ ' for the true statement related to the cutting of magnetic field lines.

(a) When the coil of wire and magnet are stationary, the magnetic field lines are cut.	
(b) When the coil of wire moves inside the stationary magnet, the magnetic field lines are cut.	
(c) Current will only be induced when the magnetic field lines are cut.	

2. How is induced current detected in this activity?
3. How is induced current produced by the d.c. generator?
4. State **two** forms of energy other than electrical energy produced in this activity.
5. State **two** advantages of LED as a lighting device compared to a filament bulb.

Electricity Generated at Power Stations

Study Figures 6.8 to 6.13. Observe how electricity is generated at power stations using various sources of energy.

1 Power station using non-renewable energy sources such as **diesel**, **natural gas** and **coal**.

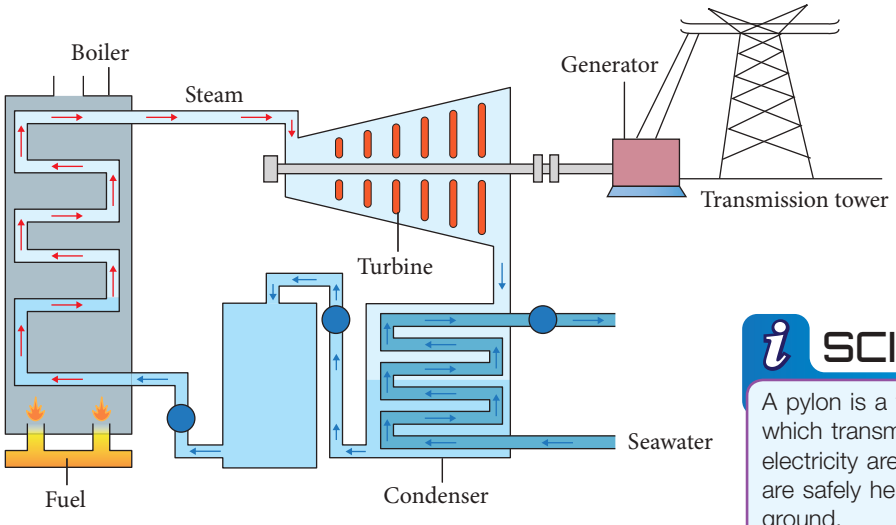


Figure 6.8 *Thermal power station*

SCIENCE INFO

A pylon is a tall metal structure to which transmission cables carrying electricity are fixed so that they are safely held high above the ground.

Mechanism

Burning of fuel → Boiling water produces steam → Steam rotates the turbine → Generator produces electricity

Energy Change

Chemical energy → Heat energy → Kinetic energy → Electrical energy

2 Power station using **solar energy**.

Mechanism

Sunrays → Solar panels convert light energy from the Sun into electricity

Energy Change

Solar energy → Electrical energy

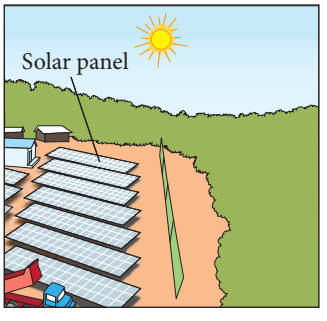


Figure 6.9 *Power station using solar energy*

3 **Hydroelectric** power station.

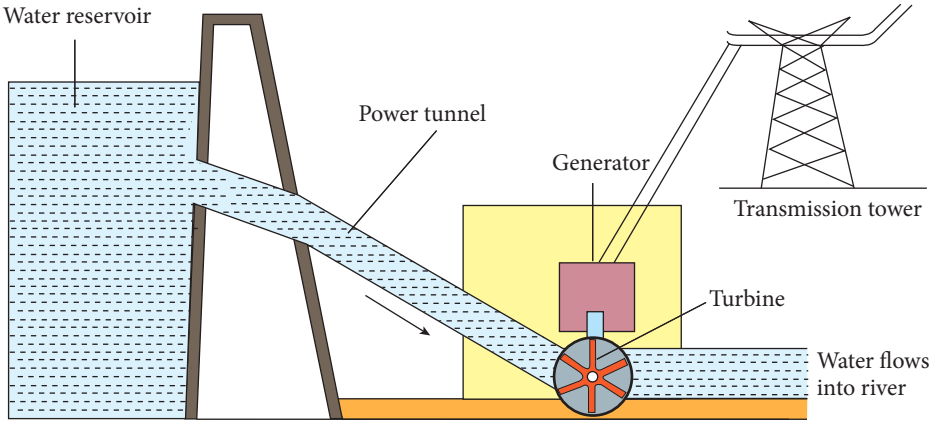


Figure 6.10 *Hydroelectric power station*

Mechanism

High dam stores water → Water flows from high level to low level → Flow of water rotates turbine → Generator produces electricity

Energy Change

Gravitational potential energy → Kinetic energy → Electrical energy

4 Power station using **wind energy**.

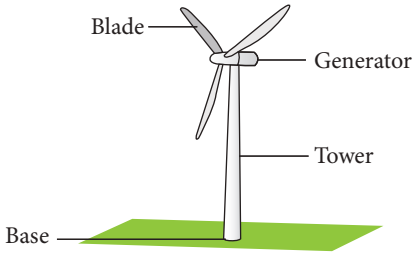


Figure 6.11 *Power station using wind energy*

Mechanism

Moving air or wind → Wind moves blades → Blades rotate turbine → Generator produces electricity

Energy Change

Kinetic energy → Electrical energy

5 Power station using **nuclear fuel**.

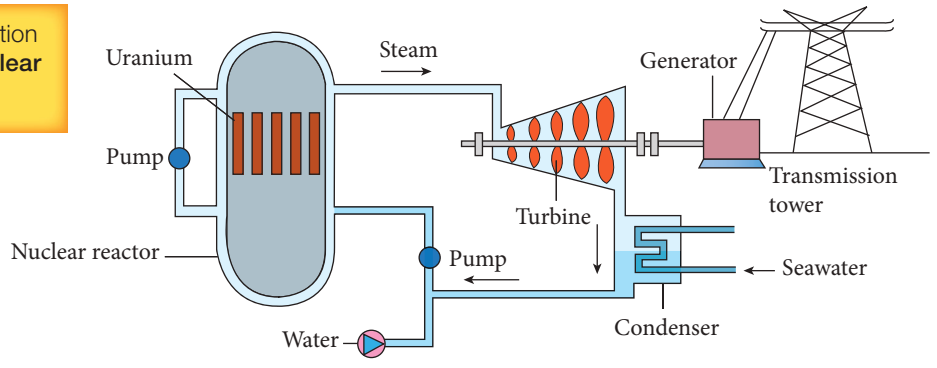


Figure 6.12 *Nuclear power station*

Mechanism

Nuclear reaction → Boiling water produces steam → Steam rotates the turbine → Generator produces electricity

Energy Change

Nuclear energy → Heat energy → Kinetic energy → Electrical energy

6 Power station using **biomass**.

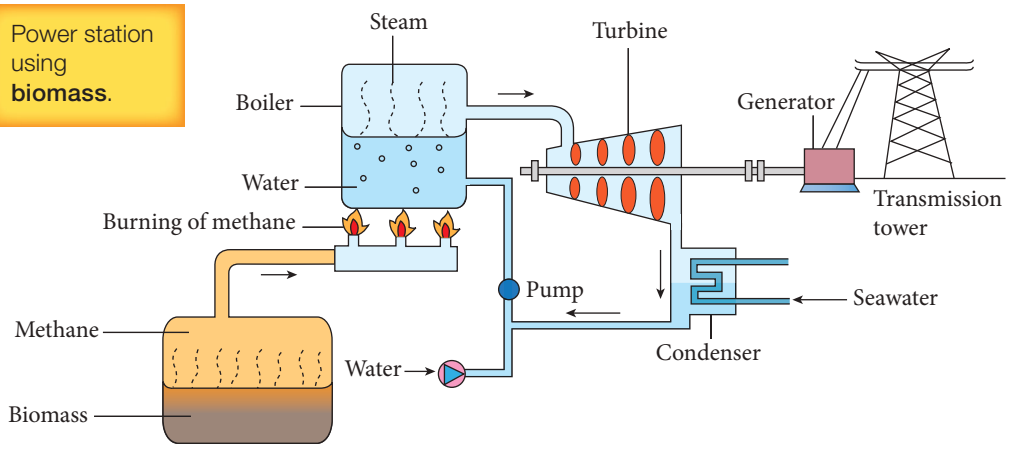


Figure 6.13 *Biomass power station*

Mechanism

Biomass produces methane → Boiling water produces steam → Steam rotates the turbine → Generator produces electricity

Energy Change

Chemical energy → Heat energy → Kinetic energy → Electrical energy

Activity 6.3

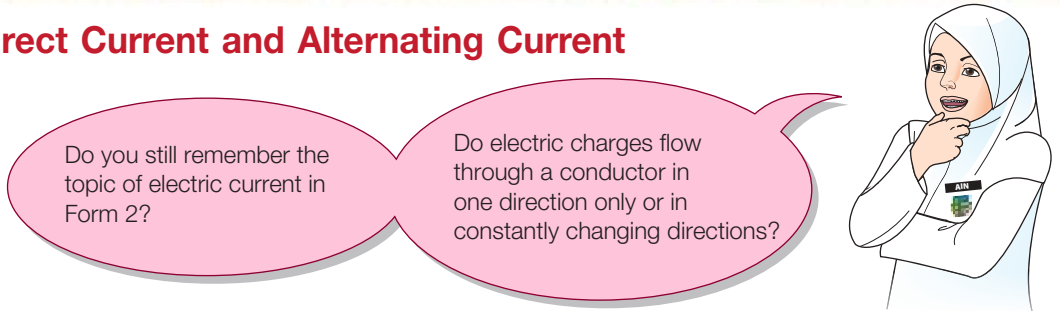
21st Century Skills
- ICS, ISS, STEM
- Discussion activity

To gather information and understand how electricity is generated at power stations

Instructions

1. Work in groups.
2. Gather information on how electricity is generated at power stations using various sources of energy as shown in Figures 6.8 to 6.13:
   (a) Process of generating electricity from various sources of energy
   (b) Locations of power stations which use various sources of energy in Malaysia
3. Share the findings of your group discussion in class.

Direct Current and Alternating Current



Electric current is divided into two types, **direct current (d.c.)** and **alternating current (a.c.).**

Direct Current (d.c.)

Direct current is an electric current that flows in one direction only. Examples of devices that use direct current are shown in Photograph 6.2.

(a) Torchlight (b) Calculator (c) Toy car

Photograph 6.2 *Examples of devices that use direct current*

Examples of generators or sources of electricity that produce direct current are shown in Photograph 6.3.

(a) Solar cells (b) Accumulators (c) Batteries

Photograph 6.3 *Examples of generators or sources of electricity that produce direct current*

Alternating Current (a.c.)

Alternating current is an electric current that flows in constantly reversing directions. Look at Photograph 6.4 which shows examples of devices that use alternating current.

(a) Bread toaster

(b) Hair dryer

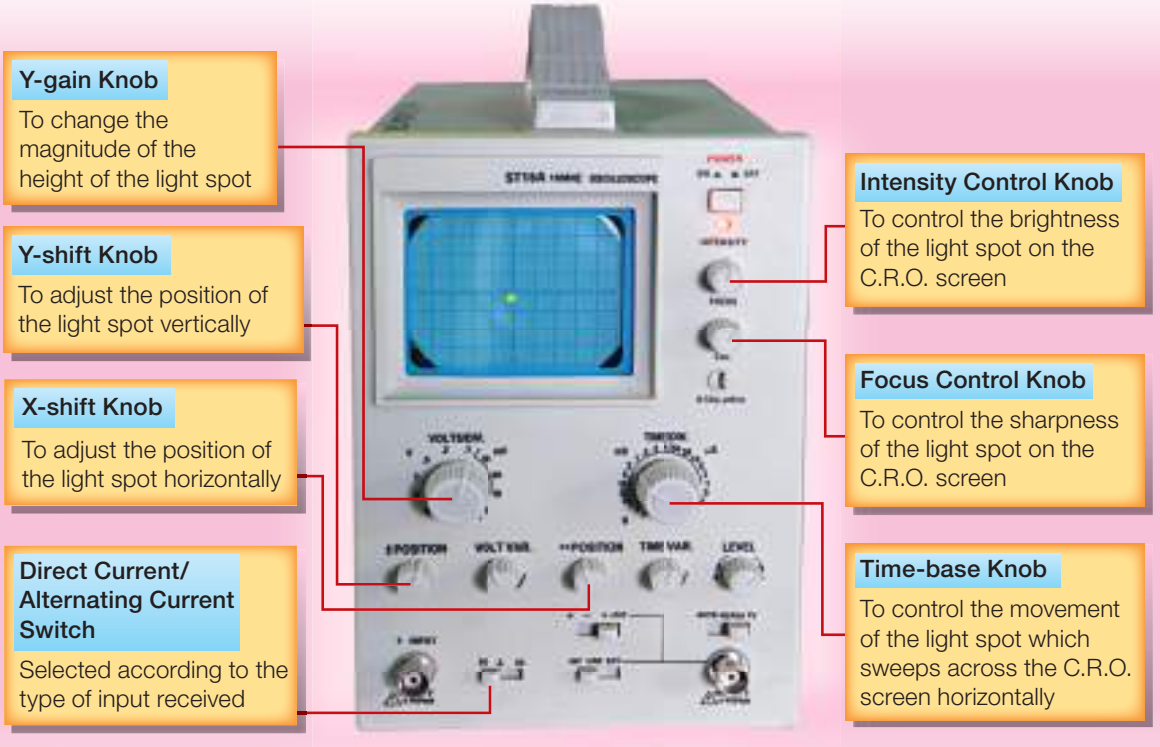
(c) Air conditioner

Photograph 6.4 *Examples of devices that use alternating current*

Do most of the electricity generators in power stations produce d.c. or a.c.?

Cathode Ray Oscilloscope (C.R.O.)

Cathode Ray Oscilloscope (C.R.O.) is an electronic device that is used to show the differences in the shape of graph, direction of current and voltage change for direct current and alternating current. For this, you are encouraged to gather information on how to handle several control switches on the C.R.O. before carrying out Activity 6.4. For this purpose, observe Photograph 6.5.



Photograph 6.5 *Switches and control knobs on the C.R.O.*

Activity 6.4

Inquiry-based activity

Using a Cathode Ray Oscilloscope (C.R.O.) to show the differences in the shape of graph, direction of current and voltage change for direct current (d.c.) and alternating current (a.c.)

Material
Dry cell

Apparatus
Connecting wire, cell holder, C.R.O. and power source

Instructions

1. Switch on the C.R.O. and wait for a light spot to appear on the screen. Turn off the time-base knob. Turn the intensity control and focus control knobs to adjust the brightness and sharpness of the light spot shown in Figure 6.14.
2. Use the X-shift and Y-shift knobs to adjust the light spot so that it is at the zero position in the centre of the screen as shown in Figure 6.14.
3. Turn on the time-base knob and observe the trace displayed on the screen as shown in Figure 6.15.

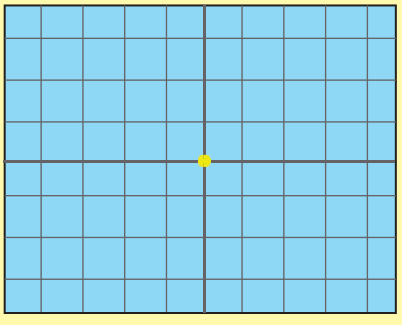


Figure 6.14

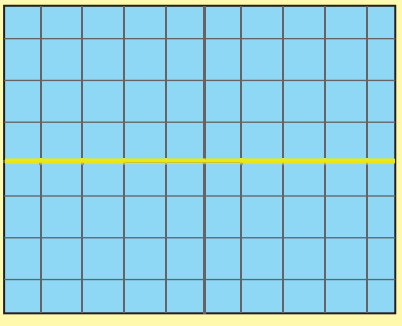


Figure 6.15

4. Select the input switch to d.c. and adjust the Y-gain knob to 1 V/division. Turn off the time-base knob.
5. Connect a dry cell to the Y-input (Photograph 6.6).

Photograph 6.6

6. Observe and record the trace displayed on the screen shown in Figure 6.16. Determine the voltage across the dry cell by multiplying the displacement with the value of Y-gain.
7. Turn on the time-base knob. Observe and record the trace displayed on the screen as shown in Figure 6.17.

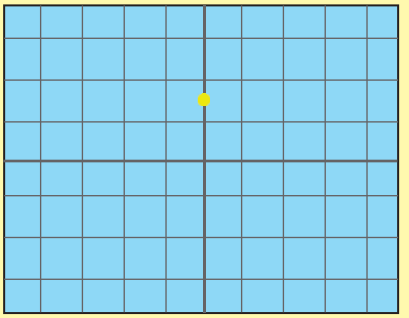


Figure 6.16

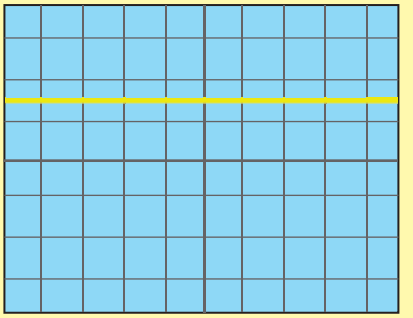


Figure 6.17

8. Repeat steps 5 to 7 but reverse the connection of the dry cell terminals. Observe and record the trace displayed on the screen shown in Figure 6.18.
9. Turn on the time-base knob. Observe and record the trace displayed on the screen as shown in Figure 6.19.

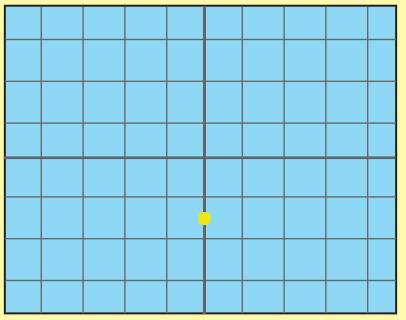


Figure 6.18

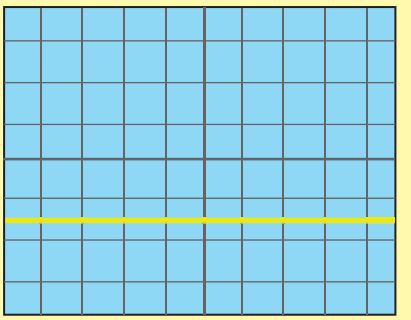
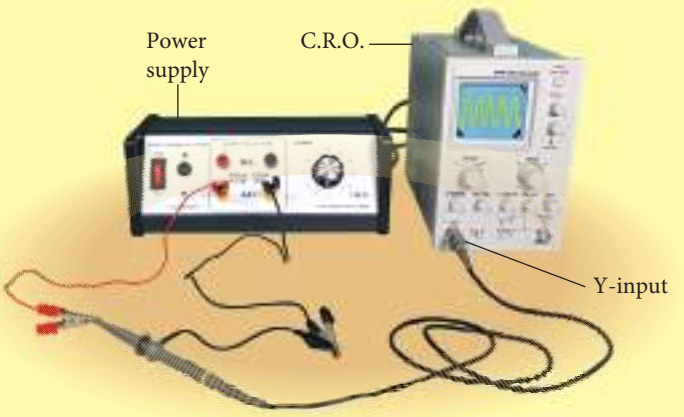


Figure 6.19

10. Select the input switch to a.c. and adjust the Y-gain knob to 1 V/division. Turn off the time-base knob.
11. Connect a 2 V a.c. terminal from the power supply to the Y-input as shown in Photograph 6.7.
12. Observe and record the trace displayed on the screen as shown in Figure 6.20.



Photograph 6.7

13. Turn on the time-base knob. Observe and record the trace displayed on the screen as shown in Figure 6.21.

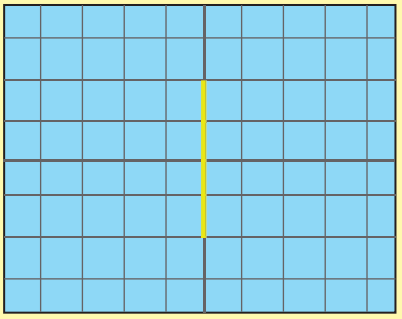


Figure 6.20

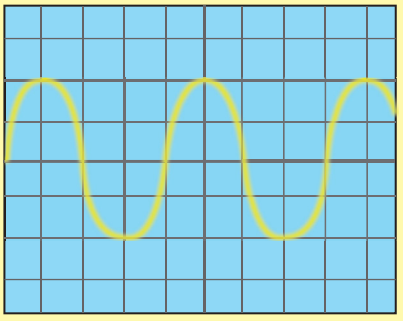


Figure 6.21

14. Repeat steps 10 to 13 but reverse the connection of the terminals of the power supply. Observe and record the trace displayed on the screen as shown in Figure 6.22.
15. Turn on the time-base knob. Observe and record the trace displayed on the screen as shown in Figure 6.23.

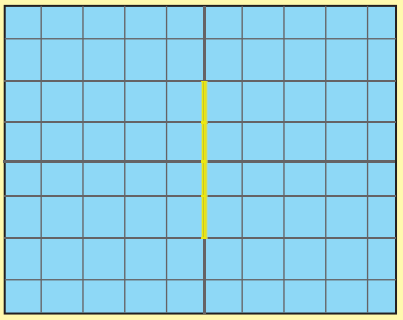


Figure 6.22

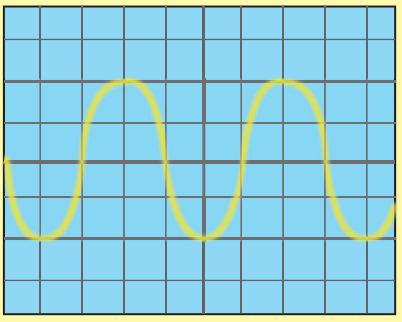


Figure 6.23

Observations

Step	Trace observed on the screen
6	
7	
8	
9	
12	
13	
14	
15	

Questions

1. What is the function of the C.R.O. in this activity?
2. Compare and contrast the traces displayed on the screen as shown in steps 6 and 8.
3. What **two** inferences can be made based on your observations of the trace displayed on the screen in steps 7 and 9?
   (a) First inference
   (b) Second inference
4. Based on your observations of the trace displayed on the screen in steps 12 and 14, describe the change in voltage produced by the power supply. Explain your answer.
5. What are **two** inferences that can be made based on your observations of the trace displayed on the screen in steps 13 and 15?
   (a) First inference
   (b) Second inference
6. Name the type of electric current supplied by the following energy sources:
   (a) Dry cell
   (b) Power supply

Solving Problems Related to Electricity Supply in Life

Have you ever experienced disruptions of electricity supply while at home or in school? If disruptions of electricity supply is a big problem in your life, can you imagine the lives of people living in rural areas without any electricity supply? Let us carry out Activity 6.5 to make a model of a generator that can produce electricity.

My Malaysia

'Giant' generators known as **gensets** from TNB are used to provide backup supply of electricity during disruptions.

Activity 6.5

21st Century Skills
- ICS, CPS
- Project-based activity

To create or innovate a model for generating electricity using turbines and generators in rural areas without affecting the environment

Instructions

1. Work in groups.
2. Create or innovate a model for generating electricity using turbines and generators in rural areas without affecting the environment.

6.1.3 6.1.4

Examples of innovations to generate electricity.

Roof with solar cells

Absorbs and changes solar energy to electrical energy without affecting the environment

Wireless electrical transmission and distribution

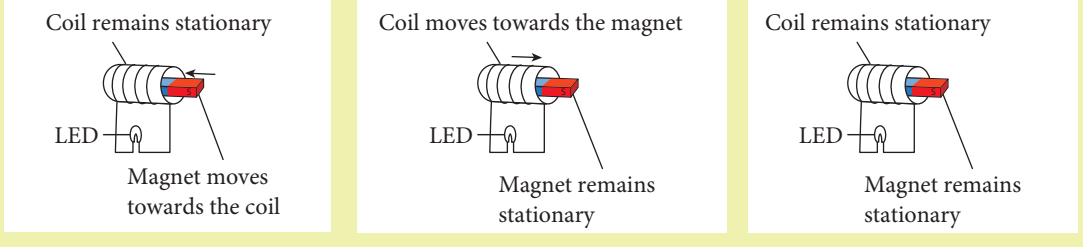
Changes electrical energy to radio wave or microwave energy to be transmitted and distributed without wires to electrical devices. These electrical devices then change the radio wave or microwave energy back to electrical energy.

3. Present your model or innovation using turbines and generators to generate electricity.

Formative Practice 6.1

1. What is meant by renewable energy sources and non-renewable energy sources?

2. Figure 1 shows three arrangements, P, Q and R with moving or stationary magnet and coil of wire.



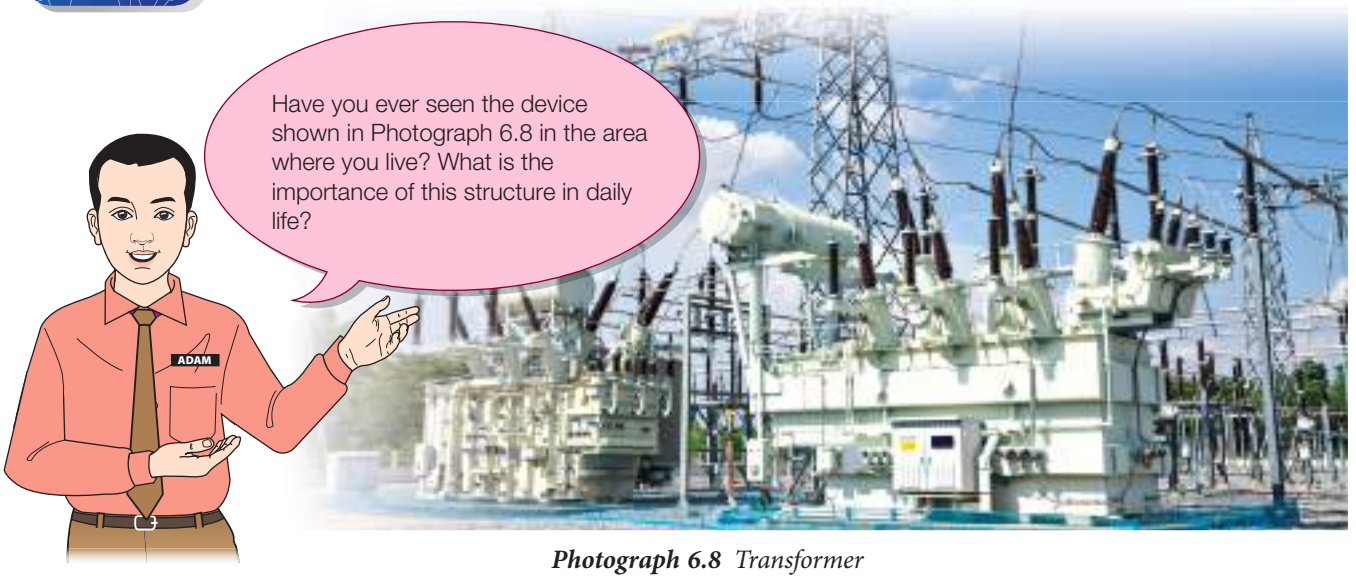
Arrangement P | Arrangement Q | Arrangement R

Figure 1

(a) In which arrangement does the LED light up? Explain your answer.
(b) In which arrangement does the LED not light up? Explain your answer.

3. What is the function of a cathode ray oscilloscope or C.R.O.?

6.2 Transformer



Photograph 6.8 *Transformer*

Step-up Transformer and Step-down Transformer

A transformer is a device for changing the voltage of an alternating current ($V_{a.c.}$). A simple transformer is made up of **laminated soft iron core** which is wrapped by two insulated coils, the **primary coil** and the **secondary coil** as shown in Figure 6.24.

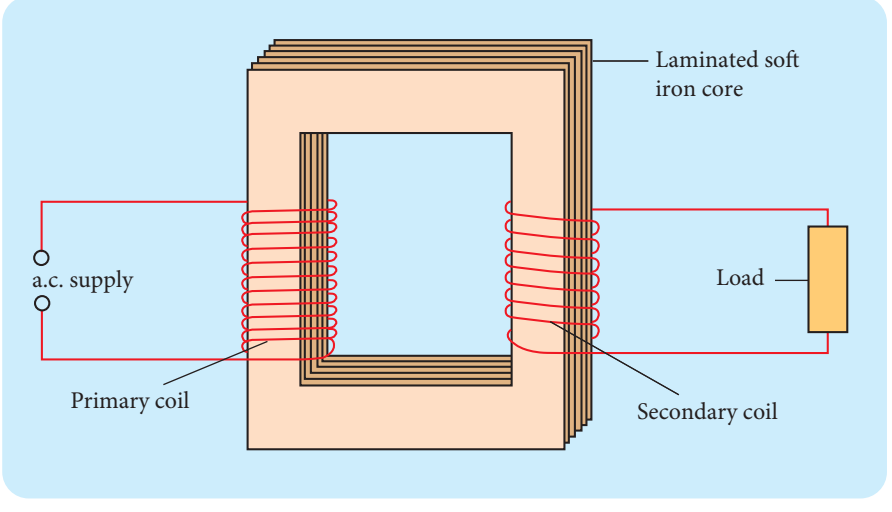
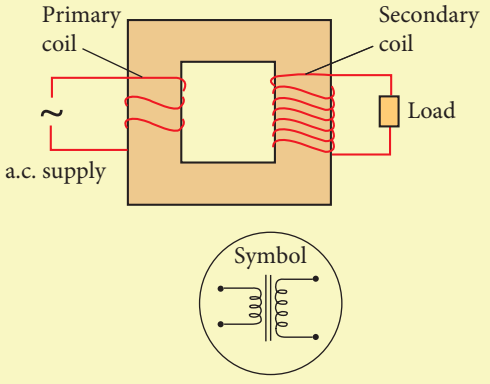
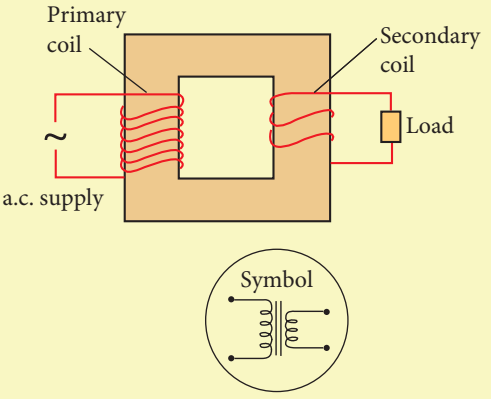


Figure 6.24 *Structure of a simple transformer*

There are two types of transformers, the **step-up transformer** and the **step-down transformer** as described in Table 6.1.

Table 6.1 *Step-up transformer and step-down transformer*

Step-up transformer	Step-down transformer
	
Primary voltage (input), V_p, across the primary coil is **lower** than the secondary voltage (output), V_s, across the secondary coil.	Primary voltage (input), V_p, across the primary coil is **higher** than the secondary voltage (output), V_s, across the secondary coil.
Number of turns of the primary coil is **less** than that in the secondary coil.	Number of turns of the primary coil is **more** than that in the secondary coil.

Carry out Experiment 6.1 to construct and study the functions of simple step-up and step-down transformers.

Experiment 6.1

Aim

To construct and study the functions of simple step-up and step-down transformers using laminated soft iron core

Problem statement

What are the functions of step-up and step-down transformers?

Hypothesis

(a) In a step-up transformer, the secondary voltage (output) is higher than the primary voltage (input).
(b) In a step-down transformer, the secondary voltage (output) is lower than the primary voltage (input).

Variables

(a) manipulated variable : Number of turns of the secondary coil, N_s
(b) responding variable : Brightness of light bulb
(c) constant variable : Number of turns of the primary coil, N_p

Materials

Connecting wire, insulated copper wire and light bulbs

Apparatus

a.c. power supply and laminated C-shaped soft iron core

Procedure

1. Wind 30 turns of wire around one arm of the laminated soft iron core to form a primary coil as shown in Figure 6.25.
2. Wind 15 turns of wire around the other arm of the laminated soft iron core to form a secondary coil as shown in Figure 6.25.
3. Connect the primary coil to an a.c. power supply. Then, connect light bulb P to the primary coil and light bulb S to the secondary coil as shown in Figure 6.25.

Safety Precaution

Practise safety steps while handling power supply.

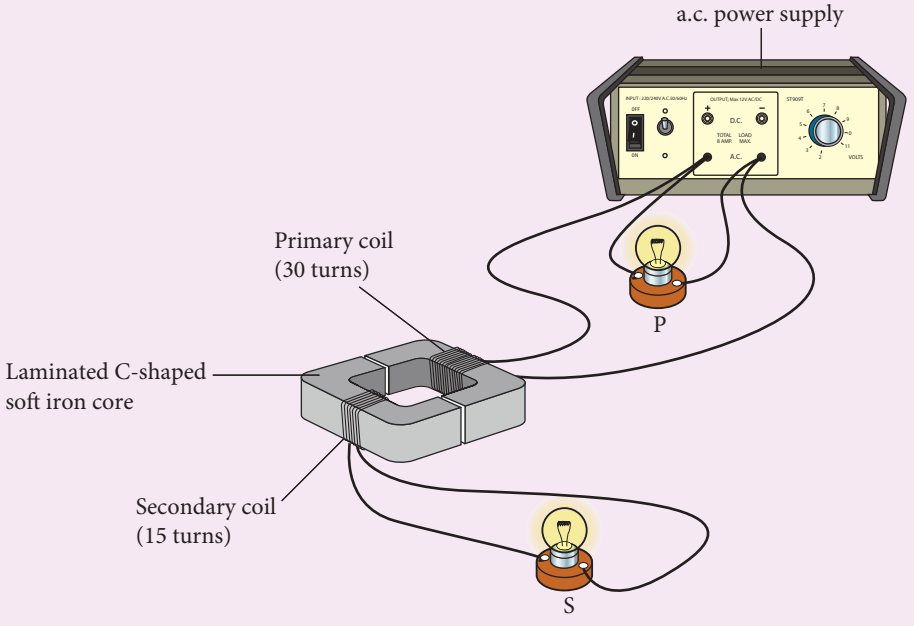


Figure 6.25

4. Switch on the a.c. power supply and adjust its voltage to 2 V.
5. Observe and compare the brightness of the two bulbs.
6. Repeat steps 3 to 5 but using a primary coil with 30 turns and a secondary coil with 60 turns.

Observations

Number of turns of primary coil, N_p	Number of turns of secondary coil, N_s	Brightness of bulb	
		P	S
30	15		
30	60		

Conclusion

Is the hypothesis of the experiment accepted? What is the conclusion of this experiment?

Questions

1. Based on the results of this experiment:
   (a) What is the effect on the brightness of the bulb if $N_p > N_s$?
   (b) What is the relationship between V_p and V_s if $N_p > N_s$?
   (c) What type of transformer is this?
2. Based on the results of this experiment:
   (a) What is the effect on the brightness of the bulb if $N_p < N_s$?
   (b) What is the relationship between V_p and V_s if $N_p < N_s$?
   (c) What type of transformer is this?
3. What happens to the change in voltage of the alternating current in a transformer if the difference between the number of turns in its primary coil and the number of turns in its secondary coil is increased?
4. Why are the numbers of turns in the primary and secondary coils different in all transformers?

Function of Transformer in Home Electrical Appliances

In Malaysia, the supply voltage of alternating current provided to our home is **240 V**. Give **one** example of an electrical appliance at home that operates at 240 V alternating current without using a transformer.

Most electrical appliances at home use transformers such as those in mobile phone chargers (Photograph 6.9).

Photograph 6.9 *A mobile phone charger*

Is the transformer in a mobile phone charger a step-up or step-down transformer? Let us carry out Activity 6.6 to discuss the transformers and their functions in home electrical appliances.

SCIENCE INFO

An induced current formed in the iron core of a transformer is known as the **eddy current**. The formation of the eddy current in a transformer will reduce the efficiency of the transformer. Due to this, a laminated iron core is used to reduce eddy current and increase the efficiency of the transformer. A laminated iron core is made up of layers of soft iron and layers of insulators arranged alternately.

Activity 6.6

21st Century Skills
- ICS
- Technology-based activity

To discuss the transformer and its functions in home electrical appliances

Instructions

1. Work in groups.
2. Use various sources to gather information on transformers and their functions in home electrical appliances.

Examples of the use of transformers in home electrical appliances

(a) Battery charger of a laptop

(b) Mobile phone charger

(c) Ceiling fan regulator

3. Discuss the gathered information.
4. Present the outcome of the discussion using multimedia presentation.

Solving Problems Related to Transformers in Daily Life

Figure 6.26 shows an example of a home electrical appliance which is a ceiling fan regulator that uses a step-down transformer. What is the formula used to determine the number of turns in the secondary coil to lower the input voltage from 240 V to voltages ranging from 2 V to 10 V?

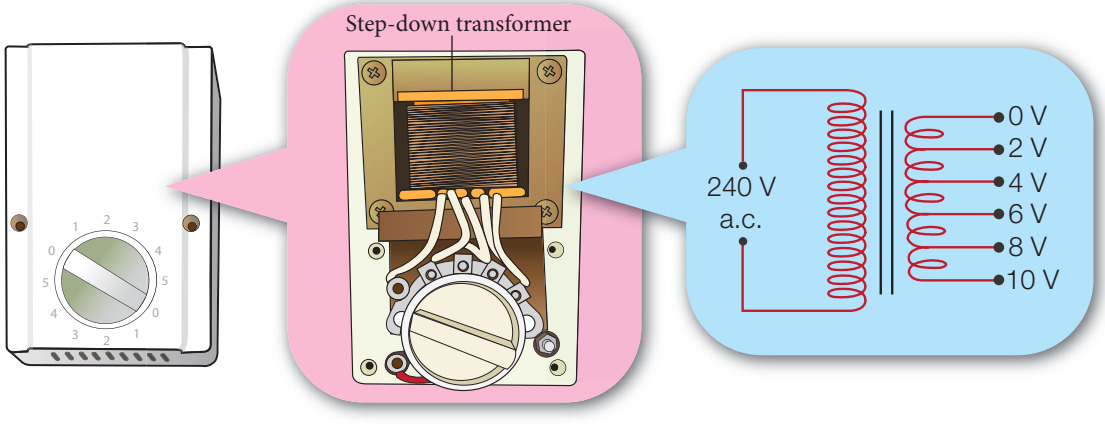


Figure 6.26 *Ceiling fan regulator*

6.2.2 6.2.3

Transformer Equation

The ratio of the primary voltage to the secondary voltage is **equal** to the ratio of the number of turns of the primary coil to the number of turns of the secondary coil in a transformer. This relationship can be written in the following formula:

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

where V_p = input voltage of the primary coil or primary voltage
V_s = output voltage of the secondary coil or secondary voltage
N_p = number of turns of primary coil
N_s = number of turns of secondary coil

Example

Figure 6.27 shows a 40 V bulb connected to a 240 V power supply through a transformer.

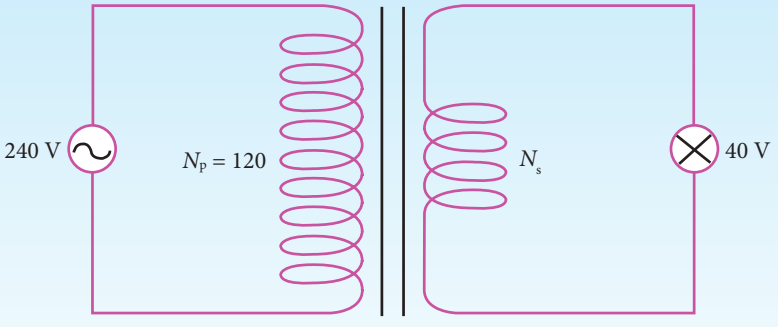


Figure 6.27

Find out the number of turns of the secondary coil, N_s, that is required for the bulb to light up at normal brightness?

Solution

The bulb will light up at normal brightness if it is supplied with a voltage of 40 V.

- Output voltage, V_s = 40 V
- Input voltage, V_p = 240 V
- Number of turns in primary coil, N_p = 120

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$\frac{240}{40} = \frac{120}{N_s}$$

$$N_s = 120 \times \frac{40}{240}$$
$$= 20$$

Number of turns in secondary coil, N_s = 20

Formative Practice 6.2

1. What is a transformer?

2. Underline the correct answers.
   (a) Transformers only function using (direct/alternating) current.
   (b) In a step-down transformer, the number of turns in the primary coil is (more/less) than the number of turns in the secondary coil.
   (c) A (step-up/step-down) transformer is used to change 25 kV to 250 kV.
   (d) A (step-up/step-down) transformer is fixed in a radio.

3. State **one** example of a home electrical appliance which uses the following types of transformers:
   (a) Step-up transformer
   (b) Step-down transformer

4. Figure 1(a) shows a transformer in a 5 V mobile phone charger connected to the 240 V main power supply.

Figure 1(a)

Figure 1(b) shows a circuit diagram of the transformer in the mobile phone charger.

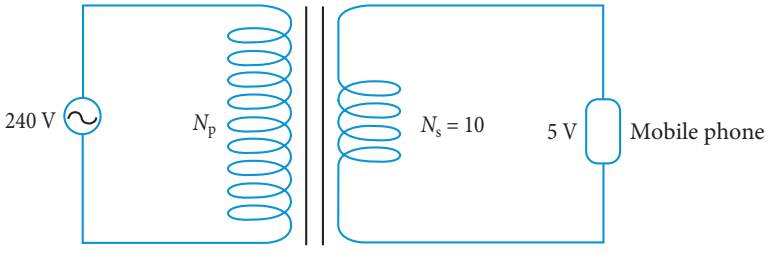


Figure 1(b)

(a) Calculate the number of turns in the primary coil.
(b) Is the transformer in the mobile phone charger a step-up or step-down transformer? Explain your answer.

6.3 Transmission and Distribution of Electricity

Functions of the Components in the Electricity Transmission and Distribution System

The electricity transmission and distribution system that connects a power station to your house is shown in Figure 6.28.

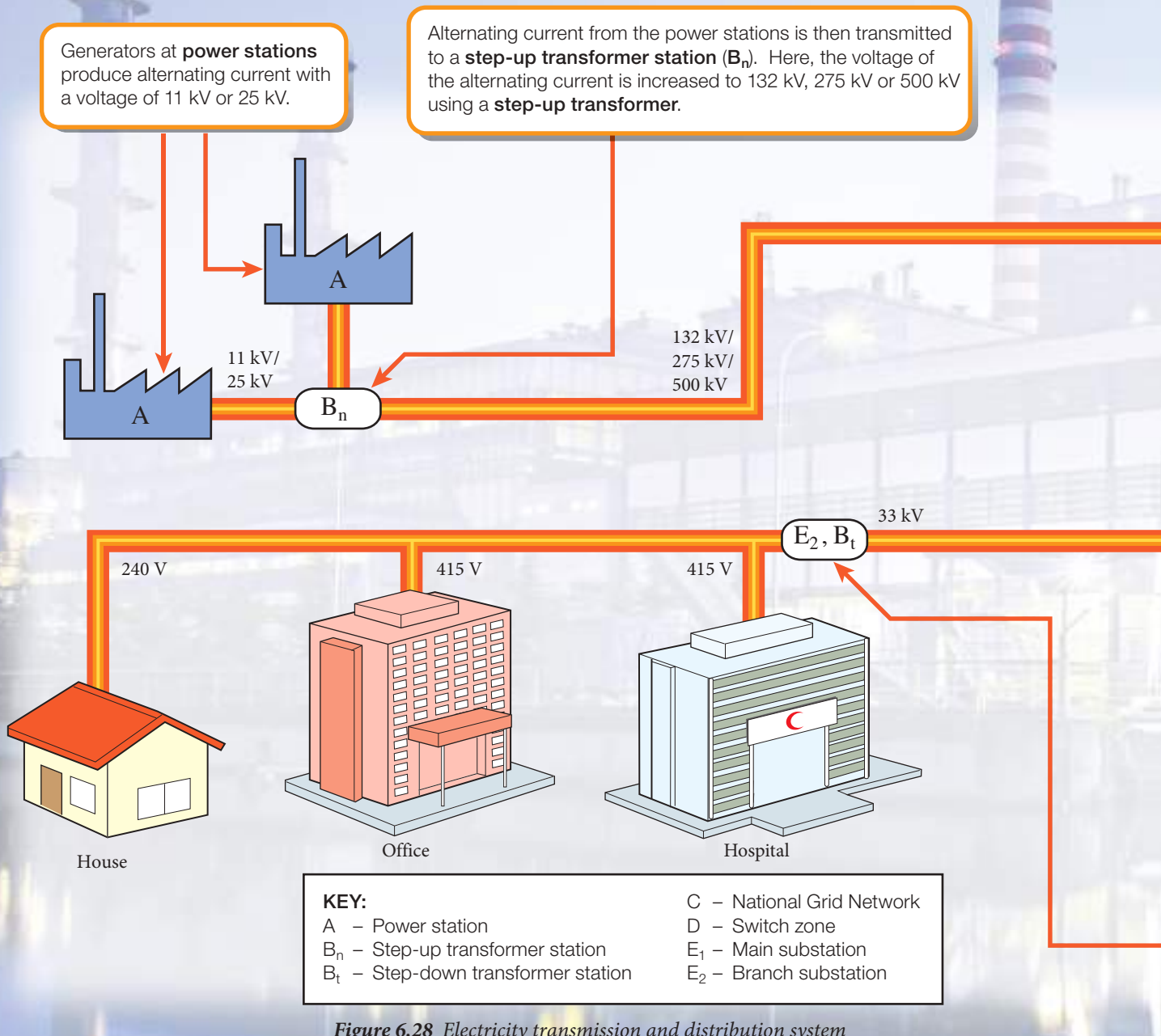
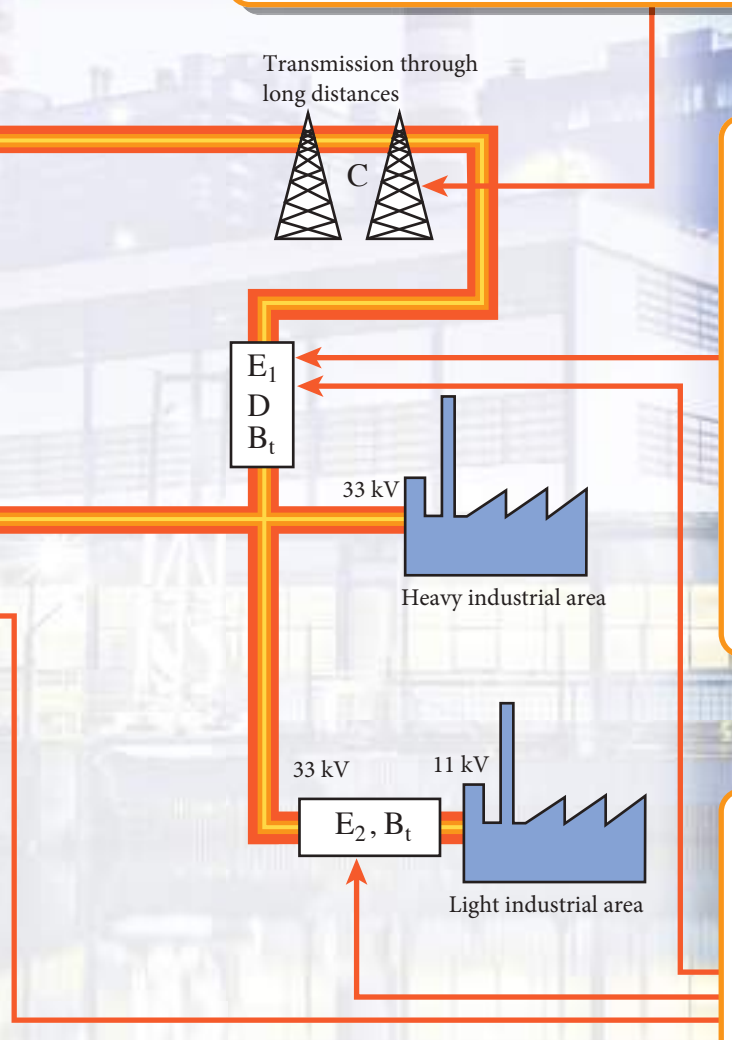


Figure 6.28 *Electricity transmission and distribution system*

The high voltage alternating current is then transmitted through a network of transmission cables called the **National Grid Network (C)** as shown in the photographs below.

500 kV alternating current transmission cables along the North-South Highway.

132 kV alternating current transmission cables at the Tanjung Kling Power Station, Malacca



At the end of the grid, the alternating current flows to a **switch zone (D)** at the **main substation (E_1)**. This switch zone enables electricity to be sent to the **branch substation (E_2)** when needed. This switch zone is also used to enable specific power stations and grids to be closed for maintenance works without disrupting the electricity supply to consumers.

Main substation

Switch zone

At the **main substation (E_1)** and **branch substation (E_2)**, the alternating current is transmitted through a series of **step-down transformers (B_t)** at the step-down transformer station. The voltage of the alternating current is reduced gradually to different voltage values to be supplied to consumers according to their needs. For example:

- heavy industrial area at **33 kV**
- light industrial area at **11 kV**
- office, business and residential areas at **240 V**

Impact on Residences Located Near the National Grid Network Pylons

High voltage alternating current is transmitted through transmission cables on the National Grid Network pylons as shown in Photograph 6.10. A strong **electromagnetic field** is produced by the high voltage alternating current and can be detected in the surrounding areas close to the pylons. Observe the effect of this electromagnetic field by using a compass. What happens to the position of the compass needle?

Photograph 6.10 *Transmission cables on the National Grid Network pylons*

My Malaysia

Go to the following websites:
https://www.tnb.com.my/
https://www.sesb.com.my/
http://www.sarawakenergy.com.my/
What are the facilities provided by Tenaga Nasional Berhad (TNB), Sabah Electricity Sdn. Bhd. (SESB) and Sarawak Energy Berhad (Sarawak Energy) to consumers in Malaysia?

Let us carry out Activity 6.7 to discuss the impact of the National Grid Network pylons on nearby residences.

Activity 6.7

21st Century Skills
- ICS, CPS
- Discussion activity

To discuss the impact of the National Grid Network pylons on nearby residences

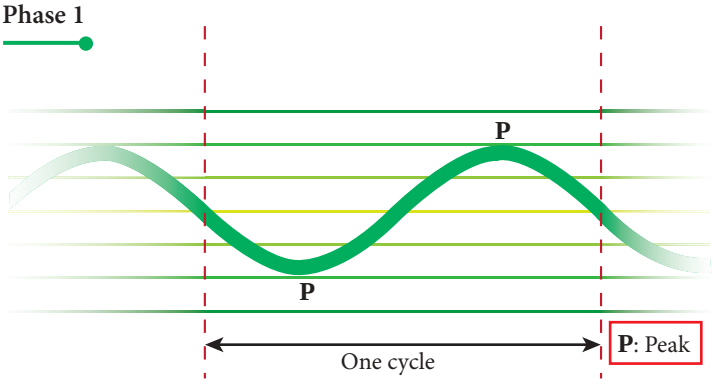
Instructions

1. Work in groups.
2. Gather information related to the issues of the impact on residences located near the National Grid Network pylons as follows:
   (a) Strength of electromagnetic field close to the National Grid Network pylons
   (b) The impact of electromagnetic field on human health perceived by locals and confirmed by medical experts
   (c) Ways to solve the issues regarding the electromagnetic field on residential areas close to the National Grid Network pylons
3. Share the outcome of your group discussion in class.

Photograph 6.11 *Residences located near a National Grid Network pylon*

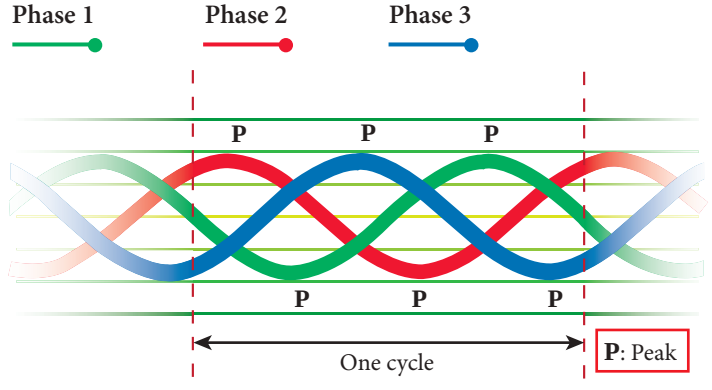
Electrical Wiring System in Malaysia

The electrical wiring system in Malaysia consists of two different types, **one-phase wiring** (or single-phase) and **three-phase wiring** as shown in Figures 6.29 and 6.30.



The single-phase wiring is only suitable and stable enough for electricity usage not exceeding 10 kW or 50 A, such as in rural residential areas.

Figure 6.29 *Single-phase wiring*



In commercial and industrial areas where electricity usage is more than 10 kW or 50 A, the **three-phase wiring** which is more stable and reliable is used.

Figure 6.30 *Three-phase wiring*

BRAIN TEASER

Tenaga Nasional Berhad (TNB) suggests that users of single-phase wiring who use more than 10 kW or 50 A to switch to three-phase wiring. Compare and contrast the importance of single-phase wiring and three-phase wiring in electricity usage. Does your family accept TNB's suggestion? Give your reasons.

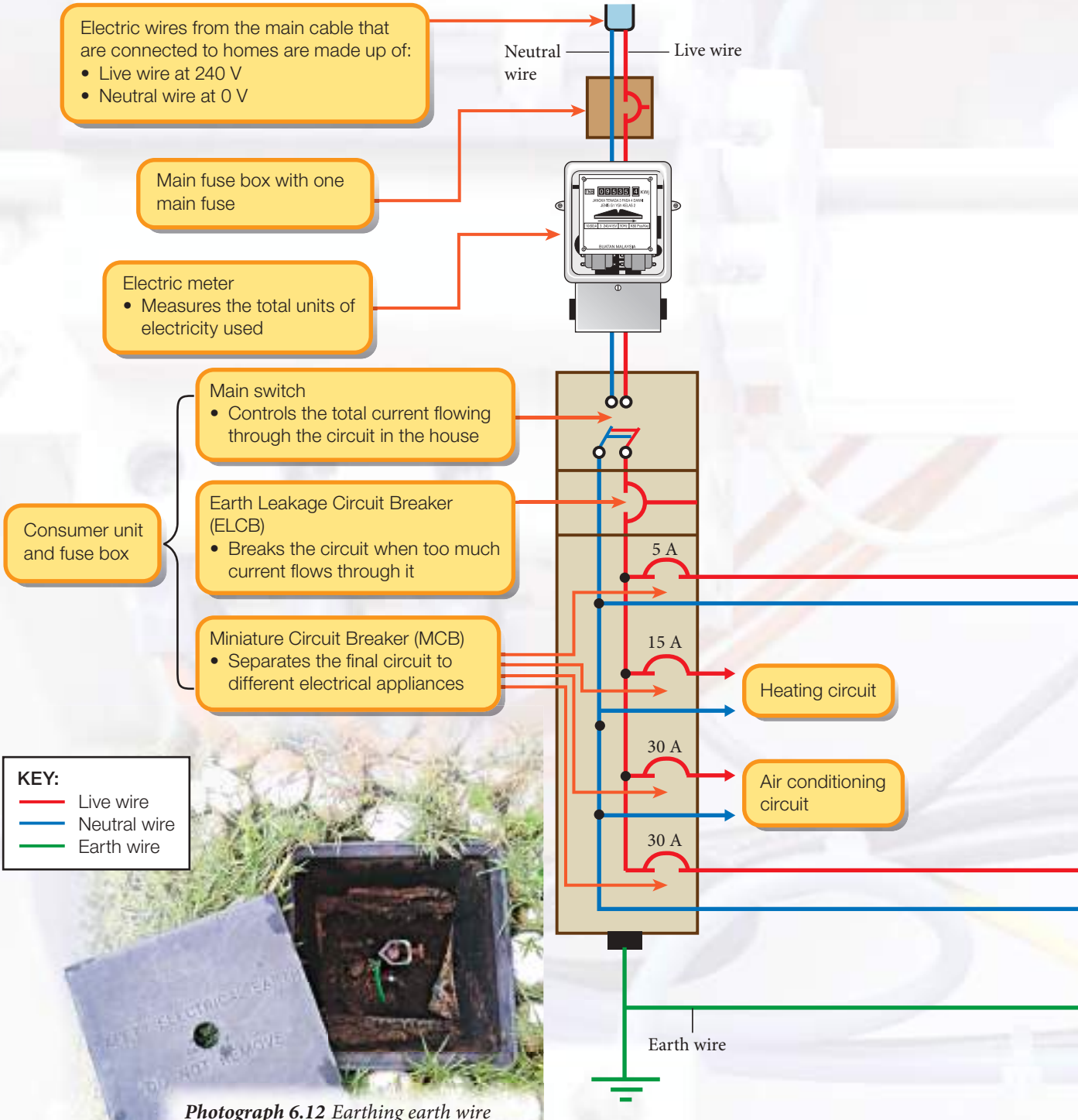
Websites

Ways to identify the types of electrical wiring

http://links.and117.com/BT_Science _187

Electricity Supply and Wiring System in Homes

Figure 6.31 shows an example of electricity supply and wiring system in homes.



Photograph 6.12 *Earthing earth wire*

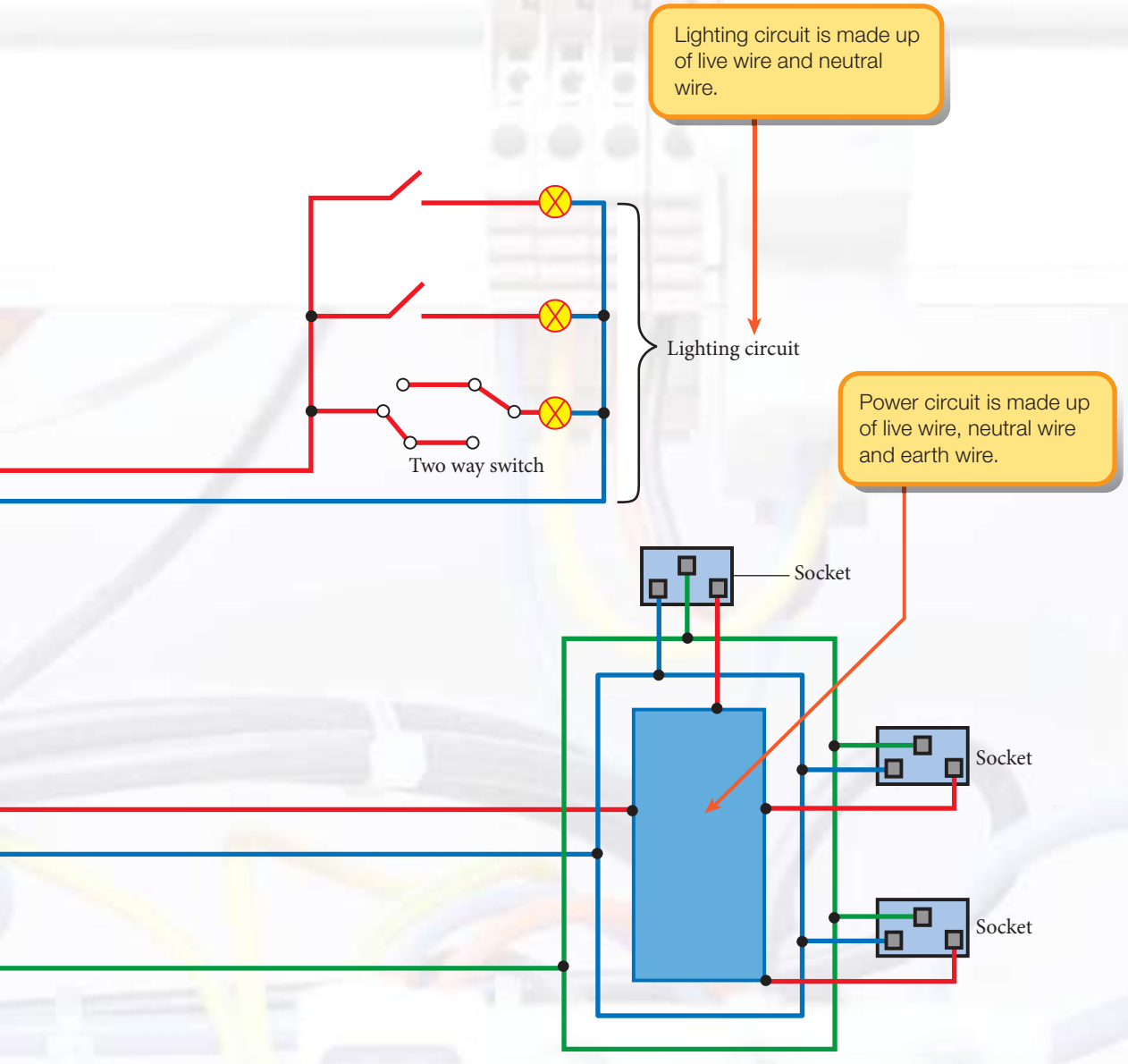


Figure 6.31 *Example of electricity supply and wiring system in homes*

6.3.2

3-pin Plugs and 2-pin Plugs

Compare and contrast the structures of the 3-pin plugs and 2-pin plugs shown in Photograph 6.13.

Photograph 6.13 *3-pin plugs and 2-pin plugs used in different countries*

The 3-pin plug and 2-pin plug used in our country are explained in Table 6.2.

Table 6.2 *3-pin plug and 2-pin plug in the wiring system in homes*

3-pin plug	2-pin plug
Electrical appliances such as electric kettles and irons obtain electricity from the sockets on the walls through 3-pin plugs.	Electrical appliances such as hair dryers and electric toothbrushes obtain electricity from the sockets on the walls through 2-pin plugs.

The live wire, neutral wire and earth wire connected to 2-pin and 3-pin plugs are required to follow the international colour code for wiring shown in Figure 6.32 to ensure the safety of electricity use.

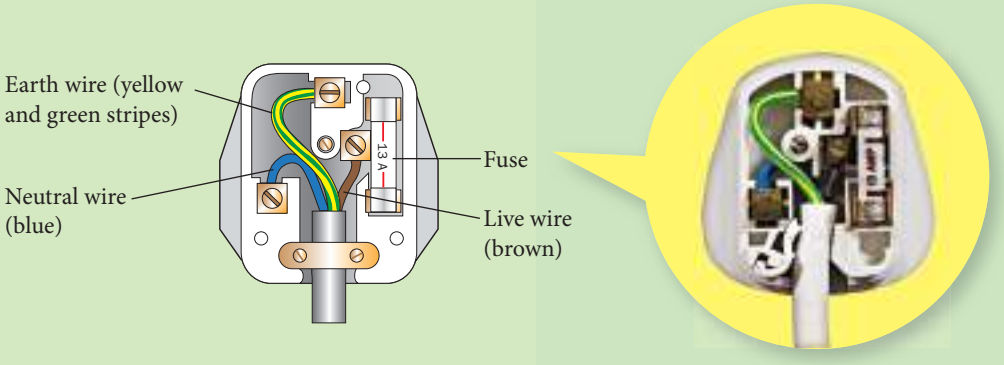


Figure 6.32 *International colour code for wiring*

Safety Components in the Wiring System in Homes

In the wiring system in homes, some of the safety components are shown in Photograph 6.14.

(a) Switch

(b) 3 A, 5 A, 10 A and 13 A fuses

(c) Earth Leakage Circuit Breaker (ELCB)

(d) Miniature circuit breaker (MCB)

(e) Earth wire

(f) Lightning conductor

Photograph 6.14 *Safety components in the wiring system in homes*

Fuse

Structure of Fuse

A **fuse**, as shown in Figure 6.33, is a fine and short wire that heats up easily and melts when the current flowing through it exceeds the value of the fuse. If the wire of the fuse melts, the electricity supply will be cut off.

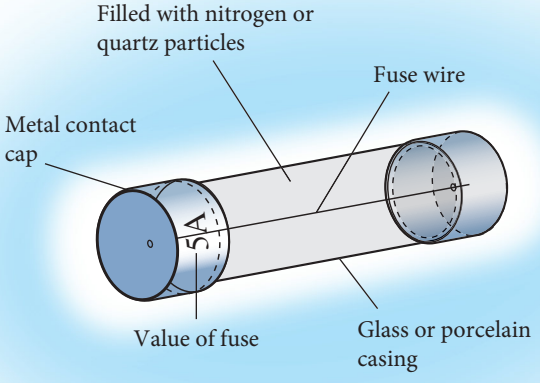
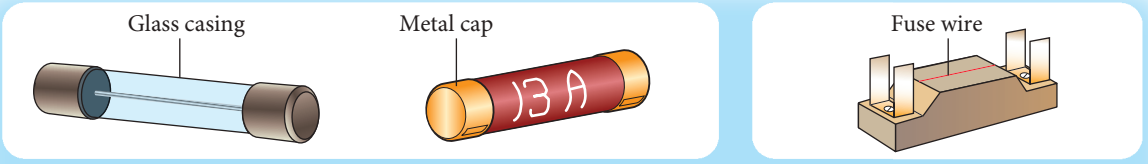


Figure 6.33 *Structure of a fuse*

6.3.2 6.3.3

Cartridge Fuse and Replaceable Wire Fuse

The two types of fuses usually used are **cartridge fuse** and **replaceable wire fuse** (fuse installed with a fuse wire) as shown in Figure 6.34.



(a) Cartridge fuse (b) Replaceable wire fuse

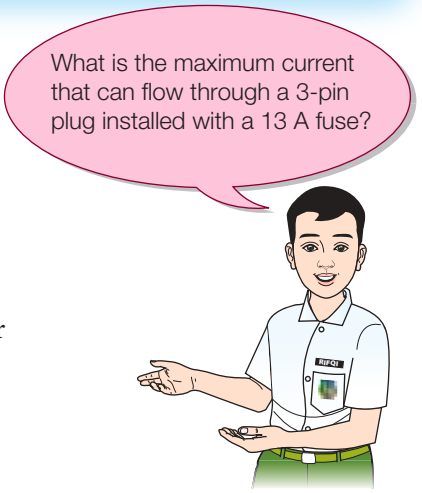
Figure 6.34 *Two types of fuses*

All fuses including cartridge fuses and replaceable wire fuses function as **electrical safety devices** in circuits or electrical appliances to protect the wires and appliances from any **excessive current** flow.

Determining the Value of a Fuse

The **value of a fuse** is the **maximum value of current** that can flow through the fuse without causing its fuse wire to **melt**. For example, a 5 A fuse wire allows a maximum current of 5 A to flow through it. Some common fuse ratings are 1 A, 2 A, 3 A, 5 A, 10 A, 13 A, 15 A and 30 A.

Choosing the value of a fuse depends on the **value of the maximum current** that flows through a circuit or electrical appliance. The fuse to be used should have a value which is slightly higher than the maximum current that flows through a circuit or electrical appliance in normal operating conditions. For example, an electric kettle that uses a maximum electric current of 11.34 A should be installed with a 13 A fuse.



BRAIN TEASER

Why is an electric kettle fixed with a 3-pin plug that has a 13 A fuse?

Activity 6.8

21st Century Skills
- ICS
- Discussion activity

To discuss the safety components in the wiring system in homes

Instructions

1. Work in groups.
2. Identify and discuss the following:
   (a) Functions, types and values of fuses
   (b) Function of an earth wire
   (c) Function of circuit breakers, namely Miniature Circuit Breaker (MCB) and Earth Leakage Circuit Breaker (ELCB)
   (d) Lightning conductor and switch
3. Use various sources to gather the required information.
4. Present the outcome of the discussion using multimedia presentation.

Safety in the Use of Electrical Appliances

When using electrical appliances, safety measures should be prioritised. This is because the ratio of deaths due to injury from electrical accidents is high compared to other categories of accidents. Failure to adhere to safety measures will result in serious accidents.

One of the safety measures in the use of electrical appliances is shown in Figure 6.35. When an individual touches the metal part that has been earthed, a large current flows to Earth through the earth wire and not through the individual. This large current also melts the fuse which then cuts off the electric circuit. Let us carry out Activity 6.9 to learn more about safety in the transmission and distribution system of electricity and the use of electrical appliances.

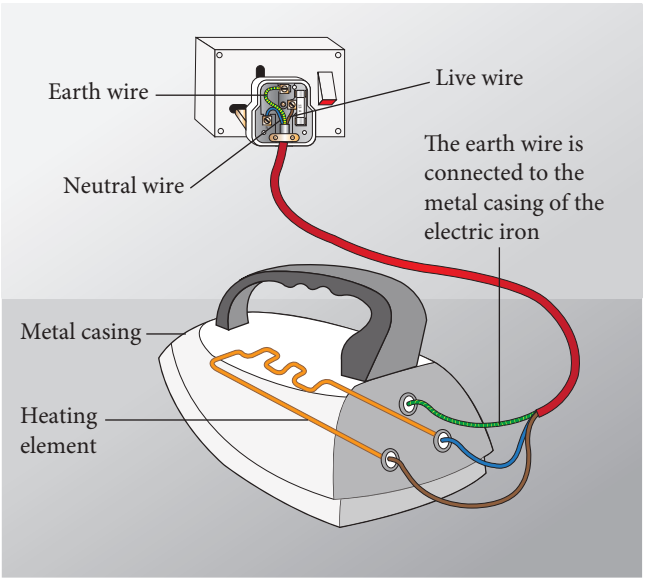


Figure 6.35 *The earth wire connects the metal casing to Earth*

Activity 6.9

21st Century Skills
- ICS
- Project-based activity

To create brochures or posters on safety and electrical accidents

Instructions

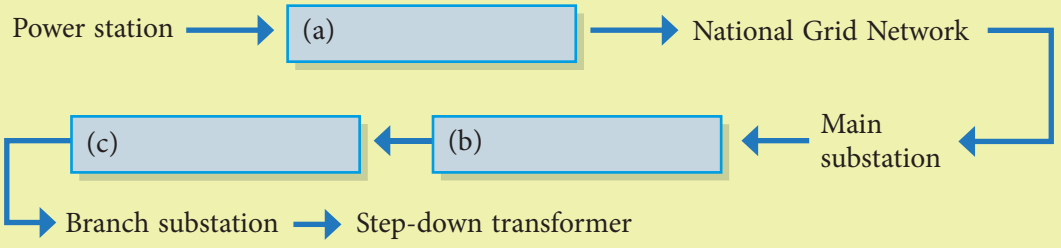
1. Work in groups.
2. Gather information from various sources regarding the following:
   (a) Causes of short circuits
   (b) Causes of electrical accidents
   (c) Safety measures when using electrical appliances
   (d) Steps to be taken when an electric shock occurs
3. Discuss the information gathered.
4. Create brochures or posters on the above matters.
5. Display the brochures or posters created on the science bulletin board in your class or science laboratory.

Formative Practice 6.3

1. In a science class, Wazir learnt about the components in an electricity transmission and distribution system.

Step-up transformer station	Step-down transformer station	Switch zone

Using the words given above, complete the following flowchart. This flowchart shows the sequence of the components in the electricity transmission and distribution system.



2. Underline the correct answers.

(a) The voltage of the alternating current is (increased/decreased) before it is transmitted through the National Grid Network.

(b) The voltage of the alternating current is highest at the (power station/National Grid Network/branch substation).

(c) The (Switch zone/National Grid Network) enables electricity to be transmitted to the branch substation when needed.

3. (a) State **three** safety components in the wiring system in homes.

(b) What is the function of a fuse?

4. (a) State **one** example of the cause of a short circuit. Explain your answer.

(b) Figure 1 shows several electrical appliances with their respective 2-pin plugs connected to a socket.

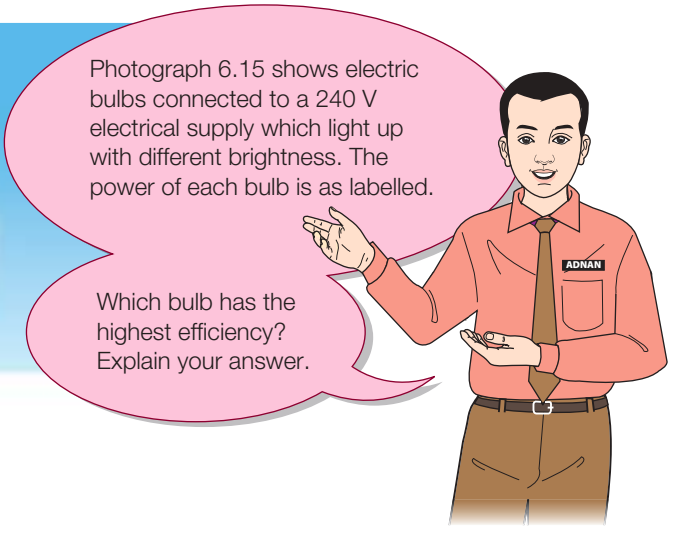
(i) State the electrical condition as shown in Figure 1.

(ii) Give **one** example of an electrical accident that might occur. Explain your answer.

Figure 1

6.4 Calculate the Cost of Electricity Consumption

Photograph 6.15 *Electric bulbs that light up with different brightness*



Energy Efficiency

Energy efficiency is the percentage of energy input converted to useful form of energy output. Energy efficiency can be defined as follows:

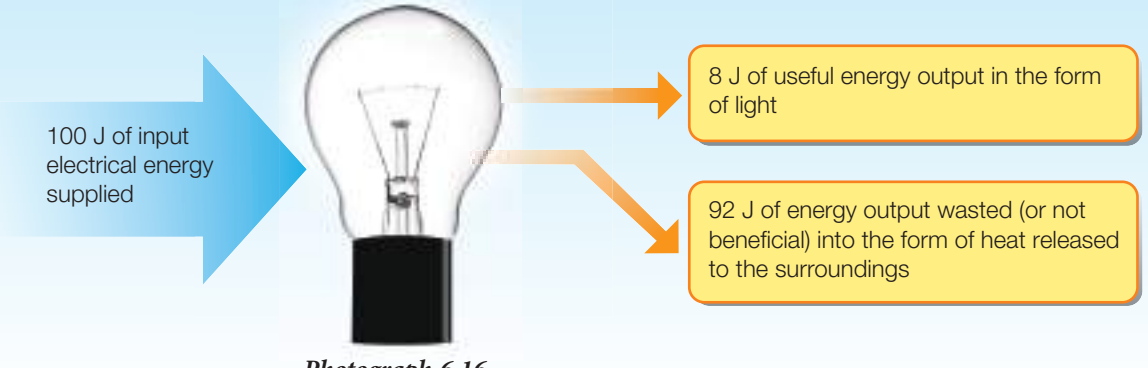
$$\text{Energy efficiency} = \frac{\text{Useful energy output}}{\text{Energy input supplied}} \times 100\%$$

BRAIN TEASER

Do you agree that the use of filament bulbs should be banned in Malaysia? Explain your reasons.

Example

Photograph 6.16 shows a lighted filament bulb. What is the energy efficiency of the bulb?



Photograph 6.16

Solution

$$\text{Energy efficiency of filament bulb} = \frac{\text{Useful energy output}}{\text{Energy input supplied}} \times 100\%$$

$$= \frac{8\ \text{J}}{100\ \text{J}} \times 100\%$$

$$= 8\%$$

Technology which Applies the Concept of Energy Efficiency

The technology of electrical lighting devices which applies the concept of energy efficiency is shown in Table 6.3.

Table 6.3 *Technology of electrical lighting devices which applies the concept of energy efficiency*

Lighting device	Filament lamp	Energy saving lamp (compact fluorescent lamp, CFL)	LED lamp
Structure			
Energy efficiency	Maximum electrical energy converted to light energy ≈ 10%	Maximum electrical energy converted to light energy ≈ 50%	Maximum electrical energy converted to light energy ≈ 90%

MARVELS OF SCIENCE

The filament bulb lasts approximately 1 000 hours, CFL lasts 8 000 hours and LED lasts between 20 000 to 50 000 hours!

Case Study

Gather information on technology applying the concept of energy efficiency from various sources including the following website:
http://links.and117.com/BT_Science_196

Discuss the information gathered. List examples of technology that apply the concept of energy efficiency in order of their importance in daily life.

Do you know how we can identify an energy efficient electrical appliance? Have you ever seen the energy efficient label introduced by the Energy Commission (EC) shown in Figure 6.36?

My Malaysia

The Energy Commission (EC) has launched an energy efficiency labelling program for various types of electrical appliances for public interest.

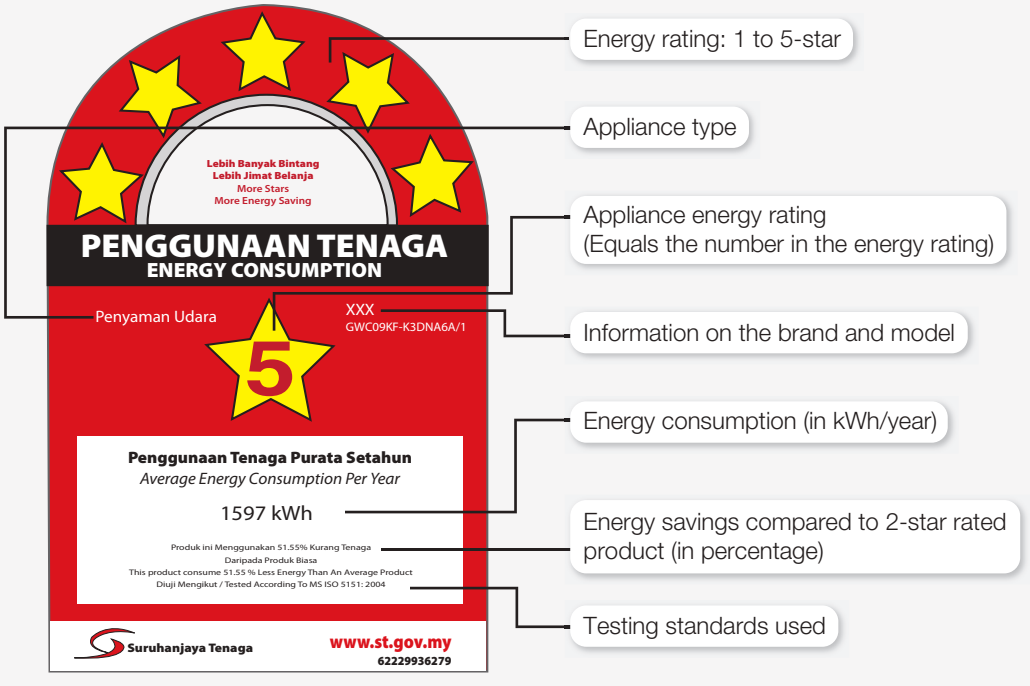
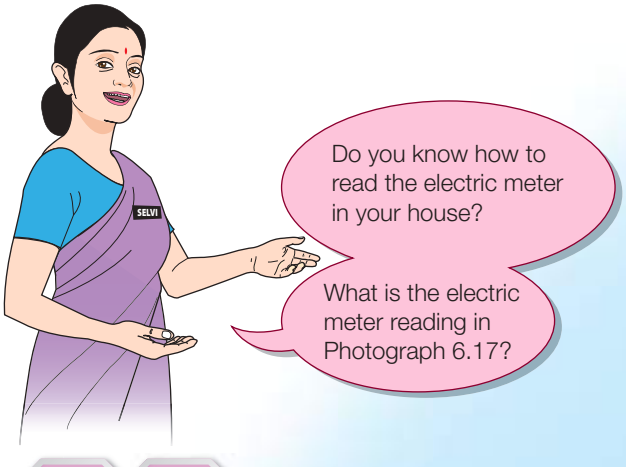


Figure 6.36 *Energy efficiency label introduced by the Energy Commission (EC)*

Use of Electricity in Electrical Appliances

Photograph 6.17 shows an electric meter for a three-phase wiring system. The function of an electric meter is to measure the **quantity of electricity** used. The reading on the electric meter is taken at the end of every month for the purpose of determining the **cost of electricity consumed**.



Photograph 6.17 *Electric meter*

6.4.2 6.4.3

Electric Power, *P*

Electric power, *P*, is the rate of **electrical energy, *E***, used by an electrical device. The S.I. unit for power is **watt (W)**. The power of 1 **watt (W)** means 1 **joule (J)** of electrical energy used in 1 **second (s)**. Electric power can be defined as follows:

$$\text{Electric power, } P \text{ (W)} = \frac{\text{Electrical energy used, } E \text{ (J)}}{\text{Time taken, } t \text{ (s)}}$$

Electric Current, *I*

Electric current, *I*, is defined as the rate of flow of **electric charge, *Q***, through a conductor. The S.I. unit for electric current is **ampere (A)** and electric charge is **coulomb (C)**. Electric current is defined as follows:

$$\text{Electric current, } I \text{ (A)} = \frac{\text{Electric charge, } Q \text{ (C)}}{\text{Time taken, } t \text{ (s)}}$$

Voltage, *V*

Voltage, *V*, is defined as the **electrical energy, *E*,** used to move a unit of **electric charge, *Q*,** through a conductor. The S.I. unit for voltage is **volt (V)**. Voltage can be defined as follows:

$$\text{Voltage, } V \text{ (V)} = \frac{\text{Electrical energy used, } E \text{ (J)}}{\text{Electric charge, } Q \text{ (C)}}$$

SCIENCE INFO

Photograph 6.18 *Two light bulbs with different electrical power*

Photograph 6.18 shows two light bulbs which are used in homes. The 40 W light bulb uses electrical energy at the rate of 40 J s^{-1} while the 60 W light bulb uses electrical energy at the rate of 60 J s^{-1}. Therefore, the 40 W light bulb with a lower watt rating uses less energy.

Calculating Flow of Current through Electrical Appliances

By relating power, voltage and electric current, the total electric current that flows through an electrical appliance can be determined. Observe the following example. Then, carry out Activity 6.10 to learn more about power, voltage and current that flows through electrical home appliance.

Example

Electric jug with
Power rating = 2 200 W
Voltage rating = 240 V

Photograph 6.19

The electric jug shown in Photograph 6.19 is rated 2.2 kW, 240 V. Calculate the current that flows through it.

Solution

Using the equation $P = VI$

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

$$= \frac{2.2\ \text{kW}}{240\ \text{V}}$$

$$= \frac{2\ 200\ \text{W}}{240\ \text{V}}$$

$$= 9.17\ \text{A}$$

BRAIN TEASER

Can the electric jug manufactured in Malaysia shown in Photograph 6.19 be used in Thailand?

In Thailand, the voltage for alternating current supplied to homes is 120 V. What will happen if the electric jug is used in Thailand?

Activity 6.10

21st Century Skills
- ICS
- Inquiry-based activity

To study the power, voltage and current flowing through electrical home appliances

Instructions

1. Work individually.
2. List examples of electrical appliances in your home. Gather information on the power and voltage of these electrical appliances.
3. Calculate the total current that flows through these electrical appliances using the following equation:

   Power (W) = Voltage (V) × Electric current (A)

4. Present the information you have gathered.

Calculating the Cost of Electrical Energy Used

The common unit used for electrical energy is **kilowatt-hour (kWh)** as shown on the electric meter in Photograph 6.17. 1 kilowatt-hour is the amount of electrical energy used at the rate of 1 kilowatt or 1 000 watts in 1 hour. 1 kWh is usually referred to as **1 unit**. Electrical energy can be calculated using the following equation:

$$\text{Electrical energy used (kWh)} = \text{Power (kW)} \times \text{Time (h)}$$

Example

A 2 kW electric kettle takes 10 minutes to boil water. Calculate the cost of electrical energy used to boil the water if the rate per unit is 21 sen.

Solution

$$\begin{aligned}\text{Electrical energy used (kWh)} &= \text{Power (kW)} \times \text{Time (h)} \\ &= 2 \text{ kW} \times \frac{10}{60} \text{ h} \\ &= \frac{1}{3} \text{ kWh} \\ &= \frac{1}{3} \text{ unit}\end{aligned}$$

$$\begin{aligned}\text{Cost of electrical energy used for the electric kettle} &= \frac{1}{3} \text{ unit} \times 21 \text{ sen/unit} \\ &= 7 \text{ sen}\end{aligned}$$

Let us carry out Activity 6.11 to audit the cost of electrical energy used at home as a way of saving electrical energy.

Activity 6.11

21st Century Skills
- CPS
- Project-based activity

To audit the cost of electrical energy used at home as a way of saving electrical energy

Instructions

1. Work individually.
2. Gather your home electricity bills for the past three months.
3. Study and draw a conclusion on the pattern of the cost of electrical energy used in your home which is observed based on the records of the electricity bills.
4. Download the PDF page from the URL on the right.
5. Suggest other practices that save electrical energy besides those listed in the electrical energy saving guide.
6. Take measures to save electrical energy for a period of three months. Compare and contrast the pattern of the cost of electrical energy used in your home before and after the measures are taken.
7. Share your findings in class.

http://links.and117.com/BT_Science_200

6.4.4 6.4.5

Ways to Save Electrical Energy Consumption

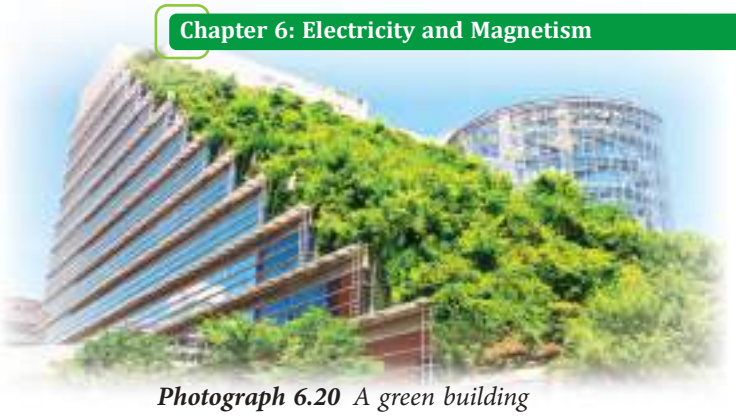
Other than encouraging the saving of electrical energy consumption in homes, the Energy Commission also provides services such as ECOS for the use of industries and businesses that apply the concept of energy conservation.

The **green building** shown in Photograph 6.20 which applies the concept of energy conservation has succeeded in reducing the cost of electrical energy consumption.

The construction of green buildings is gradually expanding in Malaysia. Among the features of a green building are as follows:

- Efficient ventilation system to reduce the use of air conditioning and fans
- Maximising the use of natural lighting to reduce the cost of electrical energy consumption
- Installation of solar panels as a renewable energy source to replace conventional energy sources

Let us carry out Activity 6.12 to further understand the green building concept in local and global contexts.



Photograph 6.20 *A green building*

My Malaysia

ECOS – Online system provided by Energy Commission related to energy efficiency.
http://links.and117.com/BT_Science_202_2

BRAIN TEASER

Does a green building mean a building that only has green plants?

Activity 6.12

21st Century Skills
- ICS, ISS
- Technology based activity

To understand the green building concept in the local and global contexts

Instructions

1. Work in groups.
2. Gather and share information on the following:
   (a) Green building concept in the local context
   (b) Green building concept in the global context

Latest information on greenhouse and reducing the release of carbon dioxide.
http://links.and117.com/BT_Science_201

CAUTION!
1. Obey the ethics of social media use.
2. Respect intellectual property rights.

3. Discuss the information shared.
4. Present the findings of your group discussion using multimedia presentation such as MS PowerPoint or social media.

Designing a Model of a Green Building

Did you build a model of a greenhouse when you were in Form 2? Let us carry out Activity 6.13 to innovate or invent another model of a greenhouse which uses the concept of energy savings.

Activity 6.13

21st Century Skills
- ICS, ISS, CPS
- Project-based

Innovate or design a model of a green building using the concept of energy savings

Instructions

1. Work in groups.
2. Innovate or create a green building model using the concept of energy conservation in a local or global context. Among the points to be emphasized are:
   (a) energy efficiency
   (b) power sales
   (c) appliances with Energy Efficiency Rating and Labelling
3. You can refer to the following websites:

TNB – Energy efficiency, power sales, appliances with Energy Efficiency Rating and Labelling *http://links.and117.com_BT_Science_202_1*

ECOS – Energy Commission (EC) services related to energy efficiency *http://links.and117.com/BT_Science_202_2*

4. Present your group's innovation or creation of the green building model in class.

Formative Practice 6.4

1. Give the definition of energy efficiency.

2. The electrical energy used by an air conditioner for 2 minutes is 180 kJ. Calculate the power of this air conditioner in the following units:
(a) W (b) kW

3. A microwave oven rated 1.2 kW, 240 V is connected to a 240 V electricity supply. Calculate the current that flows through the oven.

4. An electric rice cooker rated 800 W, 230 V is switched on for 30 minutes.
(a) How much electrical energy is used by the rice cooker?
(b) Calculate the cost of energy that is used by the rice cooker if the cost per kWh is 30 sen.

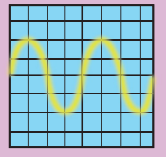
5. (a) What is the importance of star rating labelling of an electrical appliance?
(b) How many stars in the star rating label of an electrical appliance should be used? Explain your answer.

Summary

Electricity and magnetism

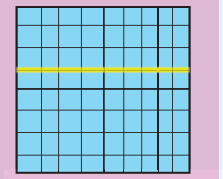
is applied in

- **Generation of electricity**
  - *from*
    - Renewable energy sources
      - *such as*
      - Hydro, wave, solar, tidal, wind, biomass, geothermal energies
    - Non-renewable energy sources
      - *such as*
      - Nuclear energy, coal, natural gas, petroleum
  - *producing*
  - Induced current
  - *when*
  - magnetic field lines are cut by coil of wire
- **Electricity generator**
  - *produces*
  - Alternating current
  - With variable voltage

    C.R.O. screen
  - With a.c. voltage
  - *increased by* / *decreased by*
  - Step-up transformer / Step-down transformer
  - According to the formula:

    $$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$
- **Solar cells and dry cells**
  - *produce*
  - Direct current
  - With fixed voltage

    C.R.O. screen
  - With fixed d.c. voltage
- **Transmission and distribution system**
  - *made up of*
  - Power station, step-up transformer station, National Grid Network, step-down transformer station, main substation, switch zone, branch substation
  - *with*
  - One-phase and three-phase wiring systems
  - *and*
  - Safety components
- **Electric efficiency**
  - *depends on*
  - Power, voltage, current, energy consumption, cost of energy consumption
  - *and*
  - Method of saving electrical energy used

Self-reflection

After studying this chapter, you are able to:

6.1 Generation of Electricity

- ☐ Describe energy sources in terms of renewable energy and non-renewable energy.
- ☐ Explain with examples the process of generating electricity from various sources of energy.
- ☐ Differentiate between direct current and alternating current.
- ☐ Solve problems related to electricity supply in life.

6.2 Transformer

- ☐ Carry out an experiment to build step-up and step-down transformer.
- ☐ Communicate transformers and the use of transformers in electrical home appliances.
- ☐ Solve numerical problems using formula involving transformers.

6.3 Transmission and Distribution of Electricity

- ☐ Explain the functions of the components in the transmission and distribution of electricity by drawing.
- ☐ Explain with examples electricity supply and wiring systems in homes.
- ☐ Distinguish between safety components in a home electrical wiring system.
- ☐ Communicate safety in transmission and distribution of electricity and the use of electrical appliances.

6.4 Calculate the Cost of Electricity Consumption

- ☐ Define energy efficiency.
- ☐ List examples of technology that applies the concept of energy efficiency.
- ☐ Determine the amount of electricity used in electrical appliances.
- ☐ Relate electrical energy consumption, power and time by calculating the cost of electrical energy used by electrical appliances.
- ☐ Conduct a home energy audit of electrical appliances used as a measure of saving electricity use at home.
- ☐ Communicate ways of saving electrical energy use at home.

Summative Practice 6

Answer the following questions:

1. Determine whether the given statements about electricity or magnetism are **True** or **False**. Write your answer in the space provided.

(a) Power stations that use wind energy do not contaminate the air.	
(b) Solar cells can produce alternating current.	
(c) 2-pin plugs are not connected to the earth wire.	

2. Match each of the following energy sources with the correct type of energy.

Energy source	Type of energy source
(a) Coal	
(b) Biomass	Renewable energy source
(c) Geothermal	Non-renewable energy source
(d) Wave	

3. A coil of wire is moved in the direction of the arrow through the space between two magnets as shown in Figure 1.

(a) What is the effect on the magnetic field when the coil is moved?

(b) What is produced in the coil of wire?

(c) What happens to the LED? Explain your answer.

(d) Name a device in power stations that applies a similar concept.

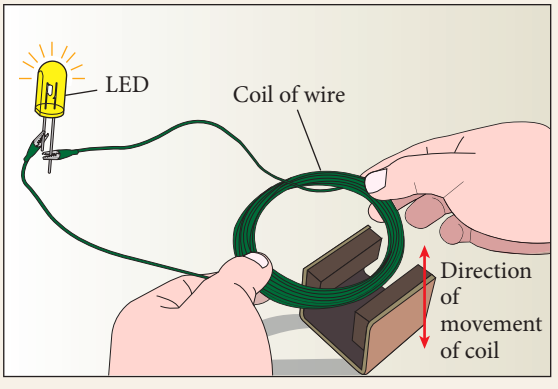


Figure 1

4. Figure 2(a) shows a device used to investigate electric current.

Figure 2(a)

(a) Name the device shown in Figure 2(a).
(b) What are the properties of electric current studied using this device?
(c) Figures 2(b) and 2(c) show two traces displayed on the screen of this device.

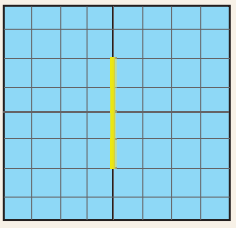


Figure 2(b)

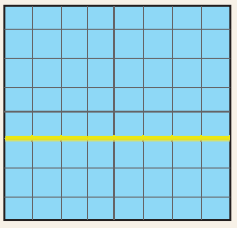


Figure 2(c)

Name the type of electric current represented by the trace on the screen in the following figures:
(i) Figure 2(b) (ii) Figure 2(c)

5. Figure 3 shows a type of transformer.
(a) Name the type of transformer.
(b) Explain your answer in question **5**(a).
(c) Why is a laminated iron core used in a transformer?
(d) If the number of turns in the primary coil is 100 and the number of turns in the secondary coil is 20, calculate the secondary voltage if the primary voltage is 10 V.

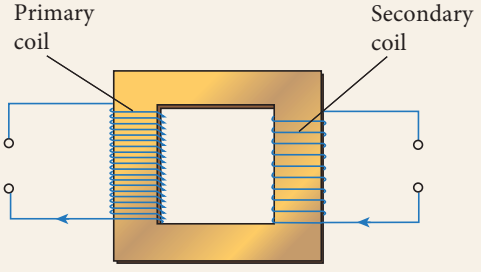


Figure 3

6. (a) Name the safety component in the electrical wiring system in homes supplied by TNB, SEB or SESB.
(b) State **one** similarity and **one** difference between a fuse and Miniature Circuit Breaker (MCB).
(c) What is the suitable fuse rating of a hair dryer rated 700 W, 240 V? Explain your answer.

Focus on HOTS

7. An electric heater is rated 230 V, 10 A.
(a) Calculate the power of the electric heater in kW.
(b) Which fuse is most suitable for the electric heater? Explain your answer.
(c) Explain why other fuses are not suitable to be used based on the answer for question 7(b).

8. Figure 4 shows a model of Miniature Circuit Breaker (MCB).

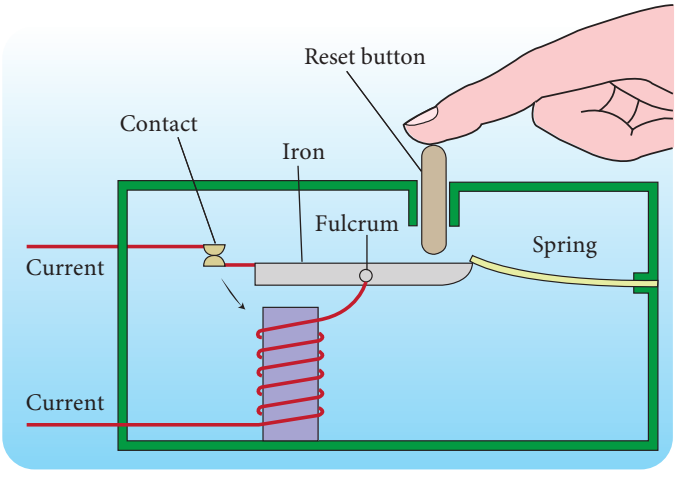
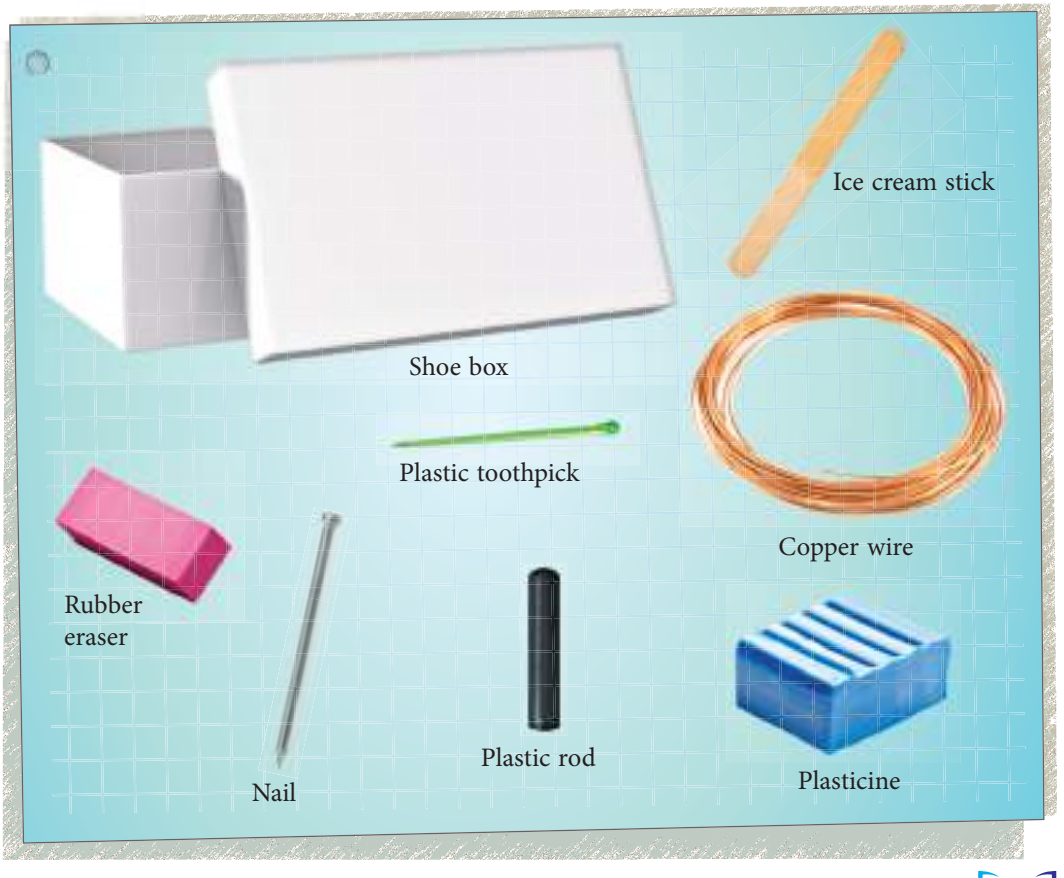


Figure 4

(a) What is an MCB?
(b) State the function of an MCB and the way it works.
(c) You are required to build an MCB model using the materials provided below. Explain the function of each part.



Chapter 7

Energy and Power

What is the definition of work, energy and power?

What is meant by gravitational potential energy, elastic potential energy and kinetic energy?

What is the Principle of Conservation of Energy?

Let's study

- Work, energy and power
- Potential energy and kinetic energy
- Principle of Conservation of Energy

Science Gallery

Activities such as climbing stairs can:

- maintain the health of body organs such as the heart and lungs
- ensure a more efficient blood circulation process in the body
- reduce the risk of heart attack, diabetes, high blood pressure and colon cancer
- increase the body's immunity
- produce healthy bones and reduce the risk of osteoporosis
- strengthen muscles
- facilitate the burning of body fat and thus maintain body weight

Hospital staff and visitors of Shah Alam Hospital, Selangor, are encouraged to use the stairs. Would you climb the stairs or use the lift? Why?

Other than the number of steps, state another factor that determines the total amount of work done in climbing the stairs. What is the effect of climbing stairs within a short time on our health?

Keywords

- Work
- Energy
- Power
- Gravitational potential energy
- Elastic potential energy
- Kinetic energy
- Displacement
- Average force
- Principle of Conservation of Energy
- Oscillation of a simple pendulum
- Oscillation of a loaded spring
- Closed system

7.1 Work, Energy and Power

Work

What is the meaning of work? Compare and contrast your meaning of work with the definition of work in science as follows:

Work, ***W***, is defined as the product of **force**, ***F***, and **displacement**, ***s***, in the direction of the force, that is $W = Fs$.

SCIENCE INFO

Displacement is the distance travelled in a specified direction.

The S.I. unit for work is **joule (J)**.

1 joule (J) of work is done when a **force of 1 newton (N)** is used to move an object over a distance of **1 metre (m)** in the **direction of the force**, that is **1 J = 1 Nm**.

Moment of force and **energy** are two physical quantities other than work which are measured in units of newton metre (Nm). Larger units such as kilojoule (kJ) and megajoule (MJ) are also used in the measurement of work.

BRAIN TEASER

Complete the following:
(a) 1 kJ = _____ J
(b) 1 MJ = _____ J

Examples of Calculation of Work in Daily Activities

Study Figure 7.1 and Photograph 7.1. The figure and photograph show several activities in daily life.

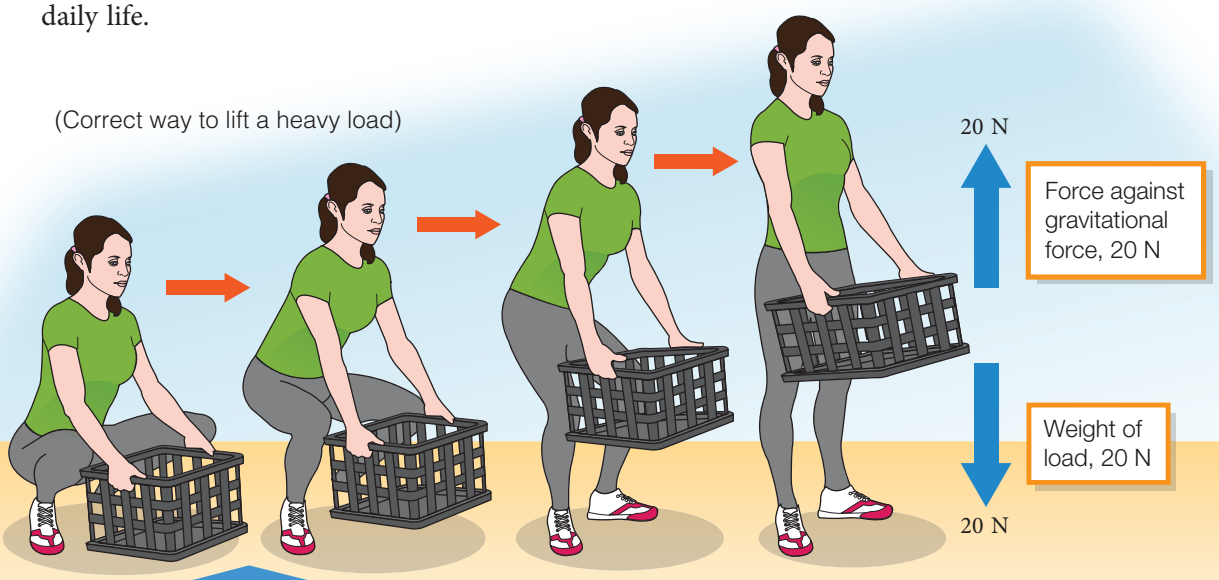


Figure 7.1 *Daily activity related to work*

Photograph 7.1 *Daily activities related to work*

The work done in Activities A, B and C are shown in Table 7.1.

Table 7.1 *Work done in Activities A, B and C*

Daily activity	Force (N)	Direction of force	Displacement in the direction of the force (m)	Work done
A	20	Vertical	1	$W = Fs$ $= 20\ \text{N} \times 1\ \text{m}$ $= 20\ \text{J}$
B	10	Horizontal	5	$W = Fs$ $= 10\ \text{N} \times 5\ \text{m}$ $= 50\ \text{J}$
C	2	Horizontal	0.3	$W = Fs$ $= 2\ \text{N} \times 0.3\ \text{m}$ $= 0.6\ \text{J}$

Calculating Work Done

Example 1

Figure 7.2 shows a student weighing 400 N carrying a load of 100 N while climbing a flight of stairs of a vertical height of 3 m. Calculate the work done.

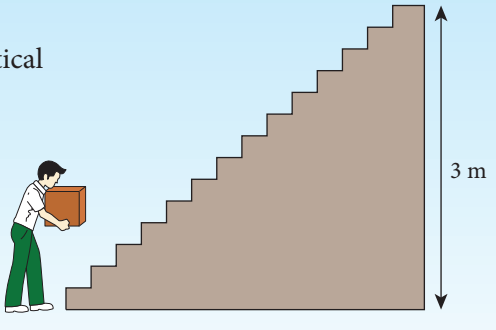


Figure 7.2

Solution

$W = Fs$
$= (400 + 100)\ \text{N} \times 3\ \text{m}$
$= 500\ \text{N} \times 3\ \text{m}$
$= 1\ 500\ \text{J}$

7.1.1

Example 2

Figure 7.3 shows Ali lifting a box of mass 10 kg from the floor to the top of a cupboard. How much work is done by Ali?
(Assume gravitational force acting on an object of mass 1 kg = 10 N)

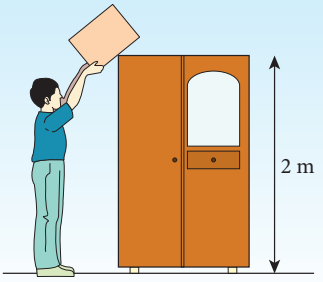


Figure 7.3

Solution

Weight of box = 10 × 10 N
= 100 N
$W = Fs$
= 100 N × 2 m
= 200 J

Example 3

A labourer pulled a bucket of cement weighing 300 N from the ground to the first floor of a building using a pulley system. The first floor is 10 m from the ground. What is the work done by the labourer?

Solution

$W = Fs$
= 300 N × 10 m
= 3 000 J

BRAIN TEASER

Is work done in the situation shown in the photograph?

Energy and Power

Energy is defined as the ability to do work. The S.I. unit for energy is **joule (J)**. When a force of 1 N is used to move an object over a distance of 1 m in the direction of the force, 1 J of energy is used.

Study Figure 7.4. If Kamal and Ah Kit climbed the steps starting from the ground floor simultaneously, who has a higher power? Why?

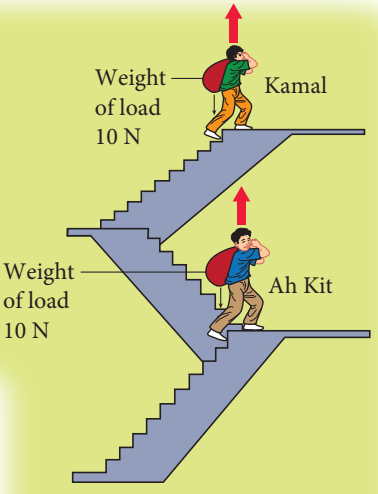


Figure 7.4

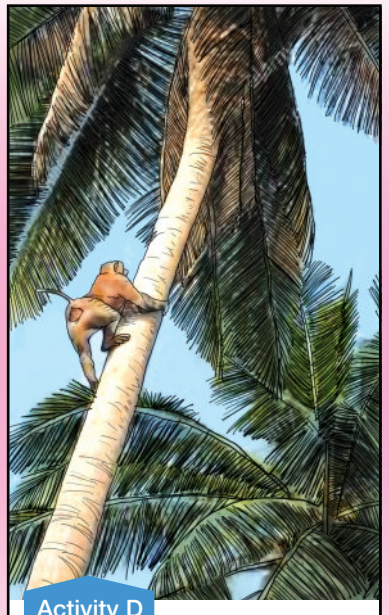
Power, ***P***, is defined as the rate of doing work, *W*, that is:

$$\textbf{Power, } P = \frac{\text{Work done, } W}{\text{Time taken, } t}$$

The S.I. unit for power is **watt (W)**. When **1 joule (J)** of work is done in **1 second (s)**, power of **1 watt (W)** is used, that is **1 W = 1 J s^{-1}**.

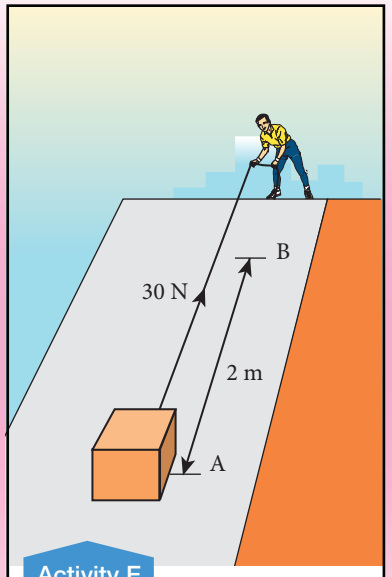
Examples of Calculation of Power in Daily Activities

Figure 7.5 shows several activities in daily life.



Activity D

A monkey weighing 50 N climbed a height of 3 m up a tree in 20 s.



Activity E

Aizul pulled a box up a smooth ramp from A to B with a force of 30 N over a distance of 2 m (in the direction of the force) in 5 s.

Activity F

A 150 N weight is lifted to a height of 1 m in 0.5 s.

Figure 7.5 *Daily activities related to power*

Work done and power needed in activities D, E and F are shown in Table 7.2.

Table 7.2 *Work done and power needed in Activities D, E and F*

Daily activity	D	E	F
Force (N)	50	30	150
Displacement in the direction of force (m)	3	2	1
Work done	$W = Fs$ $= 50\ \text{N} \times 3\ \text{m}$ $= 150\ \text{J}$	$W = Fs$ $= 30\ \text{N} \times 2\ \text{m}$ $= 60\ \text{J}$	$W = Fs$ $= 150\ \text{N} \times 1\ \text{m}$ $= 150\ \text{J}$
Time taken (s)	20	5	0.5
Power needed	$P = \frac{W}{t}$ $= \frac{150\ \text{J}}{20\ \text{s}}$ $= 7.5\ \text{W}$	$P = \frac{W}{t}$ $= \frac{60\ \text{J}}{5\ \text{s}}$ $= 12\ \text{W}$	$P = \frac{W}{t}$ $= \frac{150\ \text{J}}{0.5\ \text{s}}$ $= 300\ \text{W}$

Activity 7.1

Inquiry-based activity

Aim: To calculate work and power needed

Materials
100 g weight, thread and wooden block

Apparatus
Spring balance, metre rule and stopwatch

Instructions

1. Set up the apparatus as shown in Figure 7.6.

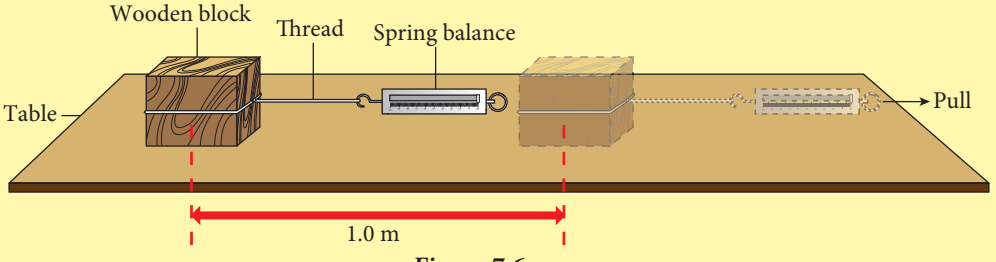


Figure 7.6

2. Pull the spring balance until the wooden block starts to move and record the force shown on the spring balance.
3. Pull the wooden block over a distance of 1.0 m with the force as shown in Figure 7.6. Ask your friend to measure the time taken to move the wooden block by using a stopwatch.
4. Record the time taken. Calculate and record the work done and power needed in a table.
5. Set up the apparatus as shown in Figure 7.7.
6. Lift the 100 g weight to a vertical height of 0.5 m from the floor by using the spring balance.
7. Record the force shown on the spring balance.
8. Ask your friend to measure the time taken to move the weight by using the stopwatch.
9. Record the time taken. Calculate and record the work done and power needed in a table.

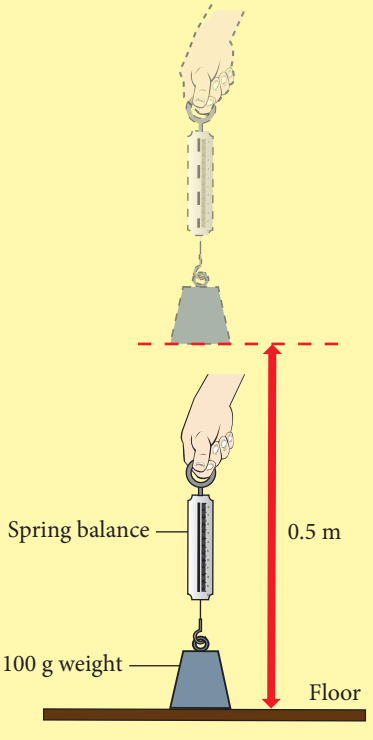


Figure 7.7

7.1.1 7.1.2

Activity	Force (N)	Distance (m)	Work (J)	Time (s)	Power (W)
Pulling a wooden block over a distance of 1.0 m horizontally					
Lifting a 100 g weight to a height of 0.5 m vertically					

Questions

1. State the type of force to overcome when:
   (a) pulling a wooden block on the surface of the table
   (b) lifting a 100 g weight vertically from the floor
2. Which activity involves more work?
3. State **three** factors that affect power.
4. Which activity is carried out with higher power?
5. (a) Give **one** example of an activity or object in daily life that involves high power.
   (b) Give **one** example of an activity or object in daily life that involves low power.

Today in history

A unit usually used for power in the olden days is horsepower (hp).

Formative Practice 7.1

1. (a) State the definition of work.
(b) What is the S.I. unit for work?

2. What is the meaning of energy?

3. (a) State the definition of power.
(b) What is the S.I. unit for power?

4. Figure 1 shows an electromagnetic crane lifting a load weighing 2 500 N to a height of 4 m.
(a) Calculate the work done.
(b) How much energy is used by the crane to lift the load?
(c) If the time taken by the crane to lift the load is 1.2 minutes, calculate the power of the crane.

Figure 1

7.1.1 7.1.2

7.2 Potential Energy and Kinetic Energy

Gravitational Potential Energy

In a piledriver shown in Photograph 7.2, a hammer is pulled upwards and then released to fall and hit a pile. The force produced by the hammer in a vertical direction drives the pile into the ground.

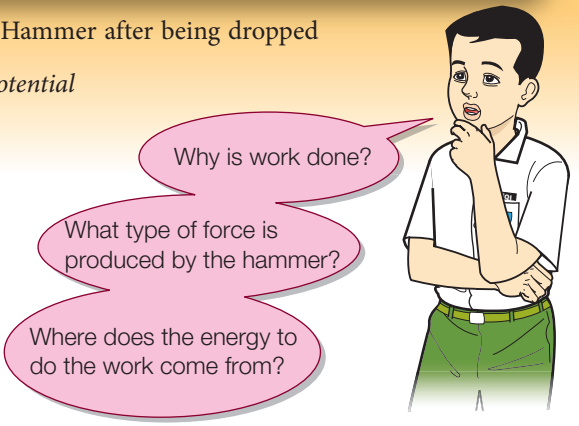
VIDEO

Watch this video to see piling operations

SCAN PAGE

(a) Hammer before being dropped (b) Hammer after being dropped

Photograph 7.2 *Gravitational potential energy is used in a piledriver*



A hammer lifted to a height, h from the Earth's surface possesses gravitational potential energy. **Gravitational potential energy** is the work done to lift an object to a height, h, from the Earth's surface.

Gravitational potential energy = *mgh*

- ***m*** is the object mass in kg
- ***g*** is the gravitational acceleration in m s^{-2}
- ***h*** is the height in m

SCIENCE INFO

Weight = mass, m × gravitational acceleration, g where g is estimated at 10 m s^{-2} (or 10 N kg^{-1})

7.2.1

Relationship between Work and Gravitational Potential Energy

Figure 7.8 shows an object of mass, m, being lifted vertically to a height, h, from Earth's surface.

Work done = Force × displacement in direction of force
= Weight × height lifted
= $(m \times g) \times h$
= mgh

Since there is no other form of energy produced, all work done on the object will be converted to gravitational potential energy.

Gravitational potential energy = work done
= mgh

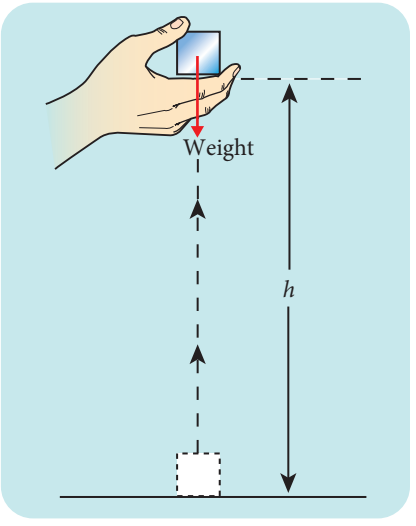


Figure 7.8

Example of numerical problem

Photograph 7.3 shows a lift at KLCC mall. The lift can carry a load of mass 1 500 kg to a height of 30 m.

(a) How much work is done by this lift?
(b) What is the gravitational potential energy of this lift at a height of 30 m?
(c) What is the relationship between work done by the lift and gravitational potential energy of the lift?
(d) What is the power of the lift in kW if the time taken to lift a load of mass 1 500 kg to a height of 30 m is 0.5 minutes?

Solution

(a) $W = Fs$
$= mgh$
$= 1\ 500\ \text{kg} \times 10\ \text{m s}^{-2} \times 30\ \text{m}$
$= 450\ 000\ \text{J}$

(b) Gravitational potential energy = mgh
$= 1\ 500\ \text{kg} \times 10\ \text{m s}^{-2} \times 30\ \text{m}$
$= 450\ 000\ \text{J}$

(c) Work done by the lift = Gravitational potential energy of the lift

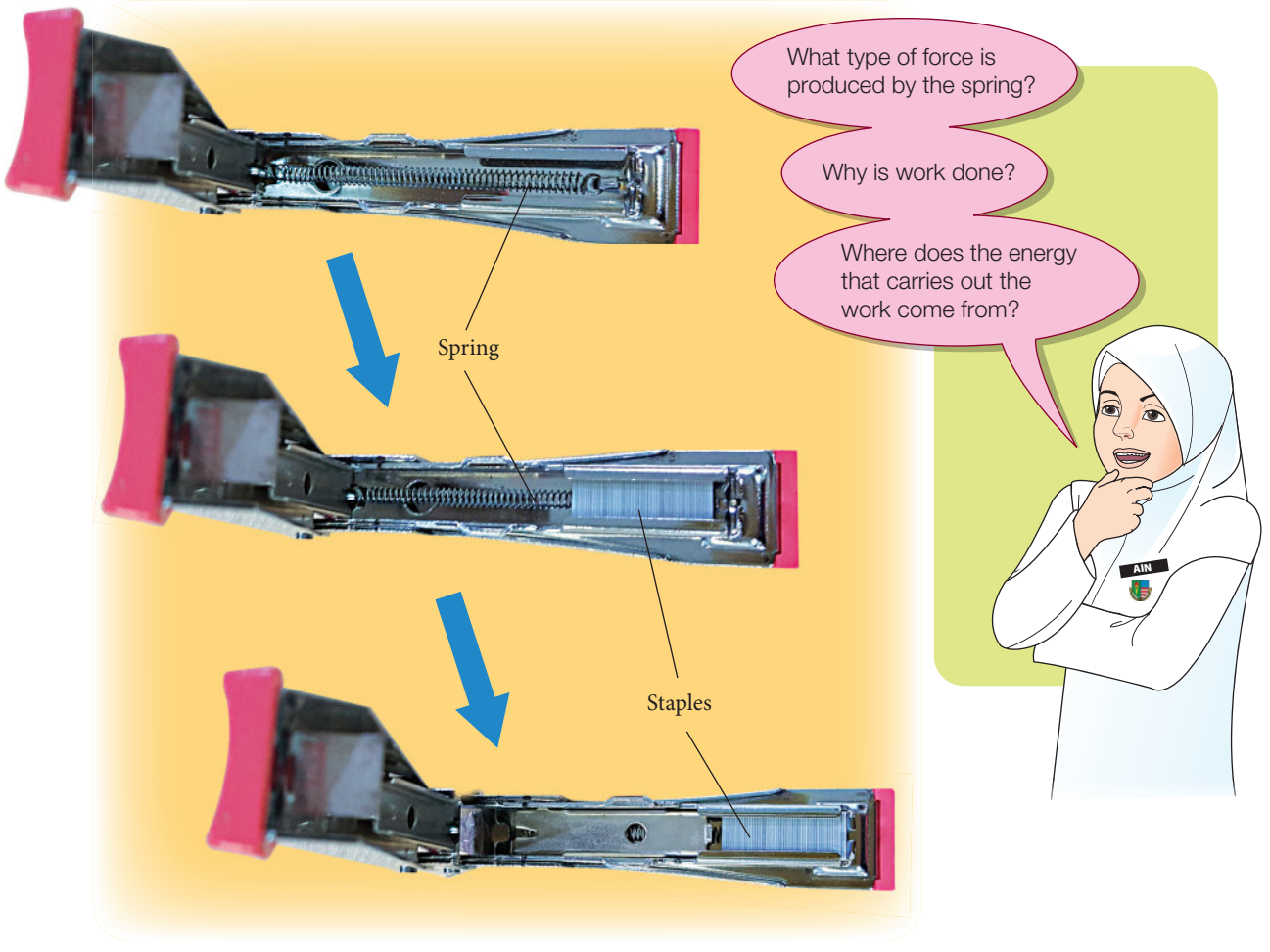
(d) Power, $P = \frac{W}{t}$
$= \frac{450\ 000\ \text{J}}{0.5\ \text{minutes}}$
$= \frac{450\ 000\ \text{J}}{30\ \text{s}}$
$= 15\ 000\ \text{W}$
$= 15\ \text{kW}$

Additional Examples
http://links.andl17.com/BT_Science_217_2

Photograph 7.3

Elastic Potential Energy

Photograph 7.4 shows the steps to refill a stapler with staples. There is a spring that is stretched and then released. The force produced by the stretched spring moves the staples in the direction of the force.



Photograph 7.4 *Elastic potential energy used in a stapler*

A spring that is compressed or stretched possesses elastic potential energy. **Elastic potential energy** is the work done to compress or stretch an elastic material over a displacement of x from the position of equilibrium.

$$\textbf{Elastic potential energy} = \frac{1}{2}Fx$$

- F is the stretching or compression force in N
- x is the displacement from the equilibrium position in m

Relationship between Work and Elastic Potential Energy

Assume a spring is stretched x m with a force of F N (Figure 7.9(a)). So, the value of force acting on the spring changes from 0 N to F N as shown in the graph (Figure 7.9(b)). For situations involving springs, work done is equivalent to the area under the F-x graph.

Elastic potential energy = work done
= area under the graph
$= \frac{1}{2} Fx$

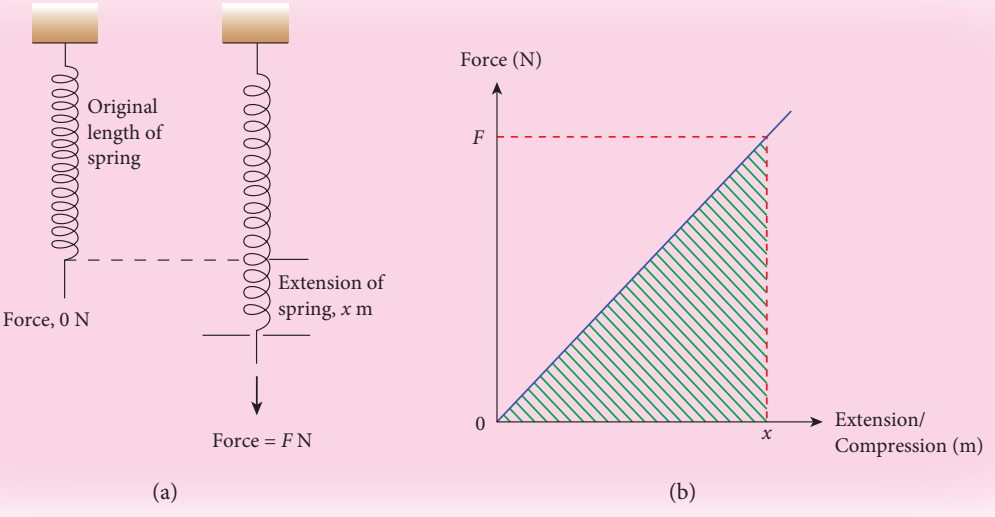


Figure 7.9 *Relationship between work and elastic potential energy*

Example of numerical problem

The original length of spring S is 20 cm. When the final force exerted on spring S is 20 N, its new length becomes 12 cm. Calculate the elastic potential energy possessed by the compressed spring S.

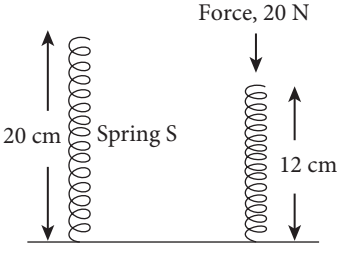


Figure 7.10

Solution

Distance of compression, x = original length – new length
= 20 cm – 12 cm
= 8 cm
= 0.08 m

Elastic potential energy $= \frac{1}{2} Fx$
$= \frac{1}{2} \times 20 \text{ N} \times 0.08 \text{ m}$
= 0.8 J

Additional Examples
http://links.andl17.com/BT_Science_219_2

Kinetic Energy

Kinetic energy is the energy possessed by a moving object.

$$\text{Kinetic energy} = \frac{1}{2}mv^2$$

- m is mass in kg
- v is velocity in m s^{-1}

Example of numerical problem

Example 1

When a train of mass 500 000 kilogram moves with a velocity of 360 km h^{-1}, how much kinetic energy is possessed by the train?

Solution

$$\text{Velocity of train} = 360 \text{ km h}^{-1} = \frac{360 \text{ km}}{1 \text{ h}} = \frac{360\,000 \text{ m}}{3\,600 \text{ s}} = 100 \text{ m s}^{-1}$$

$$\text{Kinetic energy of train} = \frac{1}{2}mv^2 = \frac{1}{2} \times 500\,000 \text{ kg} \times (100 \text{ m s}^{-1})^2 = 2\,500\,000\,000 \text{ J}$$

Example 2

A ball bearing of mass 0.2 kg possesses kinetic energy of 3.6 J. What is the velocity, v of the ball bearing?

Solution

$$\text{Kinetic energy} = \frac{1}{2}mv^2$$

$$3.6 \text{ J} = \frac{1}{2} \times 0.2 \text{ kg} \times v^2$$

$$\therefore v^2 = \frac{3.6 \text{ J}}{0.1 \text{ kg}} = 36 \text{ m}^2 \text{ s}^{-2}$$

$$v = \sqrt{36 \text{ m}^2 \text{ s}^{-2}} = 6 \text{ m s}^{-1}$$

Example 3

Calculate the kinetic energy of an electron of mass 9×10^{-31} kg and velocity 4×10^6 m s^{-1}.

Solution

$$\text{Kinetic energy of electron} = \frac{1}{2}mv^2 = \frac{1}{2} \times (9 \times 10^{-31} \text{ kg}) \times (4 \times 10^6 \text{ m s}^{-1})^2 = 7.2 \times 10^{-18} \text{ J}$$

Let us carry out Activity 7.2 to discuss the meaning and examples of gravitational potential energy, elastic potential energy and kinetic energy in daily life.

Activity 7.2

21st Century Skills
- ICS, ISS
- Discussion activity

To discuss the meaning and examples of gravitational potential energy, elastic potential energy and kinetic energy in daily life

Instructions

1. Work in groups.
2. Each group needs to search for information on the meaning and examples of gravitational potential energy, elastic potential energy and kinetic energy in daily life.
3. Present the information in a mind map.

Formative Practice 7.2

1. (a) What is the relationship between gravitational potential energy and work?
(b) What is the relationship between elastic potential energy and work?

2. Liza lifts a chair weighing 40 N to a height of 50 cm.
(a) How much work is done by Liza to lift the chair?
(b) What is the form of energy possessed by the chair?
(c) How much energy is possessed by the chair?

3. Force, *F*, is exerted on a plank to compress a spring towards the wall as shown in Figure 1. Given that the original length of the spring is 50 cm, final length is 30 cm and final force exerted on the spring is 20 N. How much elastic potential energy is possessed by the compressed spring?

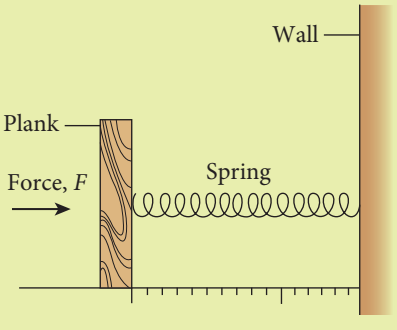


Figure 1

4. (a) Why are heavy vehicles shown in Figure 2 usually of low velocity but possess high kinetic energy?
(b) State **one** example of a daily object that possesses high kinetic energy in the following conditions:
(i) Object of small mass but high velocity
(ii) Object of large mass and high velocity

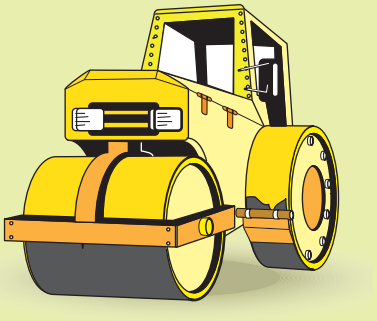


Figure 2

7.3 Principle of Conservation of Energy

Photograph 7.5 *Roller coaster*

The roller coaster shown in Photograph 7.5 involves transformation in the forms of energy. State the transformation in the forms of energy.

Principle of Conservation of Energy

The **Principle of Conservation of Energy** states that energy cannot be created or destroyed but can only be converted from one form to another.

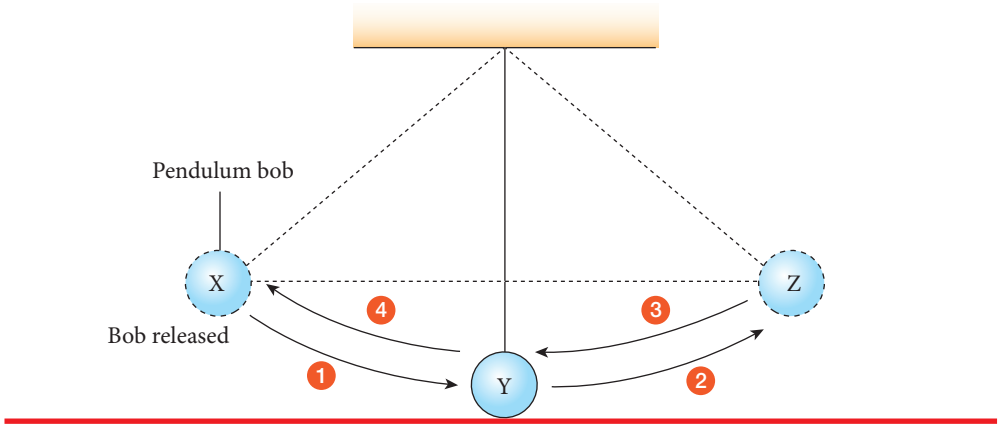
Oscillating systems such as the oscillation of a simple pendulum and the oscillation of a loaded spring always experience transformation in the forms of energy between **gravitational potential energy** or **elastic potential energy** and **kinetic energy**. Do oscillating systems obey the Principle of Conservation of Energy?

SCIENCE INFO

Useful energy is energy in a form that can be easily converted into other forms to do work. For example, chemical energy stored in fossil fuels is useful energy because the chemical energy can be easily converted to heat energy and light energy through the combustion of fossil fuels.

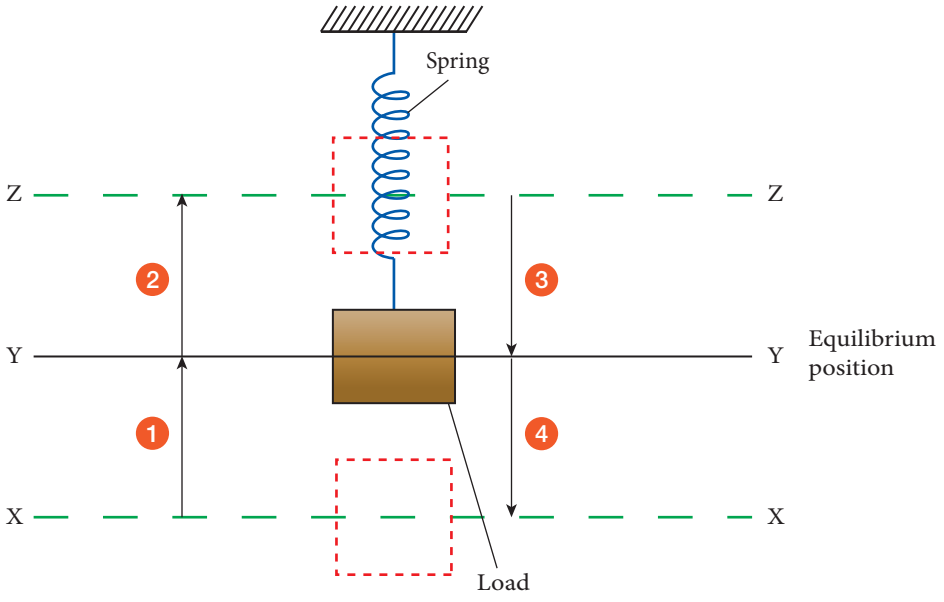
Oscillating Systems Obey the Principle of Conservation of Energy

Study Figures 7.11 and 7.12. Let us observe the transformation in the forms of energy that occurs in the oscillation of a simple pendulum and a loaded spring which are the examples of the Principle of Conservation of Energy.



Condition of pendulum bob	Transformation in the forms of energy for the bob between gravitational potential energy (gravitational P.E.) and kinetic energy (K.E.)
At position **X**	Gravitational P.E. = maximum (bob at maximum height) K.E. = zero (bob stationary, speed = zero)
1 From position **X** to **Y**	Gravitational P.E. of bob decreasing (height of bob decreasing) K.E. of bob increasing (speed of bob increasing)
At position **Y**	Gravitational P.E. = minimum (bob at minimum height) K.E. = maximum (bob at maximum speed)
2 From position **Y** to **Z**	Gravitational P.E. of bob increasing (height of bob increasing) K.E. of bob decreasing (speed of bob decreasing)
At position **Z**	Gravitational P.E. = maximum (bob at maximum height) K.E. = zero (bob stationary, speed = zero)
3 From position **Z** to **Y**	Gravitational P.E. of bob decreasing (height of bob decreasing) K.E. of bob increasing (speed of bob increasing)
At position **Y**	Gravitational P.E. = minimum (bob at minimum height) K.E. = maximum (bob at maximum speed)
4 From position **Y** to **X**	Gravitational P.E. of bob increasing (height of bob increasing) K.E. of bob decreasing (speed of bob decreasing)
At position **X**	Gravitational P.E. = maximum (bob at maximum height) K.E. = zero (bob stationary, speed = zero)

Figure 7.11 *Oscillation of a simple pendulum*



Condition of loaded spring	Transformation in the forms of energy for the load between elastic potential energy (elastic P.E.) and kinetic energy (K.E.)
At position **X**	Elastic P.E. = maximum (spring is most stretched) K.E. = zero (spring is stationary, speed = zero)
1 From position **X** to **Y**	Elastic P.E. decreasing (spring is gradually becoming less stretched) K.E. increasing (speed of spring increasing)
At position **Y**	Elastic P.E. = minimum (spring at equilibrium) K.E. = maximum (speed of spring at maximum)
2 From position **Y** to **Z**	Elastic P.E. increasing (spring is gradually becoming more compressed) K.E. decreasing (speed of spring decreasing)
At position **Z**	Elastic P.E. = maximum (spring is most compressed) K.E. = zero (spring is stationary, speed = zero)
3 From position **Z** to **Y**	Elastic P.E. decreasing (spring is gradually becoming less compressed) K.E. increasing (speed of spring increasing)
At position **Y**	Elastic P.E. = minimum (spring at equilibrium) K.E. = maximum (speed of spring at maximum)
4 From position **Y** to **X**	Elastic P.E. increasing (spring is gradually becoming more stretched) K.E. decreasing (speed of spring decreasing)
At position **X**	Elastic P.E. = maximum (spring is most stretched) K.E. = zero (spring is stationary, speed = zero)

Figure 7.12 *Oscillation of a loaded spring*

Transformation of Kinetic Energy and Potential Energy in a Closed System

In a **closed system**, the transformation of energy between potential energy and kinetic energy obeys the Principle of Conservation of Energy. Therefore, the total potential energy and kinetic energy in a closed oscillation system is **constant**. An example of a closed oscillation system is shown in Figure 7.13(a). Figure 7.13(b) shows the transformation of energy in a graph.

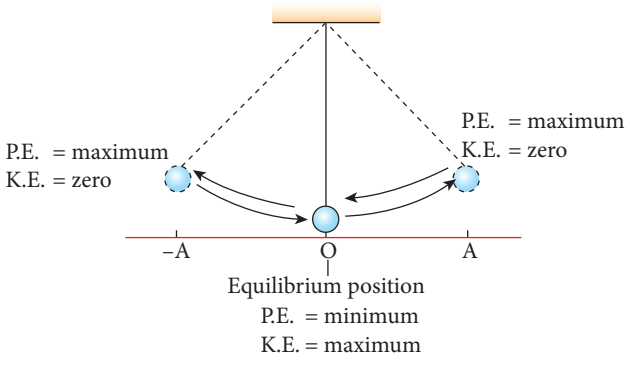


Figure 7.13(a) Oscillation of a pendulum in a closed system

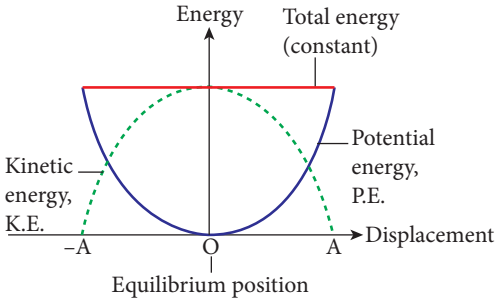


Figure 7.13(b) Graph of the transformation in the forms of energy

SCIENCE INFO

Based on the Principle of Conservation of Energy, energy can transform from one form to another. When energy transforms, a small portion of the energy is converted into useful energy. A large portion of the energy is converted into wasted energy such as heat energy caused by friction. A closed system is a system in which there is no external force such as friction. Hence, heat energy is not produced in a closed system.

Let us carry out Activity 7.3 to discuss daily situations involving transformation of energy.

Activity 7.3

21st Century Skills
- ICS, ISS
- Discussion activity

To discuss daily situations involving transformation of energy

Instructions

1. Work in groups.
2. Each group needs to gather information on transformation of energy in daily situations such as the oscillation of a swing, an object falling from a certain height, a roller coaster and toys with springs such as toy cars and pistols.
3. Label and state the form and transformation of energy at certain positions.
4. Present the outcome of your group discussion in class.

Example of numerical problem

Figure 7.14 shows a toy pistol. The length of the spring in the toy pistol is 300 mm. If a force of 5 N is used to compress the spring until its length becomes 50 mm, calculate the maximum speed of the plastic ball of mass 50 g when it is fired from the pistol. State an assumption that is made in solving this problem.

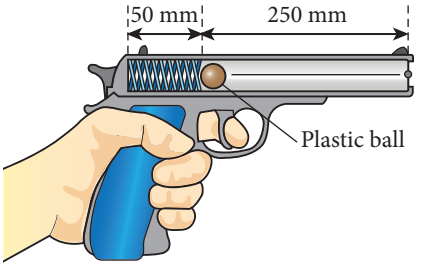


Figure 7.14

Solution

Based on the Principle of Conservation of Energy,
elastic potential energy stored in the spring = kinetic energy of the plastic ball.

$$\frac{1}{2}Fx = \frac{1}{2}mv^2$$

$$\frac{1}{2} \times 5\ \text{N} \times \frac{250}{1\,000}\ \text{m} = \frac{1}{2} \times \frac{50}{1\,000}\ \text{kg} \times v^2$$

$$\therefore v^2 = 25\ \text{m}^2\ \text{s}^{-2}$$

$$v = \sqrt{25\ \text{m}^2\ \text{s}^{-2}}$$

$$= 5\ \text{m s}^{-1}$$

Assumption: No energy loss into the surroundings.

Additional Example
http://links.andl17.com/BT_Science_226_2

Formative Practice 7.3

1. State the Principle of Conservation of Energy.

2. An oscillating loaded spring as shown in Figure 1 is a closed oscillation system.
(a) State the position of the load where the elastic potential energy of the system is maximum.
(b) State the position of the load where the elastic potential energy of the system is minimum.

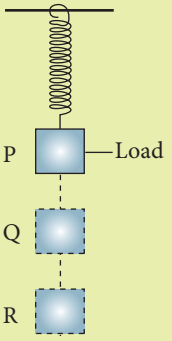


Figure 1

3. Figure 2 shows a metal sphere of mass 2 kg released from a height of 2.5 m from the surface of Earth.
(a) Calculate the gravitational potential energy possessed by the metal sphere before being released.
(b) What is the maximum speed of the metal sphere after being released?

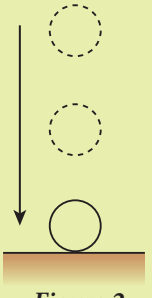
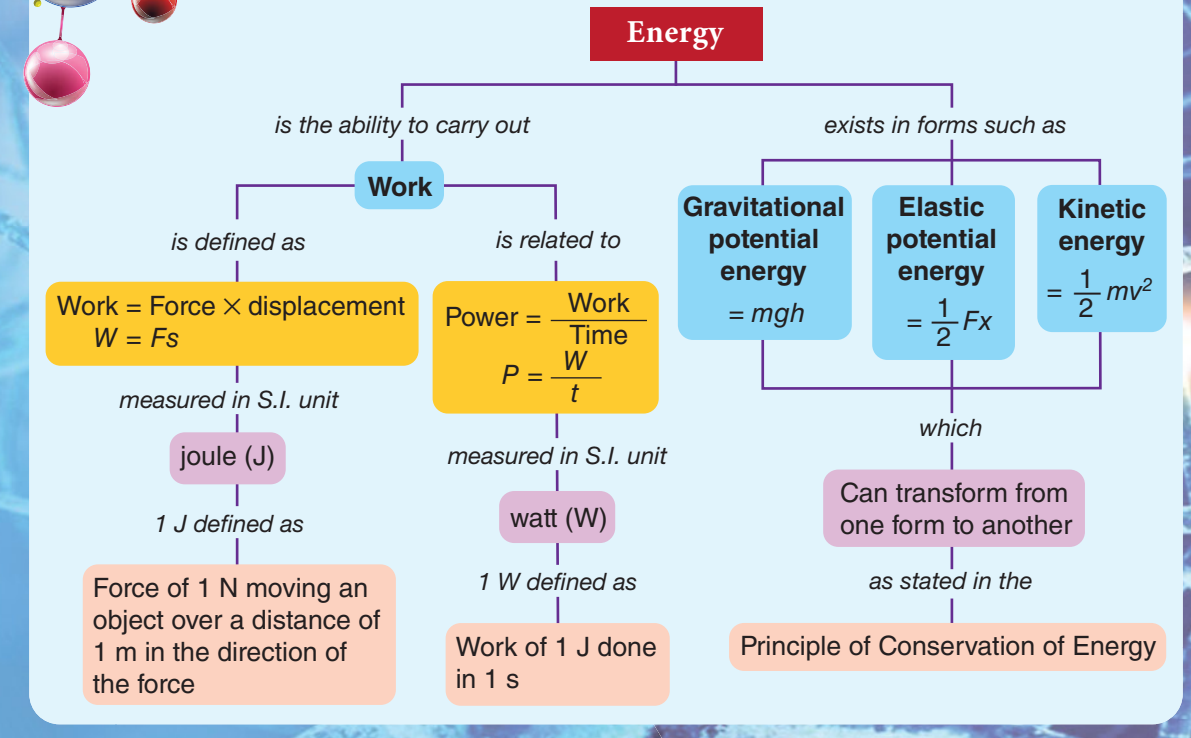


Figure 2

Summary



Self-reflection

After studying this chapter, you are able to:

7.1 Work, Energy and Power

- ☐ Define work and solve problems related to energy in the context of daily life.
- ☐ Relate power with work and solve problems in the context of daily life.

7.2 Potential Energy and Kinetic Energy

- ☐ Explain with examples gravitational potential energy and solve problems in the context of daily life.
- ☐ Calculate elastic potential energy in the context of daily life.
- ☐ Explain with examples kinetic energy in the context of daily life.

7.3 Principle of Conservation of Energy

- ☐ Explain with examples the Principle of Conservation of Energy.
- ☐ Solve qualitative and quantitative problems involving the transformation of kinetic energy and potential energy in a closed system.

Summative Practice 7

Answer the following questions:

1. There are many forms of energy. Match the following form of energy with its correct definition.

Form of energy	Definition
(a) Potential energy	Ability to do work
(b) Kinetic energy	Energy possessed by a moving object
	Energy possessed by an object due to its position or condition

2. Underline the correct answers.
(a) The unit for energy is (J s/N m).
(b) (Work/Power) is defined as the product of force and displacement in the direction of the force.
(c) A (stationary/moving) object does not possess kinetic energy.
(d) The Principle of Conservation of Energy states that energy (can/cannot) transform its form.
(e) Weight is the product of mass and (force/acceleration) of gravity.

3. Figure 1 shows a motor lifting a load of mass 5 kg to a height of 2 m.
(a) Calculate the work done by the motor.
(b) How much energy is used by the motor to lift the load?

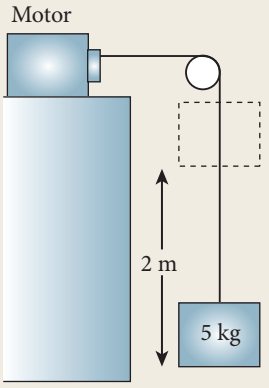


Figure 1

4. State the formula for the following energy:
(a) Gravitational potential energy
(b) Elastic potential energy
(c) Kinetic energy

5. Figure 2 shows a female archer pulling her bowstring back 0.4 m with a maximum force of 200 N.
(a) How much work is done?
(b) Calculate the elastic potential energy possessed by the stretched bowstring.
(c) Not all the work done to pull the bowstring back is changed into elastic potential energy. Why?

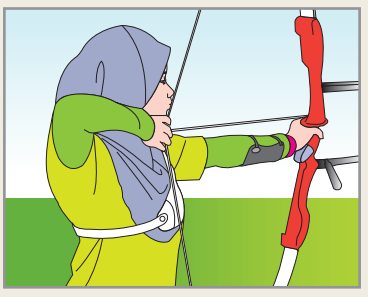


Figure 2

Focus on HOTS

6. Figure 3 shows the oscillation of a simple pendulum in a closed system. The mass of the pendulum bob is 40 g.

(a) State the principle that needs to be obeyed by the oscillation of a simple pendulum in a closed system.

(b) At which position does the pendulum possess gravitational potential energy and kinetic energy of equal value?

(c) Calculate the difference in gravitational potential energy of the pendulum at positions X and Y.

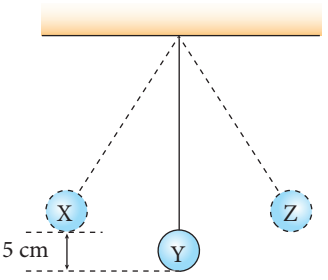


Figure 3

7. Figure 4 shows a model of a simple roller coaster.

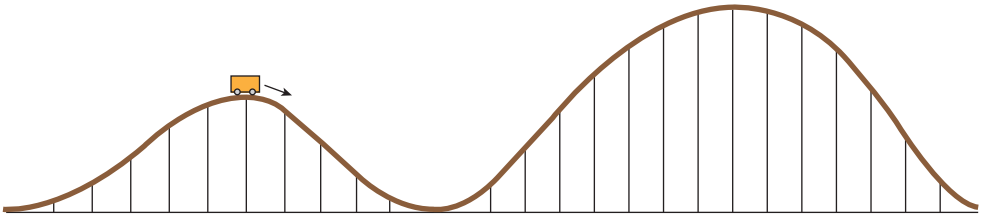


Figure 4

You are required to build a functional model of a roller coaster using the materials below.

Rubber hose

Ball bearing

Retort stands

Sketch your roller coaster model. Explain the special features of the model.

Chapter 8

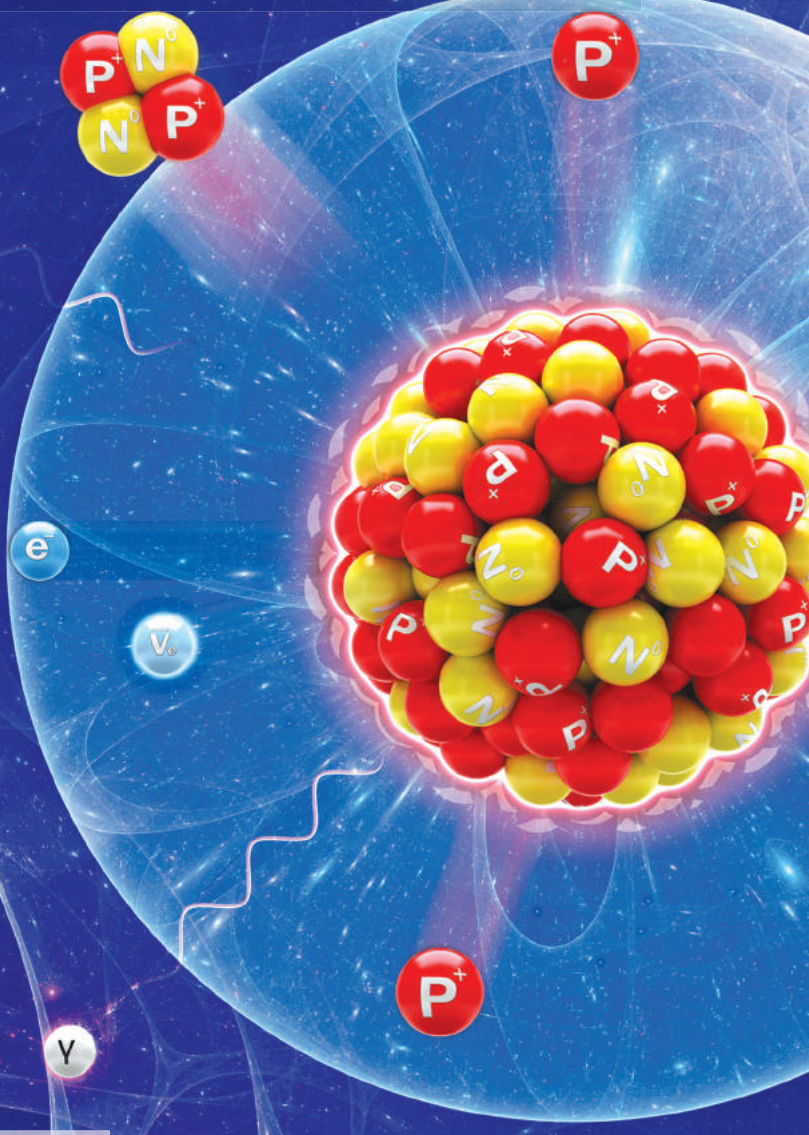
Radioactivity

When was radioactivity first discovered?

What are atom and nucleus?

What are ionising radiation and non-ionising radiation?

What are the uses of radioactive radiation in daily life?



Let's study

- Discovery of radioactivity
- Atom and nucleus
- Ionising radiation and non-ionising radiation
- Uses of radioactive radiation

Science Gallery

The Sun is the largest radioactive source which is close to Earth. However, many scientific investigations show that the Sun's rays are normal and do not contain any radioactive radiation. Due to this, the Sun is considered a safe radioactive source because no radioactive radiation is released. Is this fact true?

The analysis of gathered data about the coronal mass ejection in the Sun on 6 September 2017 from the astronomical telescope, Fermi, shows that the Sun's rays also contain gamma rays (radioactive radiation). How do we protect ourselves from these gamma rays?

The UV umbrella shown in the photograph below is used to block the ultraviolet rays from the Sun's rays. Can the UV umbrella protect our body from gamma rays as well? Suggest one material to make an umbrella which is able to block gamma rays. Is the material practical? Explain your answer.

UV umbrella (Umbrella that can block ultraviolet rays)

Keywords

- Radioactivity
- Radioactive radiation
- Radioactive substance
- Radioactive decay
- Half-life
- Becquerel (Bq)
- Curie (Ci)
- Dalton's Atomic Theory
- Ionising power
- Cosmic ray
- Archaeology
- Geochronology

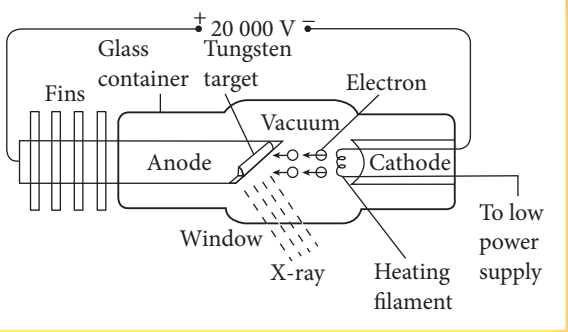
8.1 Discovery of Radioactivity

History of Radioactivity

Study Figure 8.1 on the discovery of radioactivity.

Wilhelm Roentgen

Wilhelm Roentgen's X-ray photograph of his wife's hand



X-ray tube

In 1895, **Wilhelm Conrad Roentgen**, a German physicist, discovered X-ray. He had unintentionally taken an X-ray photograph of his wife's hand. This success led Wilhelm Conrad Roentgen to receive the first **Nobel Prize** in Physics in 1901 for the discovery of X-ray.

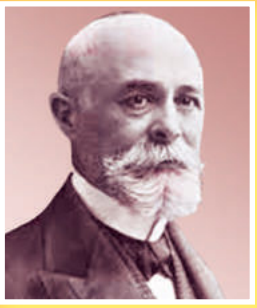
Science Careers

Various types of careers exist in the field of radioactivity.
Among them are:

- researcher at Malaysian Nuclear Agency
- nuclear physicist
- nuclear engineer
- nuclear medical specialist

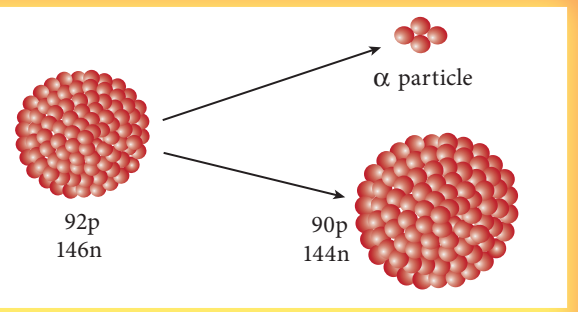
However, Marie Curie died at the age of 67 from a disease caused by prolonged exposure to gamma rays. Since the discovery of radium, the gamma rays emitted by radium have been used in various fields including medicine in cancer treatment.

Figure 8.1 *The discovery of radioactivity*



Henri Becquerel

Blackened photographic plate



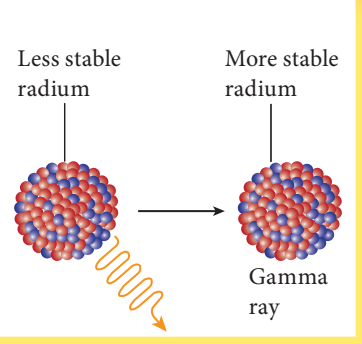
Rays emitted from the nucleus of uranium

In 1896, **Antoine Henri Becquerel**, a French physicist, became the first person to successfully discover **radioactivity**. He found a radioactive compound, uranium and unintentionally produced rays that can blacken a photographic plate even in the dark. The rays were detected based on the ionising property. Due to this, Antoine Henri Becquerel received the **Nobel Prize** in Physics in 1903 for the discovery of radioactivity.

Today in history

After attending a session of the paperwork presentation by Roentgen on 20 January 1896, Becquerel was surprised because his study could not produce the X-ray. Hence, Becquerel replaced the material being studied with uranium compound.

Marie and Pierre Curie with their child



Gamma ray from radium

SCIENCE INFO

Marie Curie is the only woman who received two Nobel Prizes, the Nobel Prize in Physics in 1903 and the Nobel Prize in Chemistry in 1911.

Today in history

The rays discovered by Becquerel cannot produce X-ray of bones, thus nobody was interested to pursue Becquerel's study for one and a half years! Perhaps this was what attracted the interest of Marie and Pierre Curie.

At the end of 1897, Marie and Pierre Curie, a married couple from Poland, successfully detected radioactive radiation through its ionising power and not through the photographic effect. Beginning with uranium ore which is known as **pitchblende**, they successfully extracted two radioactive elements, **polonium** and **radium**.

Radioactivity

Radioactivity is a random and spontaneous decay process of an unstable nucleus by emitting radioactive radiation as shown in Figure 8.2. Radioactive radiation consists of:

- alpha particles (alpha radiation), α
- beta particles (beta radiation), β
- gamma ray, γ

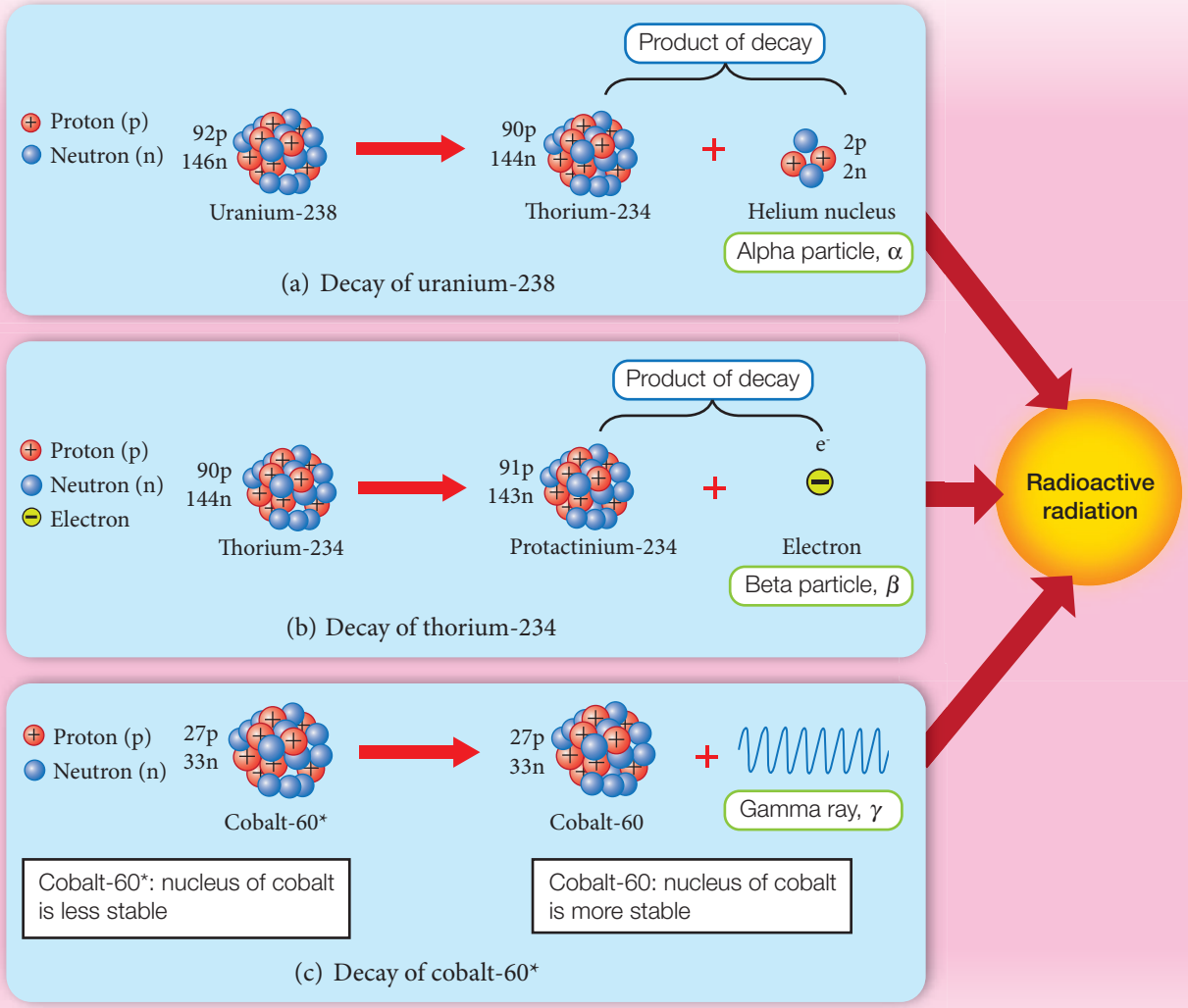


Figure 8.2 *Three types of radioactive radiation emitted from the spontaneous decay of nuclei*

Radioactive decay is a random and spontaneous process where an unstable nucleus emits radioactive radiation until the nucleus becomes more stable. Examples of radioactive elements that have unstable nuclei and decay spontaneously by emitting radioactive radiation are as follows:

- Carbon-14 (C-14)
- Radon-222 (Rn-222)
- Thorium-234 (Th-234)
- Uranium-238 (U-238)

Units of Radioactivity

The first unit of radioactivity introduced was **curie (Ci)**. The rate of unstable nuclei decay (or **activity** in nuclei decay) is measured in curie. One curie is 3.7×10^{10} decays per second, that is:

$$1 \text{ Ci} = 3.7 \times 10^{10} \text{ decays/s}$$

The S.I. unit of radioactivity is **becquerel (Bq)**. 1 becquerel (Bq) is 1 decay per second, that is:

$$1 \text{ Bq} = 1 \text{ decay/s}$$

SCIENCE INFO

1 Ci is approximately the number of decays per second in 1 g of Radium-226 (Ra-226). Radium-226 is a radioactive substance studied by Marie and Pierre Curie.

BRAIN TEASER

Complete the following:
(a) 1 Ci = _____ Bq
(b) 1 Bq = _____ Ci

Half-life of Radioactive Decay

Half-life, $T_{\frac{1}{2}}$ is the time taken for the number of undecayed nuclei to be reduced to half of its original number (value). The graphic description of the situation when the number of undecayed nuclei decreases with time is shown in Figure 8.3. What is the S.I. unit for half-life?

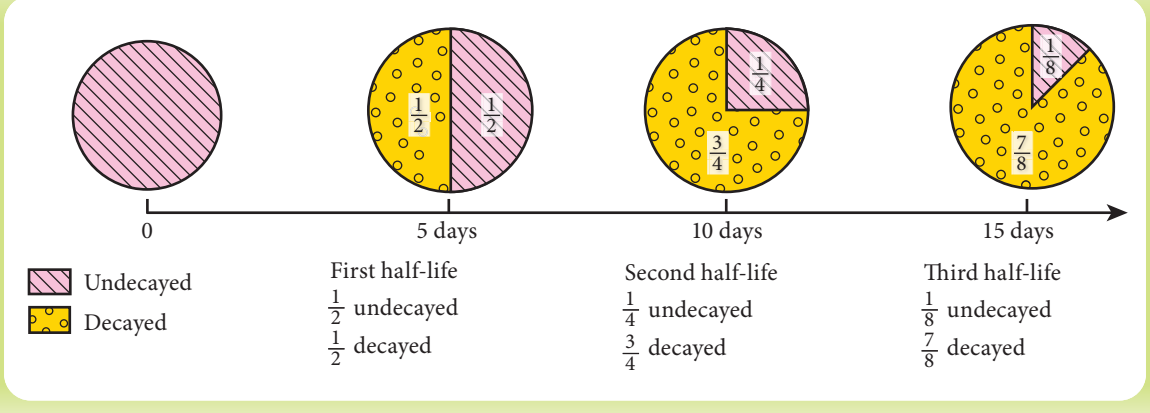


Figure 8.3 *Nuclei decay of a radioactive element with half-life of 5 days*

Example 1

Protactinium-234(Pa-234) decays to Uranium-234(U-234) with half-life, $T_{\frac{1}{2}}$, of 5.2 hours. Calculate the mass of Pa-234 after 20.8 hours with its original mass of 80 g.

Solution

0 hours	→	5.2 hours	→	10.4 hours	→	15.6 hours	→	20.8 hours
80 g		40 g		20 g		10 g		5 g

Thus, the remaining mass of Pa-234 after 20.8 hours is 5 g.

Example 2

A graph of activity against time for radioactive substance P is shown in Figure 8.4.

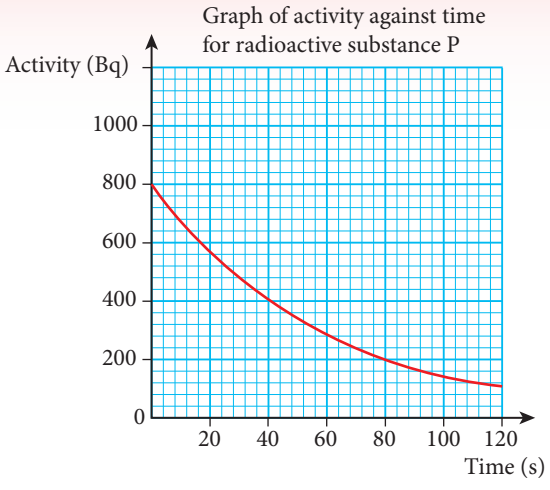


Figure 8.4

Based on the graph, what is the half-life of P?

Solution

Original activity = 800 Bq

Activity at half-life $= \frac{1}{2} \times 800$ Bq

$= 400$ Bq

When the activity is 400 Bq, the corresponding time is 40 s as shown by the dotted line on the graph in Figure 8.5.
Thus, the half-life of P is 40 s.

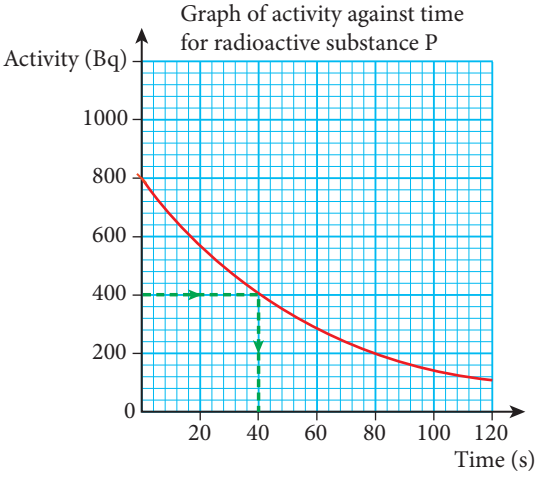


Figure 8.5

Example 3

The activity of radioactive substance Q against time is shown in Table 8.1.

Table 8.1

Time (minutes)	0	5	10	15	20	25
Activity (Bq)	120	80	56	40	28	20

(a) Draw a graph of activity against time on a piece of graph paper.
(b) Based on the graph, what is the half-life of Q?

Solution

(a)

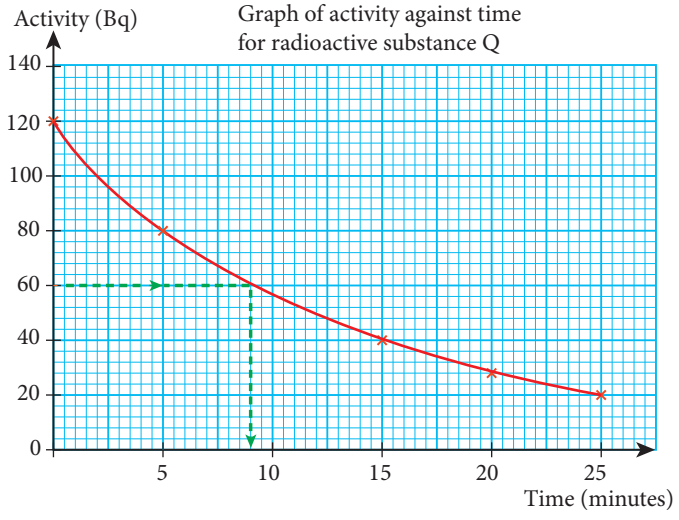


Figure 8.6

(b) Original activity = 120 Bq
Activity at half-life
$= \frac{1}{2} \times 120$ Bq
$= 60$ Bq
From the graph in Figure 8.6, the half-life of Q is 9 minutes.

Activity 8.1

21st Century Skills
- ICS
- Inquiry-based activity

To gather information on a cloud chamber to view the tracks produced by radioactive substances

Instructions

1. Work in groups.
2. Gather information on the method to build a cloud chamber to view the tracks produced by radioactive substances.
3. Present the findings of your group.

Formative Practice 8.1

1. Name the first person who discovered:
(a) the X-ray
(b) radioactive radiation
(c) gamma rays emitted by radium

2. What is the meaning of radioactivity?

3. (a) Name **two** units of radioactivity.
(b) What is the quantity measured in radioactivity unit?

4. Give **three** examples of radioactive elements.

5. What is the meaning of half-life?

8.2 Atom and Nucleus

Atoms originate from the word 'atomos' which means indivisible. In 1808, John Dalton, introduced a theory on the structure of atom. According to **Dalton's Atomic Theory**, an atom is the smallest particle and cannot be further divided. However, the development of science has succeeded in finding particles that are even smaller called protons, electrons and neutrons.

Structure of Atom

Recall the three subatomic particles in the structure of an atom that you have learnt in Form 1 as shown in Figure 8.7.

When the number of protons in an atom is the same as the number of its electrons, the atom is **neutral**.

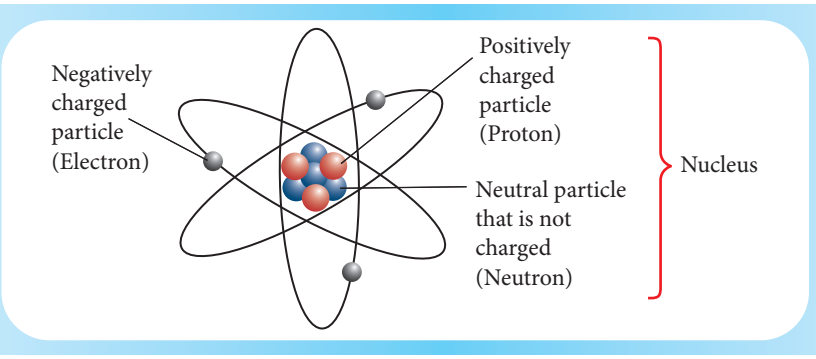


Figure 8.7 *Structure of atom*

Formation of Positive Ions and Negative Ions

When an atom loses or gains electrons, the atom becomes a charged particle known as **ion**.

Positive Ion (Cation)

An atom that **loses** electrons forms a **positive ion (cation)**.

Example

Table 8.2 *Formation of sodium ion, Na^+*

Sodium atom, Na

Subatomic particle	Number	Charge
neutron, n	12	0
proton, p	11	+11
electron, e	11	–11
The charge on sodium atom, Na		0

loses 1 e^- →

Sodium ion, Na^+

Subatomic particle	Number	Charge
neutron, n	12	0
proton, p	11	+11
electron, e	10	–10
The charge on sodium ion, Na^+		+1

Negative Ion (Anion)

An atom that **gains** electrons forms a **negative ion (anion)**.

Example

Table 8.3 Formation of chloride ion, Cl^-

Chlorine atom, Cl

Subatomic particle	Number	Charge
neutron, n	18	0
proton, p	17	+17
electron, e	17	–17
The charge on chlorine atom, Cl		0

gains 1 e^-

Chloride ion, Cl^-

Subatomic particle	Number	Charge
neutron, n	18	0
proton, p	17	+17
electron, e	18	–18
The charge on chloride ion, Cl^-		–1

Formative Practice 8.2

1. State the property of an atom according to Dalton's Atomic Theory.
2. Explain how the following ions are formed.
   (a) Positive ion
   (b) Negative ion
3. Table 1 shows the number of protons and electrons of particles P, Q, R, S and T.
   (a) Which particle is a positive ion? Explain your answer.
   (b) Which particle is a negative ion? Explain your answer.
   (c) Which particle is neutral? Explain your answer.

Table 1

Particle	Number of protons	Number of electrons
P	4	4
Q	12	10
R	17	18
S	29	27
T	35	36

4. Table 2 shows the formation of an ion.

Table 2

Bromine atom, Br

Subatomic particle	Number	Charge
neutron, n	45	0
proton, p	35	+35
electron, e	35	–35
The charge on bromine atom, Br		0

electron transfer

Ion X

Subatomic particle	Number	Charge
neutron, n	45	0
proton, p	35	+35
electron, e	36	–36
The charge on ion, X		–1

   (a) How many electrons are lost or gained by the bromine atom in the formation of ion X?
   (b) Explain your answer in **4**(a).
   (c) Name ion X that is formed and write its symbol.

8.3 Ionising Radiation and Non-ionising Radiation

Ionising Radiation and Non-ionising Radiation

When a radiation such as radioactive radiation passes through air and produces positive and negative ions, it is known as **ionising radiation** as shown in Figure 8.8.

Figure 8.8 *Radioactive radiation as ionising radiation*

What is the meaning of **non-ionising radiation**? Examples of ionising radiation and non-ionising radiation are shown in Figure 8.9.

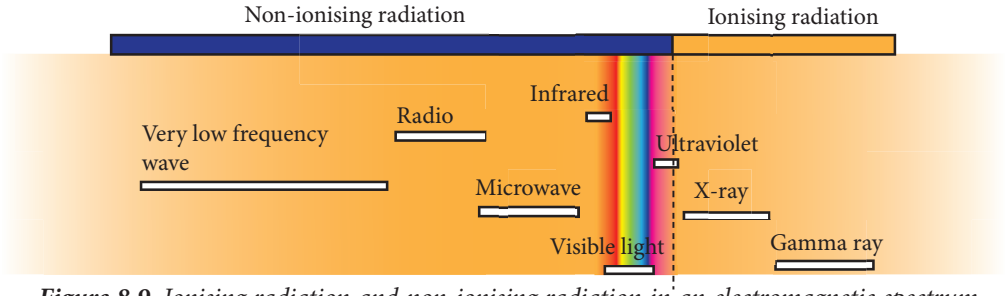


Figure 8.9 *Ionising radiation and non-ionising radiation in an electromagnetic spectrum*

Let us carry out Activity 8.2 to learn more about ionising radiation, namely alpha radiation, beta radiation, gamma ray and X-ray.

Activity 8.2

21st Century Skills
- ICS
- Discussion activity

Surf the Internet and share information on ionising radiation

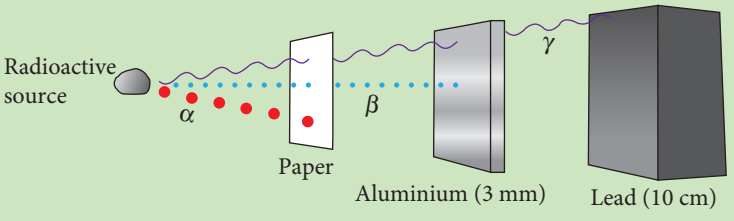
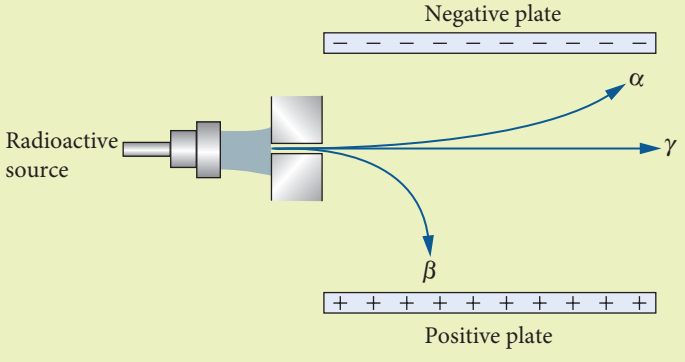
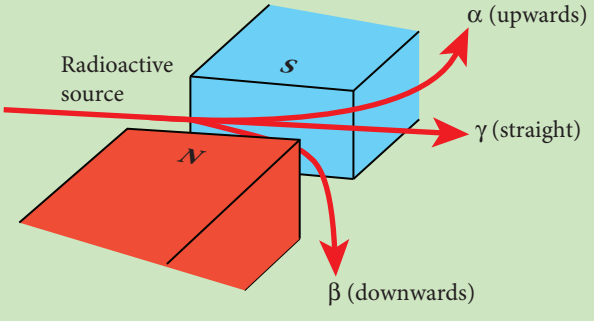
Instructions

1. Work in groups.
2. Surf the Internet to gather information on the following ionising radiation:
   (a) Alpha radiation, α (alfa particle)
   (b) Beta radiation, β (beta particle)
   (c) Gamma ray, γ
   (d) X-ray
3. Discuss several aspects such as size of particle, ionising power, penetration power, deflection by magnetic field and deflection by electric field.
4. Present the outcome of your group discussion using multimedia presentation.

Types of Ionising Radiation

Three types of radioactive radiation which are ionising radiation are **alpha radiation, α**, **beta radiation, β** and **gamma ray, γ**. Study Table 8.4.

Table 8.4 Differences between the three types of ionising radioactive radiations

Type of radioactive radiation	Alpha radiation, α	Beta radiation, β	Gamma ray, γ
Natural characteristic	Helium nucleus	High speed electron	Electromagnetic wave
Charge of particle	Positive	Negative	Neutral
Ionising power	High	Moderate	Low
Penetration power			
	Low	Moderate	High
Deflection by electric field			
Deflection by magnetic field			

Sources of Ionising Radiation in the Environment

In the environment, sources of ionising radiation are classified as **natural sources of ionising radiation** and **man-made sources of ionising radiation** as shown in Figure 8.10.

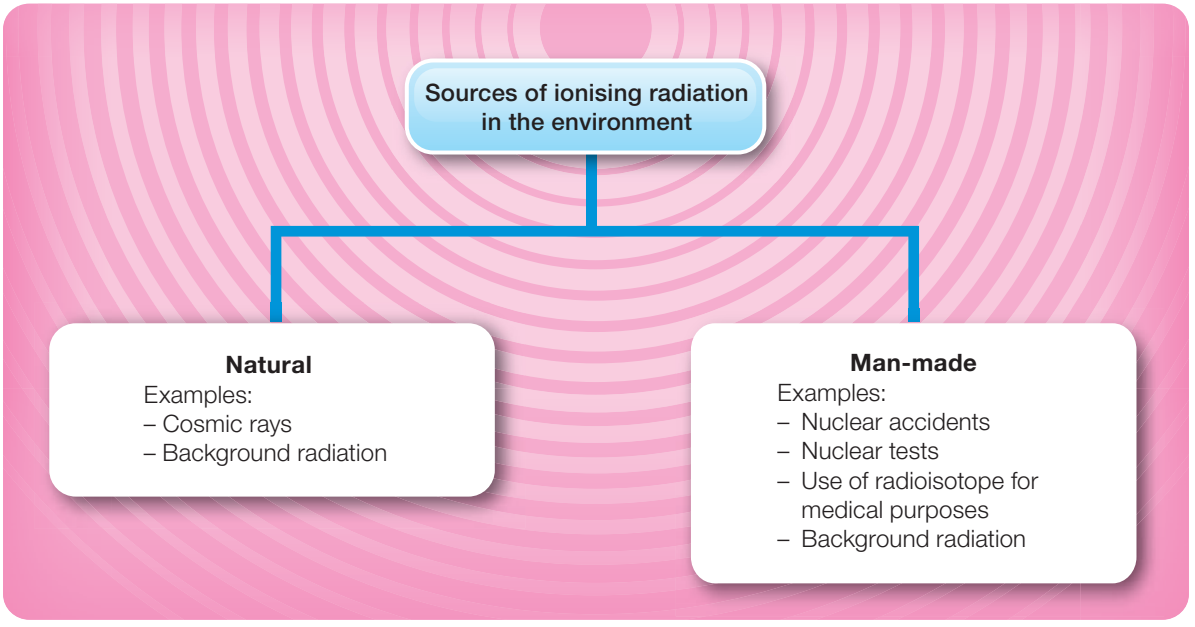


Figure 8.10 *Classification of sources of ionising radiation in the environment*

Let us carry out Activity 8.3 to detect natural sources of ionising radiation in the environment.

Activity 8.3

21st Century Skills
- CPS
- Inquiry-based activity

To gather information on natural sources of ionising radiation in the environment

Instructions

1. Work in groups.
2. Gather information on natural sources of ionising radiation in the environment.

Gather information on natural sources of ionising radiation in the environment
http://links.and17.com/BT_Science_242

3. Present your group findings.

Cosmic Rays

Cosmic rays are high-energy radiation produced outside the Solar System or from another galaxy. These cosmic rays are also known as **galactic cosmic rays**.

Photograph 8.1 *Cherenkov telescope on Mount Hopkins, United States of America used to detect cosmic rays*

Background Radiation

Background radiation is made up of various types of ionising radiation in the environment. Background radiation is released from various sources including natural sources and man-made sources. Sources of background radiation include:

- cosmic rays
- radioactive radiation from natural radioactive substances in the surroundings
- radioactive wastes from nuclear accidents and nuclear tests
- radioisotopes from medical use

Unit of Dose Rate Measurement for Background Radiation

Ionising radiation that is absorbed into the human body will damage body cells. Due to this, the biological effect from ionising radiation on human body is measured in a quantity known as **dose**. A dose of 1 Sv is equivalent to 1 joule of ionising radiation energy that is absorbed by 1 kilogram of living tissue. The unit of background radiation dose that is commonly used is **microSievert/hour (μSv/h)**.

BRAIN TEASER

What is the meaning of 1 μSv/h?

(a) In the garden

(b) In the school compound

Photograph 8.2 *Measuring background radiation using a Geiger counter*

Study and compare the readings of the dose rate of background radiation on a Geiger Counter in Photograph 8.2. What is the unit of dose rate measurement for background radiation shown in the readings on the counter?

Safe Background Radiation Dose in Daily Life

Background radiation or ionising radiation dose of **less than 0.2 μSv/h** is the **normal level** or **safe level**. Based on Photograph 8.2, the garden and school compound are safe areas because both areas have background radiation dose of less than 0.2 μSv/h.

SCIENCE INFO

Safe level of background radiation dose is:
- < 0.2 µSv/h
- < 0.0002 mSv/h
- < 1 752 µSv/year
- < 1.752 mSv/year

Websites

Exposure to radiation in daily life

http://links.and117.com/BT_Science_244_2 and click *"Radiation Level"*

The estimation of dose rate of ionising radiation from various sources in daily life are shown in Figure 8.11. Identify which sources are safe for an individual.

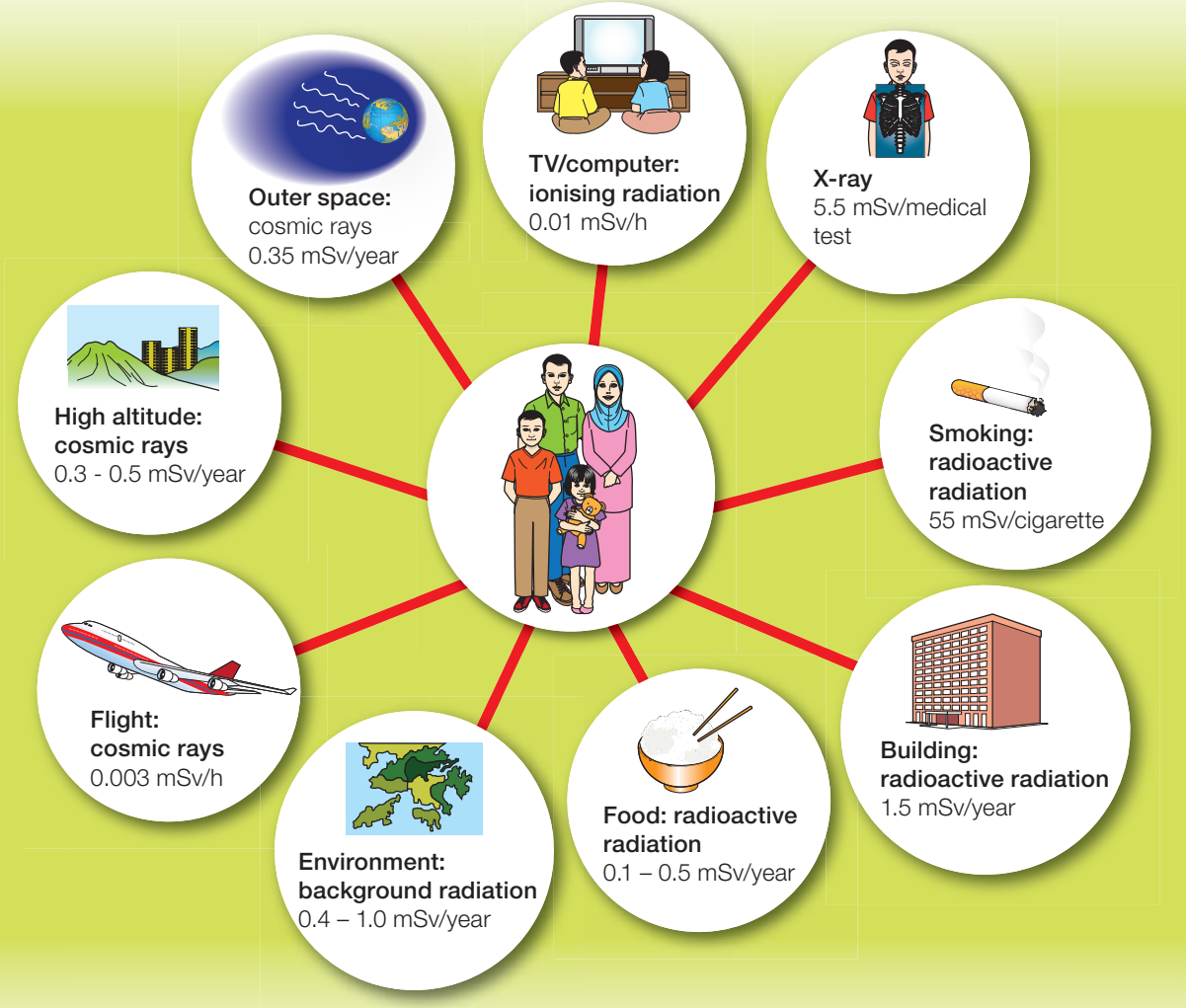


Figure 8.11 *Estimation of dose rate of ionising radiation*

Risks from Exposure to Natural Ionising Radiation

Absorption of ionising radiation by the human body imposes health risks which are affected by the dose of ionising radiation received. Several actions can be taken so that the ionising radiation dose received does not exceed the safe level for the human body as shown in Table 8.5.

Table 8.5 *Among the safety measures that need to be taken so that the ionising radiation dose received does not exceed the safe level for the human body*

Source of ionising radiation dose received	Safety measures
Background radiation	Use appropriate protective equipment such as spectacles fitted with anti-ultraviolet film, anti-ultraviolet umbrellas and others
Taking X-ray	X-ray taken with doctor's prescription
Television	Ensure the distance between the television and the viewer is at least 2 m.
Food contaminated with radioactive substances	Do not eat food produced in areas contaminated with radioactive substances such as fish from the sea contaminated with radioactive substances.
Cosmic rays	Working hours of a pilot are limited to a certain period of time because the pilot is exposed to cosmic rays.

SCIENCE INFO

Marie and Irene Curie are the only mother and daughter to have received three Nobel Prizes. Marie Curie received two Nobel Prizes, which are Nobel Prize in Physics in 1903 and Nobel Prize in Chemistry in 1911. Irene Curie, Marie Curie's daughter, received her Noble Prize in Chemistry in 1935. Without realising the risks of being exposed to ionising radiation, they died of cancer caused by excessive exposure to gamma rays during their research.

Activity 8.4

21st Century Skills
- ICS
- Simulation activity

To interpret data on health risks related to the absorption level of ionising radiation by the human body

Instructions

1. Work in groups.
2. Gather information from various sources on the health risks related to the absorption level of ionising radiation by the human body.
3. Discuss the health risks to the human body due to absorption of the following doses of ionising radiation in a year.
   (a) Doses of 10 Sv.
   (b) Doses in the range of 1 Sv to 10 Sv.
   (c) Doses in the range of 0.1 Sv to 1 Sv.
   (d) Doses of less than 0.1 Sv.
4. Share the outcome of your group discussion in class.

8.3.4

Examples of Absorption of Ionising Radiation Exceeding the Safe Level and Safety Measures that Need to be Taken

As most cosmic rays are absorbed by the atmosphere, the dose of cosmic rays on the surface of Earth is normally at a value of less than 0.2 μSv/h, which is a normal or safe level. The higher a person is from the surface of Earth, the stronger the cosmic rays he receives. Name an example of a career that involves working at high altitudes.

Photograph 8.3 *Pilots*

Websites

Safety measures for airline crew members who are exposed to cosmic rays.

http://links.and17.com/BT_Science_246

Airline crew members such as pilots (Photograph 8.3), stewards and stewardesses normally receive cosmic ray doses exceeding the safety level. They are exposed to strong cosmic rays in flights at high altitudes. Due to this, their working hours in the sky are limited to a certain period of time.

Formative Practice 8.3

1. (a) What is ionising radiation? Give **one** example of ionising radiation.
(b) What is non-ionising radiation? Give **one** example of non-ionising radiation.

2. Underline the correct answers.
(a) The ionising power of beta radiation is (higher/lower) than the ionising power of alpha radiation but (higher/lower) than the ionising power of gamma ray.
(b) The penetration power of beta radiation is (higher/lower) than the penetration power of alpha radiation but (higher/lower) than the penetration power of gamma ray.

3. (a) State **two** natural sources of ionising radiation.
(b) State **three** man-made sources of ionising radiation.

4. (a) State the unit of dose rate measurement for background radiation.
(b) What is 1 sievert (Sv)?
(c) What is considered a safe level of background radiation dose?

5. Why does the absorption level of ionising radiation for an individual working in the aviation sector normally exceed the safety level?

6. A student watches television for 2 hours every day. Calculate the dose rate of ionising radiation received by the student after 5 days. (Dose rate of ionising radiation from television = 0.01 mSv/h)

8.4 Uses of Radioactive Radiation

Radioactive Radiation in Daily Life

Radioactive radiation such as alpha radiation (α), beta radiation (β) and gamma ray (γ) are used in various fields in daily life as follows:

Archeology and geochronology

Carbon dioxide in the air is made up of carbon-12 (C-12) which is stable and carbon-14 (C-14) which is radioactive. As carbon dioxide is absorbed and released by the body of living organisms, the percentage of C-14 in the tissues of the organisms does not change.

As soon as the organisms die, the amount of C-14 in their tissues begins to decline because they decay by emitting beta radiation with a half-life, $T_{\frac{1}{2}}$, of 5 700 years. By measuring the activity of C-14, the age of the remains can be determined. This method is known as **carbon-14 dating** and is used by archeologists or geochronologists to determine the age of fossil and artifacts.

Photograph 8.4 *Dinosaur bones*

Monitoring the thickness of metal sheets (Industry)

A thickness control device monitors the thickness of metal sheets in factories. A metal sheet is passed in between a beta radiation source and a beta radiation detector. If the beta radiation detector detects too much beta radiations, this means that the metal sheet is too thin.

Photograph 8.5 *Monitoring the thickness of metal sheets*

Agriculture

In agriculture, the rate at which beta radiation is emitted during the nuclei decay of phosphorus-32 (P-32) is used to determine the absorption rate of phosphate fertiliser in plants. Radioactive radiation is also used to kill beetles, control the population of pests by sterilisation, determine the best type of phosphate fertiliser, and modify the characteristics of plants.

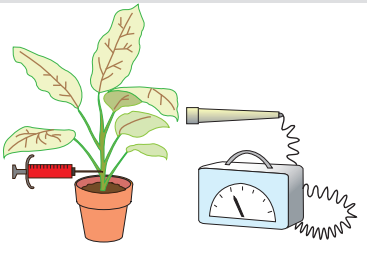


Figure 8.12 *Determining the absorption rate of phosphorus-32 (P-32) fertiliser*

Defence

Radioactive substances can be used in the field of defence such as the nuclear bomb. Besides heat, radioactive radiation released from the explosion of a nuclear bomb destroys almost all living things including humans and its effect exists for generations.

Photograph 8.6 *Atomic bomb explosion*

Today in history

On 20 September 2017, Malaysia signed the ICAN agreement to ban nuclear weapons at a United Nations (UN) Conference.

Food preservation

The **Radura** logo in Figure 8.13 is used to label food preserved using radioactive radiation such as gamma rays. Gamma rays are used in the preservation of food such as fruits to kill bacteria in the food.

Figure 8.13 *Radura logo*

Photograph 8.7 *Preservation of food using gamma rays*

Medical

Gamma rays from caesium-137 (Cs-137) or cobalt-60 (Co-60) are used to kill cancer cells. Radioactive radiation is also used to determine the location of blood clots using sodium-24 (Na-24), treat tumours in the brain using technetium-99 (Tc-99), destroy germs using cobalt-60 (Co-60) and treat thyroid glands using iodine-131 (I-131).

Photograph 8.8 *Gamma rays used to treat cancer*

Activity 8.5

21st Century Skills
- ICS
- Technology-based activity
- STEM

To carry out a Gallery Walk on the use of radioactive radiation in various fields

Instructions

1. Work in groups.
2. Gather information from the Internet, print media and other electronic media on the use of radioactive radiation in the areas of agriculture, defence, medicine, archeology or geochronology, industry and food preservation.
3. Discuss the following:
   (a) Types of radioactive radiation used
   (b) Ways of using radioactive radiation
   (c) Careers related to the use of radioactive radiation
4. Carry out the gallery walk activity.

Safe and Proper Handling of Radioactive Substances and Radioactive Waste

Safety measures in the handling of radioactive sources and radioactive waste are shown in Figure 8.14.

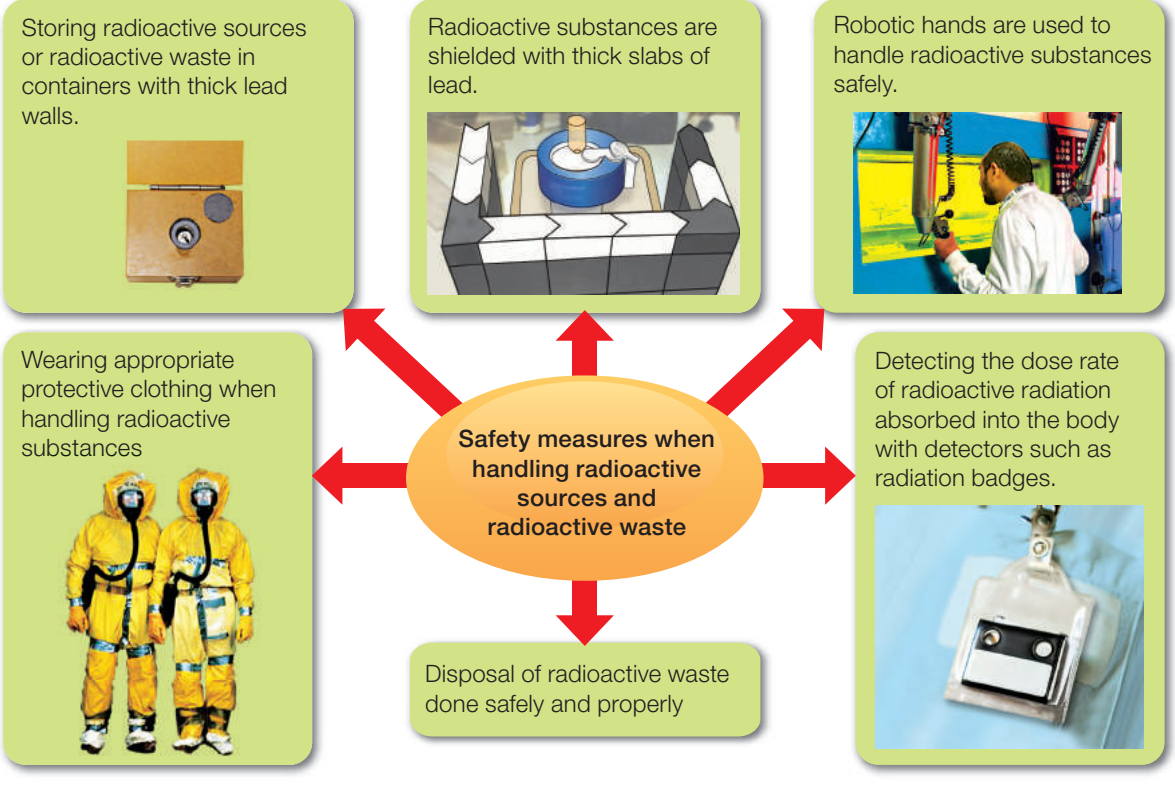


Figure 8.14 *Safety measures in the handling of radioactive sources and radioactive waste*

8.4.1 8.4.2

Appreciating the Importance of Radioactive Radiation

The importance of radioactive radiation for the well-being of humans makes us grateful to the Almighty for creating radioactive particles that have many uses to sustain life.

The first artificial radioactive element, phosphorus-30 (P-30), was created by Irene Joliot-Curie, the daughter of Marie Curie. Since 1934, many artificial radioactive elements have been produced by scientists. Artificial radioactive elements cannot be produced without the radioactive particles.

Websites

Handling the disposal of radioactive waste safely and properly

http://links.and117.com/BT_Science_250

Formative Practice 8.4

1. State **one** example of the use of radioactive radiation in the following fields:
(a) Archeology and geochronology
(b) Medicine
(c) Agriculture
(d) Defence
(e) Industry

2. (a) State the type of radioactive radiation used in the preservation of food.
(b) How can this type of radioactive radiation preserve food?

3. Why are radioactive sources or radioactive waste kept in boxes with thick lead walls?

4. Figure 1 shows a warning symbol.

Figure 1

(a) What is the meaning of the warning symbol shown in Figure 1?
(b) Name **one** example of a place or area which displays this warning symbol.
(c) Among the three types of radioactive radiations, which is the least dangerous? Explain your answer.

5. (a) State **one** metal that is used to make appropriate protective clothing to handle radioactive substances.
(b) State **one** advantage and **one** disadvantage of using the metal to make the protective clothing mentioned in **5**(a).

Summary

Radioactivity

Discovery of radioactivity

Chronological order

- Wilhelm Roentgen who discovered X-ray (1895)
- Henri Becquerel who discovered radioactivity (1896)
- Marie and Pierre Curie who succeeded in detecting radioactivity through its ionising effects (1897)

Decay process of unstable nucleus by emitting radioactive radiation

Examples of radioactive substances

- C-14, Rn-222, Th-234, U-238

units of radioactivity

- becquerel (Bq), curie (Ci)

Applying the understanding of the structure of atom and nucleus

in the

- Formation of positive and negative ions

by

- Ionising radiation

such as

- Alpha radiation, beta radiation, gamma ray and X-ray

from

- Natural sources such as cosmic rays, background radiation
- Man-made sources such as nuclear tests and artificial radioactive elements

Uses of radioactive radiation

in fields such as

- Agriculture, defence, medicine, archeology, geochronology, industry, food preservation

Safety measures

- Storing of resources
- Protective clothing
- Shield in lead box
- Use of robotic hands
- Radiation badges
- Safe and proper disposal

Self-reflection

After studying this chapter, you are able to:

8.1 Discovery of Radioactivity

- ☐ Describe the history of the discovery of radioactivity.
- ☐ Explain with examples radioactive substances, radioactivity and the concept of half-life.

8.2 Atom and Nucleus

- ☐ Draw an atomic structure in a stable state.
- ☐ Explain the formation of positive ions and negative ions.

8.3 Ionising Radiation and Non-ionising Radiation

- ☐ Describe ionising radiation and non-ionising radiation.
- ☐ Differentiate the three types of ionising radiation in radioactive decay.
- ☐ Explain with examples sources of ionising radiation in the environment, natural sources and man-made sources.
- ☐ Discuss ways to manage the risks from exposure to natural and man-made ionising radiation.

8.4 Uses of Radioactive Radiation

- ☐ Communicate the use of radioactive radiation for well-being.
- ☐ Justify the importance of proper handling radioactive substances and radioactive waste.

Summative Practice 8

Answer the following questions:

1. Mark '✓' for the correct statements and '×' for the incorrect statements.

(a) Wilhelm Roentgen discovered the X-ray. ( )

(b) Henri Becquerel used the element radium in his investigations on radioactivity. ( )

(c) The death of Marie Curie is caused by the exposure to gamma rays. ( )

2. What is the meaning of radioactive decay?

3. Name the radioactive substance in the common salt used in the medical field.

4. Pa-234 decays to U-234 by emitting beta radiation. If the half-life of Pa-234 is 5.2 hours, what is the remaining mass of Pa-234 after 20.8 hours given its original mass is 32 g?

5. Tables 1(a) and 1(b) show the formation of ions.

Table 1(a)

Magnesium atom, Mg

Subatomic particle	Number	Charge
neutron, n	12	0
proton, p	12	+12
electron, e	12	–12
The charge on magnesium atom, Mg		0

loses two electrons →

Magnesium ion, Mg^{2+}

Subatomic particle	Number	Charge
neutron, n	12	0
proton, p	12	+12
electron, e	10	–10
The charge on magnesium ion, Mg^{2+}		+2

Table 1(b)

Fluorine atom, F

Subatomic particle	Number	Charge
neutron, n	10	0
proton, p	9	+9
electron, e	9	–9
The charge on fluorine atom, F		0

gains one electron →

Fluoride ion, F^-

Subatomic particle	Number	Charge
neutron, n	10	0
proton, p	9	+9
electron, e	10	–10
The charge on fluorine ion, F^-		–1

(a) Is the ion formed in Table 1(a) a positive ion or negative ion? Explain your answer.
(b) Is the ion formed in Table 1(b) a positive ion or negative ion? Explain your answer.

Focus on HOTS

6. (a) State **three** similarities between X-ray and gamma ray.
(b) Figure 1 shows the condition of two samples of strawberries, X and Y, before and after 7 days.

Sample of strawberries X | Sample of strawberries Y

Figure 1

(i) Which sample has been preserved? Explain your answer.
(ii) What is the radioactive radiation used to preserve food?
(iii) How can this radioactive radiation preserve food?
(iv) Is food preserved using this radioactive radiation safe to be consumed? Explain your answer.

7. (a) Figure 2(a) shows an activity that is normally carried out in a laboratory to study radioactive substances.

Figure 2(a)

Based on the activity in Figure 2(a), describe the safety measures taken when handling radioactive substances.

(b) Figure 2(b) shows an example of the use of beta radiation in an industry.
Beta radiation is used to monitor the volume of drink in bottles. Beta radiation is directed towards the passing bottle as shown in Figure 2(b). If the bottle is not filled sufficiently, the beta radiation will pass through the bottle and is then detected by a detector. The circuit attached to the detector then removes the bottle.

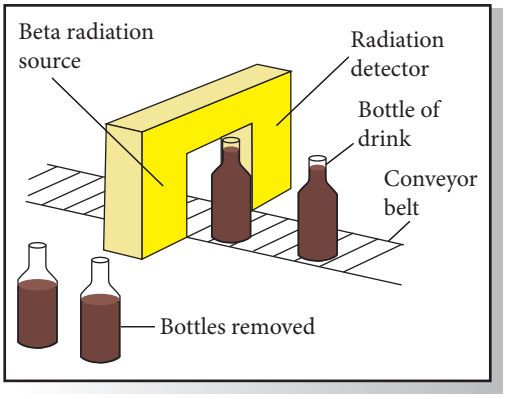


Figure 2(b)

You are required to create a model to show the quality control system that monitors the volume of drink in bottles as shown in Figure 2(b) using the materials below.

- LED
- Empty mineral water bottle
- Newspaper
- Mirror

THEME

4

Earth and Space Exploration

The RazakSAT-2 satellite is a satellite created entirely by local scientists. One of the uses of this satellite is in the field of defence.

Our life is affected by local weather conditions. For example, we will use an umbrella on a rainy day. What is the importance of space weather?

Chapter 9

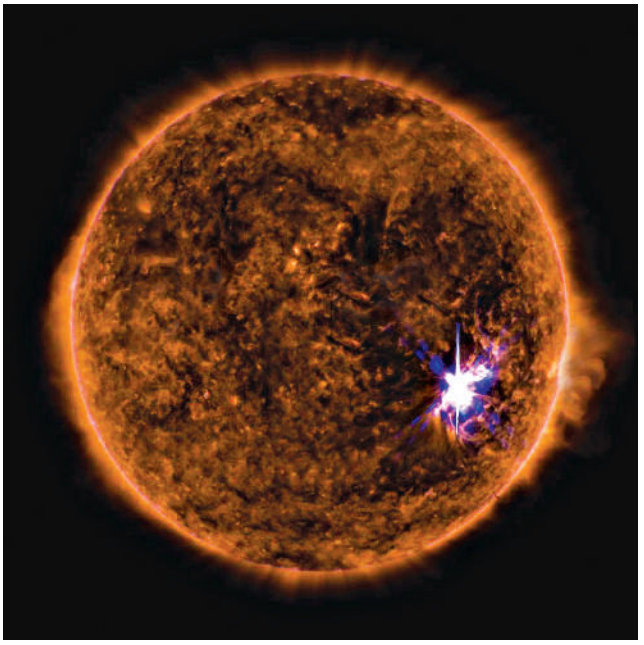
Space Weather

What is the structure of the Sun?
What phenomena occur on the surface of the Sun?
What are the effects of space weather on Earth?

Let's study

- Activities of the Sun that affect Earth
- Space weather

Science Gallery



The Sun's X9.3 class solar flare at 8.02 am on 6 September 2017

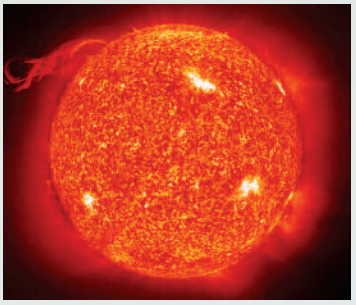
On 6 September 2017, coronal mass ejections caused disturbances to telecommunication, navigation system and electric power lines for about an hour. What are the effects of this phenomenon on daily life on Earth?

Keywords

- Sun
- Core
- Radiation zone
- Convection zone
- Photosphere
- Chromosphere
- Granule
- Corona
- Solar flare
- Sunspot
- Solar cycle
- Solar wind
- Magnetosphere
- Prominence

9.1 Activities of the Sun that Affect Earth

The **Sun** appears as a ball of glowing gases as shown in Photograph 9.1. The Sun consists almost entirely of two types of gases, **hydrogen** and **helium**.



Photograph 9.1 *The Sun*

Structure of the Sun

The structure of the Sun consists of the parts shown in Figure 9.1. Carry out Activity 9.1 to learn more about the structure of the Sun.

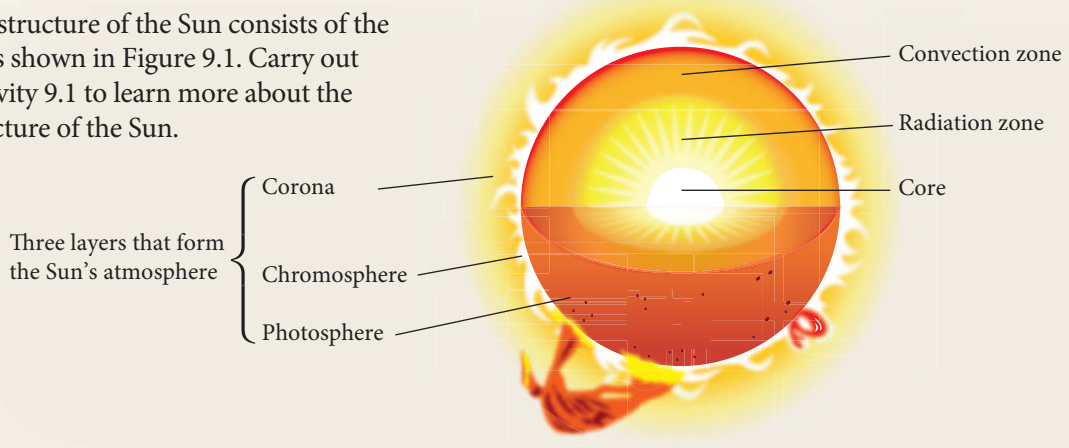


Figure 9.1 *Structure of the Sun*

Activity 9.1

To gather and share information on the structure of the Sun consisting of the core, radiation zone, convection zone, photosphere, chromosphere and corona

21st Century Skills
- ICS, ISS
- Discussion activity

Instructions

1. Work in groups.
2. Gather information from the Internet, printed media and other electronic media on the structure of the Sun consisting of the core, radiation zone, convection zone, photosphere, chromosphere and corona.
3. Discuss and share the information gathered.
4. Present the outcome of your group discussion using multimedia presentation.

Phenomena that Occur on the Surface of the Sun

Phenomena that occur on the surface of the Sun include:
- Granules
- Sunspots
- Solar cycles
- Prominences
- Solar flares
- Coronal mass ejections
- Solar winds

Science Careers

A career as a **solar scientist** is relatively new in the field of solar energy. Besides inventing solar energy equipment, a solar scientist also studies and forecasts space weather which greatly affects daily life on Earth.

Granules, Sunspots and Solar Cycle

The photosphere in the Sun's atmosphere is made up of **granules** which appear as grainy structures. The granules are the upper part of the convection zone of the plasma which is extremely hot with a temperature as high as 5 800°C. The average diameter of a granule is about 1 000 kilometres!

Sunspots are the dark regions seen on the surface of the Sun as shown in Figure 9.2. Sunspots appear dark because their temperatures are lower than their surrounding areas which are made up of granules. Sunspots are the locations of very large eruptions in the photosphere. This phenomenon may last more than a week. Sunspots are phenomena that always exist in pairs or groups.

The activity of the sunspots seems to appear and disappear according to a cycle that lasts 11 years known as the **solar cycle**. Figure 9.3 shows the position of sunspots in the photosphere since 1875.

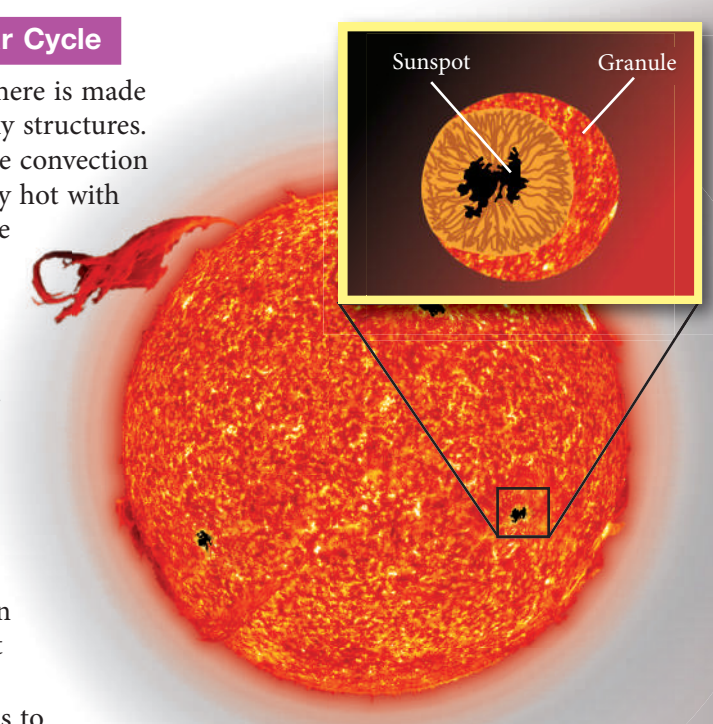
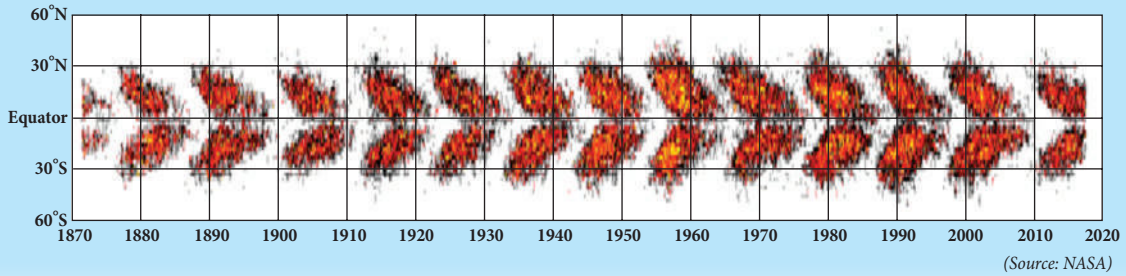


Figure 9.2 *Granules and sunspots*

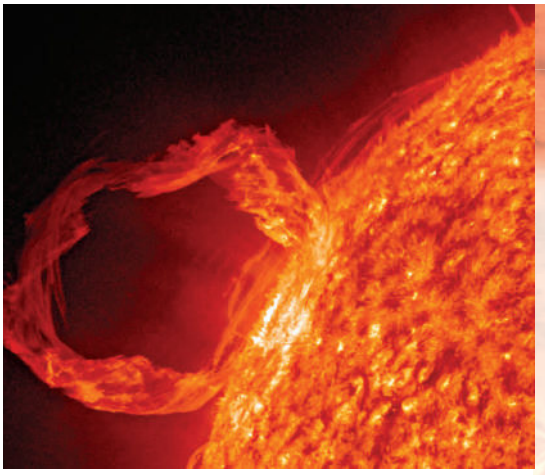


(Source: NASA)

Figure 9.3 *Position of sunspots on the surface of the Sun*

Prominence

A **prominence** shown in Photograph 9.2 is a huge loop or arched column of glowing gases over the sunspot. Prominences can reach heights of hundreds of thousands of kilometres and may last for several days or months. Prominences that are very strong can throw out matter from the Sun into space at speeds ranging from 600 km s^{-1} to more than 1 000 km s^{-1}.

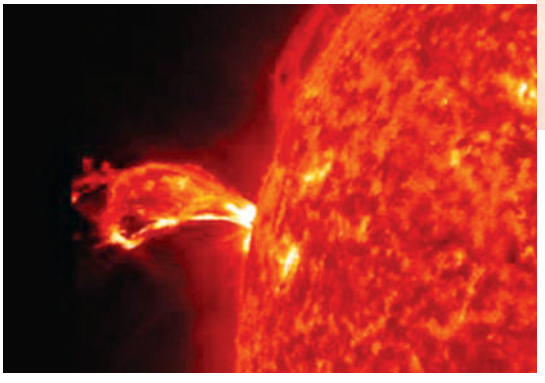


Photograph 9.2 *Prominence*

Solar Flares

A **solar flare** shown in Photograph 9.3 is a column of large amounts of charged gases erupting from the Sun and often occurs near sunspots. Solar flares are strong and spectacular explosions of gases. Solar flares attain their maximum brightness level within a few seconds or minutes and then become dim after a few minutes or hours. Solar flares spout charged gas particles at high speeds into outer space. The light from solar flares which is at the speed of light takes eight minutes to reach Earth while the charged gas particles take tens of minutes.

These charged gas particles often collide with atoms and molecules in Earth's atmosphere to produce a stunning light display in the sky known as **aurora** which uniquely occurs only in the air space around Earth's poles.

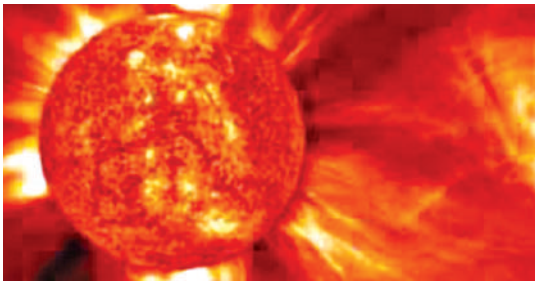


Photograph 9.3 *Solar flare*

Coronal Mass Ejections

A **coronal mass ejection** shown in Photograph 9.4 is a huge cloud of plasma that erupts from the Sun and often occurs together with solar flares which are huge and strong. A coronal mass ejection is an ejection of magnetic gas particles. The coronal mass ejection spouts magnetic particles at high speeds into outer space and appears like an expanding cloud. These magnetic particles from the coronal mass ejection take three days to reach Earth.

Like the charged gas particles in solar flares, the magnetic gas particles also react with atoms and molecules in Earth's atmosphere to produce aurora.



Photograph 9.4 *Coronal mass ejection*

VIDEO

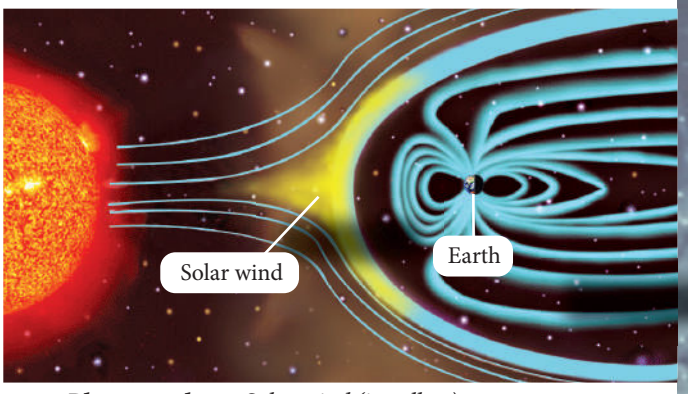
Watch a video on prominences, solar flares and coronal mass ejections.

SCAN PAGE

Solar Wind

Particles in plasma such as electrons, protons and alpha particles that erupt from the Sun to outer space travel together at high speeds known as **solar wind** as shown in Photograph 9.5.

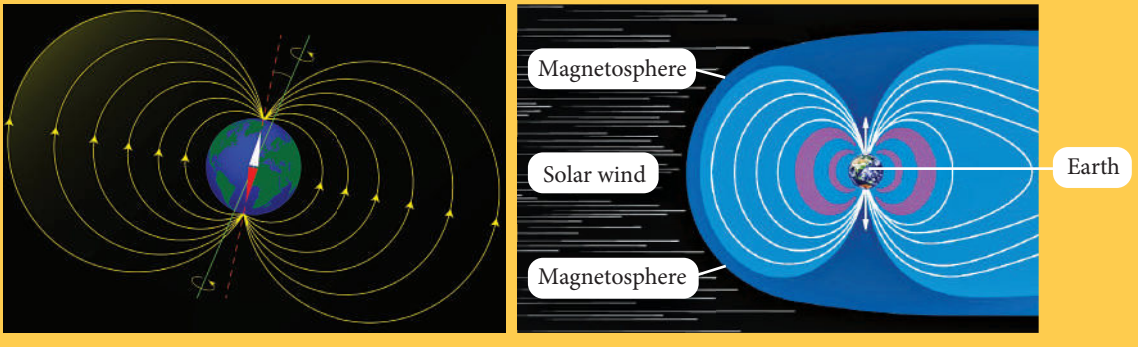
Solar wind also carries the interplanetary magnetic field along with it. The speed of solar wind is supersonic with values ranging from 250 km s^{-1} to 750 km s^{-1}. However, the speed, temperature and density of the solar wind changes along the course of its movement.



Photograph 9.5 *Solar wind (in yellow)*

Earth's Magnetosphere and its Importance

Shape of Earth's Magnetosphere



(a) Earth's magnetic field (b) Earth's magnetosphere

Figure 9.4 *Shape of Earth's magnetosphere*

Compare and contrast the pattern of magnetic field lines between Earth's magnetic field and Earth's magnetosphere. Even though both of these patterns of magnetic field lines are not fixed, the pattern of Earth's magnetic field lines changes slightly while the pattern of the magnetic field lines in the magnetosphere changes a lot based on the interaction between solar wind and Earth's magnetic field.

MARVELS OF SCIENCE

Animation that shows the relationship between magnetosphere and solar wind.

http://links.andl17.com/BT_Science_261

Definition of Earth's Magnetosphere

Earth's magnetosphere is defined as a region in outer space surrounding Earth where the magnetic field in Earth's magnetosphere is a combination of Earth's magnetic field (as the prime magnetic field) and the magnetic field in the region in outer space as shown in Figure 9.4(b).

9.1.2

Formation of Earth's Magnetosphere

Magnetosphere is formed by the interaction between the magnetic field brought by the solar wind and Earth's magnetic field. As the number and energy of particles brought by the solar wind change, the shape of the magnetosphere also changes.

Importance of Earth's Magnetosphere

The **importance of magnetosphere** is to protect Earth from the adverse effects caused by dangerous particles from the Sun or other bodies in the Universe.

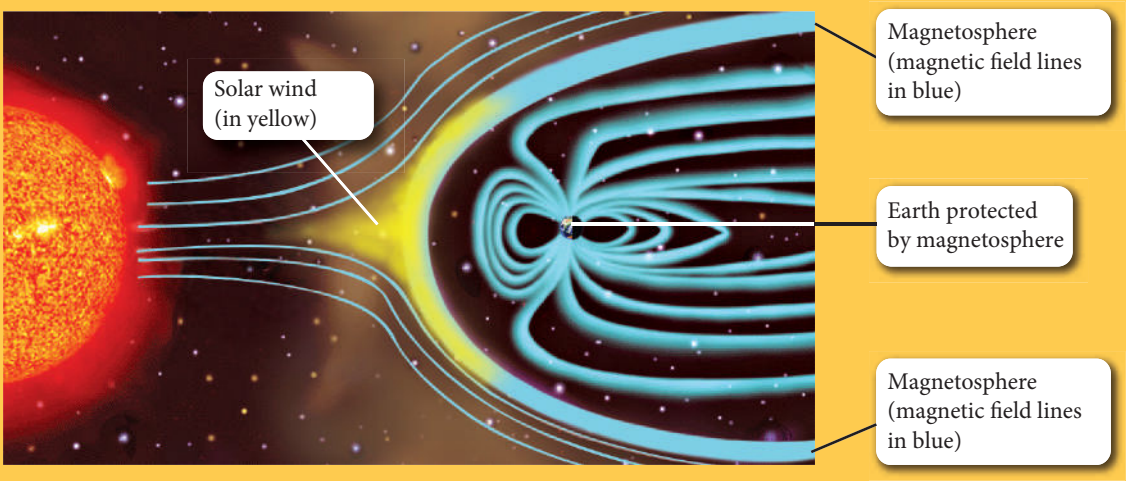


Figure 9.5 *Protection from Earth's magnetosphere*

The magnetosphere:

- functions as a biological shield to protect life on Earth from the adverse effects of solar wind
- blocks charged particles such as electrons, protons and alpha particles in the solar wind from reaching Earth. Excessive numbers of charged particles in Earth's atmosphere will disrupt telecommunication, navigation system and electric power lines
- reduces the pressure exerted by solar wind on Earth's atmosphere

Activity 9.2

21st Century Skills
- ICS, CPS, ISS
- Discussion activity

To gather and share information on the definition, formation, shape and importance of the magnetosphere

Instructions

1. Work in groups.
2. Gather information from the Internet, printed media and other electronic media on the definition, formation, shape and importance of the magnetosphere.
3. Discuss and share the information gathered.
4. Brainstorm on the condition of Earth without the magnetosphere.
5. Present the outcome of your group discussion using multimedia presentation.

Formative Practice 9.1

1. State **three** structures of the Sun that form the Sun's atmosphere.
2. State **three** phenomena that occur on the surface of the Sun where charged gases erupt.
3. Define Earth's magnetosphere.
4. What influences the shape of the magnetosphere?
5. Name **one** object in the Solar System that has the same shape as solar wind.

9.2 Space Weather

Space Weather and its Effect on Earth

Space weather is defined as the phenomena that occur:
- on the **surface of the Sun** such as solar flares, prominences, sunspots and coronal mass ejections
- in **space** such as solar wind, solar radiation storm and geomagnetic storm

Websites

Space weather

http://links.andl17.com/BT_Science_263

Study Figure 9.6. Then, carry out Activity 9.3.

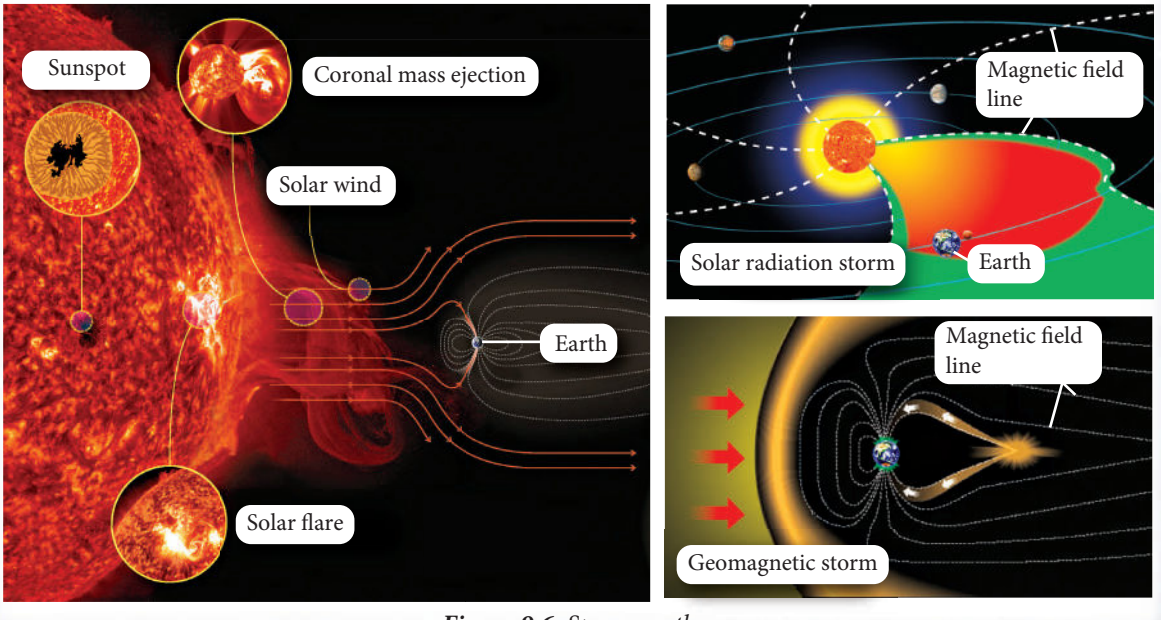


Figure 9.6 *Space weather*

Activity 9.3

21st Century Skills
- ICS, CPS, ISS
- Discussion activity

To gather and share information on the definition of space weather and its effects on Earth

Instructions

1. Work in groups.
2. Gather information from the Internet, printed media and other electronic media on the definition of space weather and effects on Earth such as the formation of the aurora, disturbances to telecommunication, navigation system as well as electrical power lines.

Space storms
http://links.andl17.com/BT_Science_264_1

Effects of geomagnetic storm, solar radiation storm and disturbances of radio transmission
http://links.andl17.com/BT_Science_264_2

3. Discuss and share the information gathered.
4. Present the outcome of your group discussion using multimedia presentation.

Interpretation of Data on Space Weather

Data on space weather is used or analysed to:
- forecast when coronal mass ejections occur in the Sun
- determine the reasons for the occurrence of solar flares and coronal mass ejections on the surface of the Sun

Activity 9.4

21st Century Skills
- ICS, CPS, ISS
- Discussion activity

To interpret data on space weather

Instructions

1. Work in groups.
2. Gather information or data on space weather from the Internet, printed media and other electronic media.

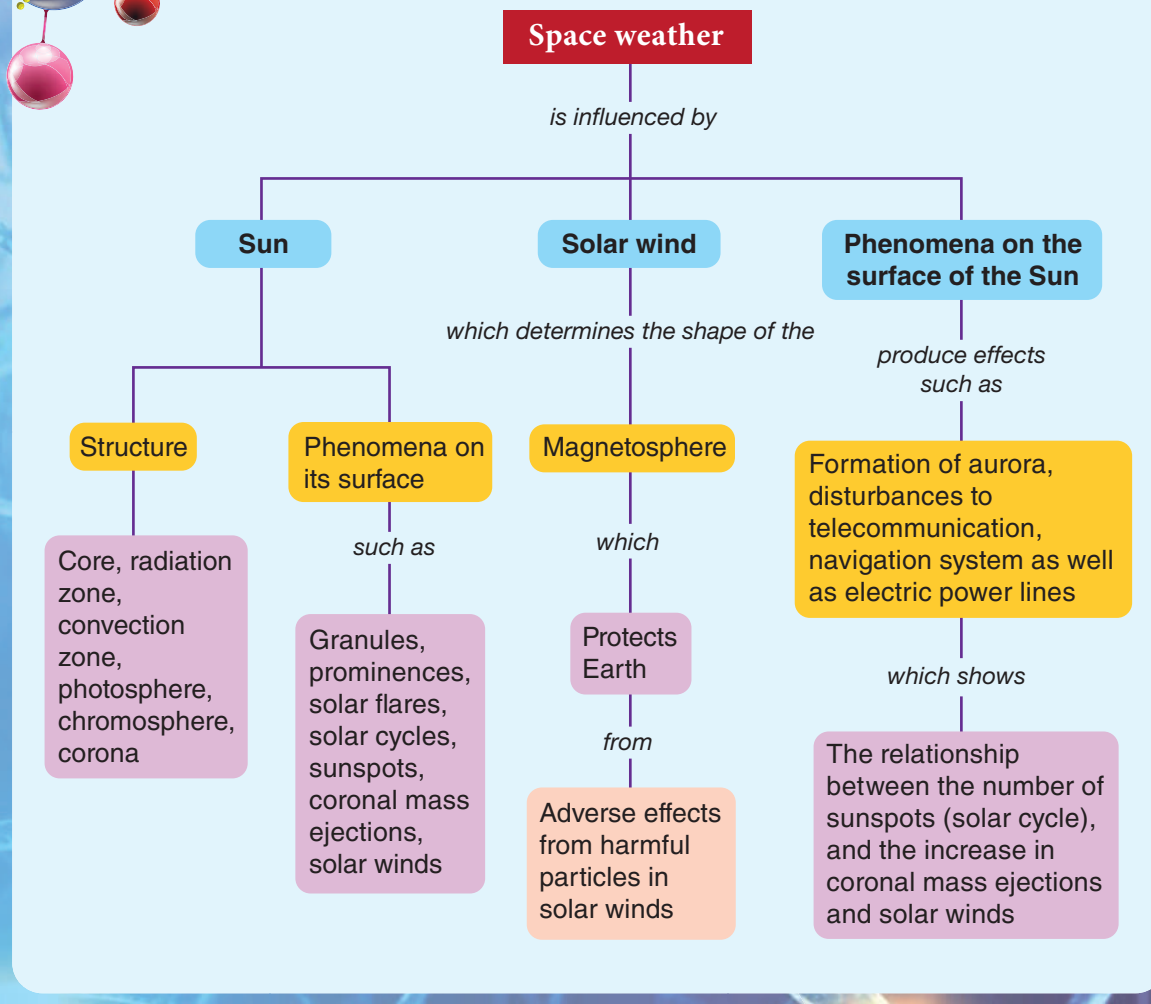
Sources of solar wind in relation to solar cycle
http://links.andl17.com/BT_Science_264_3

3. Interpret data on space weather by relating the number of sunspots or solar cycles with the increase in coronal mass ejections and solar winds.
4. Present your group's interpretation of space weather data using multimedia presentation.

Formative Practice 9.2

1. What is the definition of space weather?
2. State **four** examples of the effects of space weather on Earth.
3. What is the relationship between the number of sunspots and the increase in coronal mass ejections?

Summary



Self-reflection

After studying this chapter, you are able to:

9.1 Activities of the Sun that Affect Earth

- ☐ Explain the structure of the Sun and phenomena that occur on the Sun's surface by drawing.
- ☐ Justify the importance of Earth's magnetosphere.

9.2 Space Weather

- ☐ Communicate space weather and its effects on Earth.

Summative Practice 9

Answer the following questions:

1. Figure 1 shows the structure of the Sun.

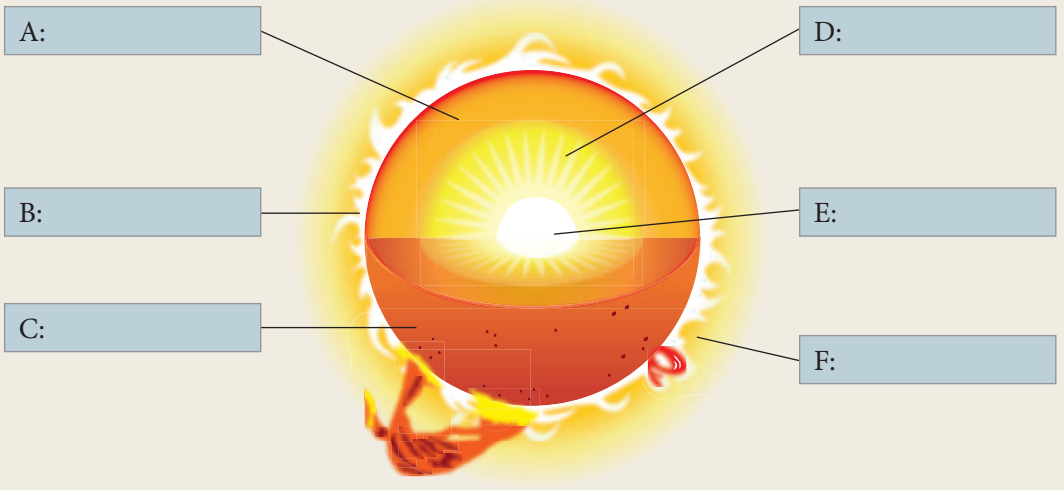


Figure 1

Name the structures labelled A to F using the following words:

Photosphere	Corona	Chromosphere
Core	Convection zone	Radiation zone

2. What is the duration of one solar cycle?

3. State the phenomenon related to solar cycle.

4. State **three** examples of equipment or service used daily which is disrupted by solar winds.

5. What would happen to the condition of Earth if there is no magnetosphere? Explain your answer.

Focus on HOTS

6. Earth's magnetosphere shown in Figure 2, is a region in space which protects Earth.

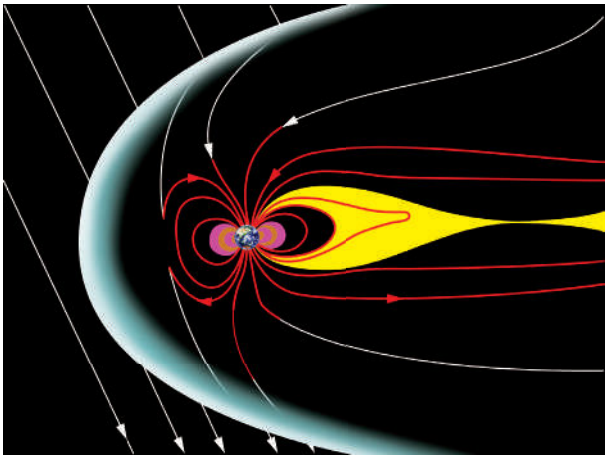


Figure 2

The shape of Earth's magnetosphere is produced by the interaction between Earth's magnetic field and solar wind. Magnetic field lines from other planets in the Solar System are represented by white lines while Earth's magnetic field lines are represented by red lines as shown in Figure 2.

You are required to create a model of the magnetosphere using the following materials:

- Green-coloured plastic bag
- White thread
- Red thread
- Polystyrene cup with a convex cover
- Plasticine

Sketch the model of the magnetosphere. Explain how the model functions.

Chapter 10

Space Exploration

How can the model of the Solar System be improved from time to time?

Give three examples of technological invention devices applied in space exploration.

Give an example of the use of remote sensing technology in field of geology.

Let's study

- Development in astronomy
- Development of technology and its application in space exploration

Science Gallery

International Space Station, ISS

The International Space Station (ISS) is a station that facilitates international research in space. The function of this station is to carry out research in space and monitor space.

Dato' Dr Sheikh Muszaphar Shukor Al Masrie bin Sheikh Mustapha is the first astronaut from Malaysia to carry out experiments in space from 10 October to 21 October 2007.

Keywords

- Geocentric
- Heliocentric
- Kepler's Law
- Ellipse
- Focal point
- Rocket
- Satellite
- Space probe
- Remote sensing
- Geology
- Disaster management
- Space Telescope

10.1 Development in Astronomy

Historical Development of the Solar System Model

Study Figure 10.1. Then, carry out Activity 10.1.

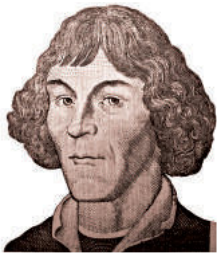
History of the Solar System Model

Ptolemy
(90 – 168 A.D.)

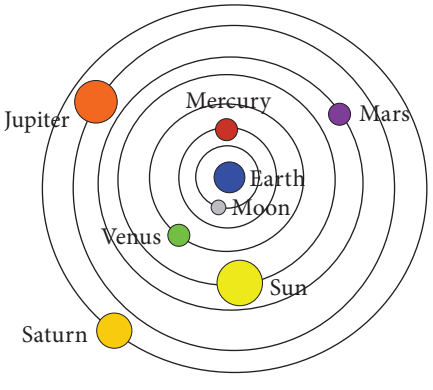
- Greek astronomer, astrologer and geographer
- Built the **geocentric** model with Earth at the centre and circular orbits

Copernicus
(1473 – 1543)

- Polish astronomer, mathematician, economist and doctor
- Built the **heliocentric** model with the Sun at the centre and circular orbits

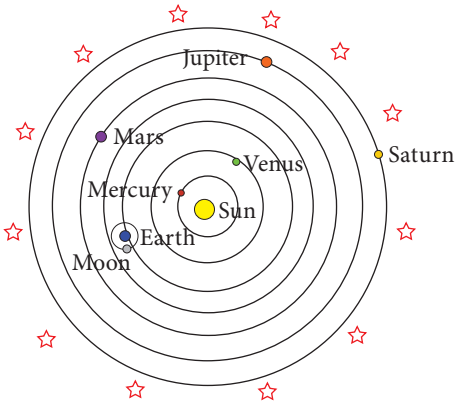


Geocentric model



- 'Geo' means Earth
- 'Centric' means centre
- Earth is at the centre of the Solar System
- Earth is stationary and all the objects such as the Sun and other planets revolve around Earth in circular orbits

Heliocentric model



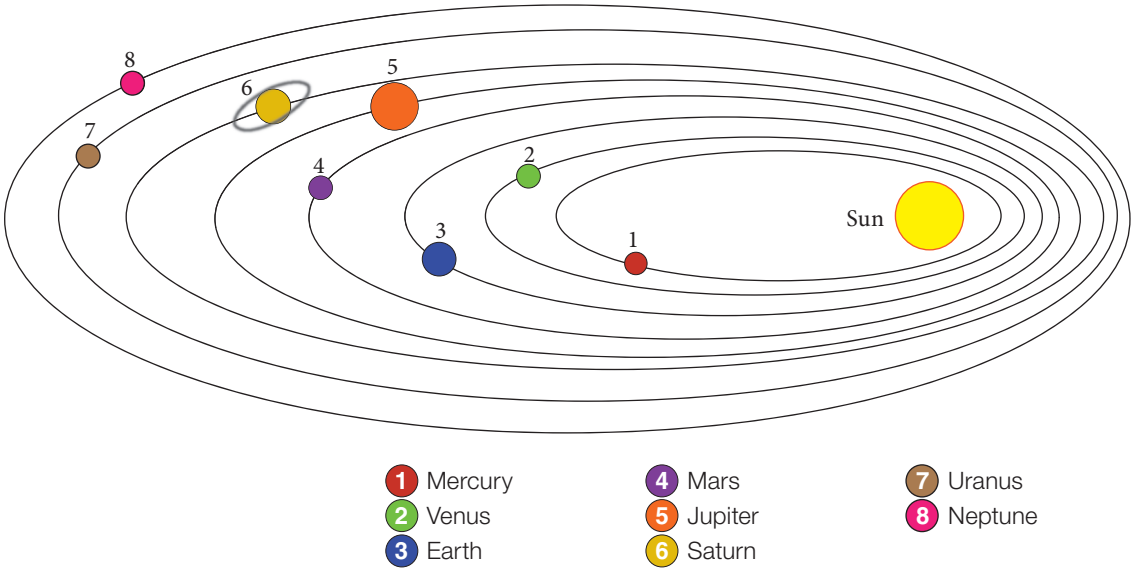
- 'Helio' means the Sun
- 'Centric' means centre
- The Sun is at the centre of the Solar System
- Earth rotates on its axis and revolves around the Sun in a circular orbit

Figure 10.1 *History of the Solar System model*

Kepler
(1571 – 1630)

- German astronomer, mathematician and astrologer
- Modified the **heliocentric** model with the Sun at one common focal point on the elliptical orbits of the planets according to **Kepler's Law**

Modified Heliocentric model according to Kepler's Law



Activity 10.1

21st Century Skills
- ICS
- Discussion Activity

To understand the development of the Solar System models built by Ptolemy, Copernicus and Kepler

Instructions

1. Work in groups.
2. Carry out active reading by visiting websites or going on a study tour to the National Planetarium to gather information on the development of the Solar System models built by:
   (a) Ptolemy
   (b) Copernicus
   (c) Kepler
   Examples of websites are as follows:

Watch these sections of the video
3.01 *Historical Solar System Models*
3.02 *Current Solar System Model*
http://links.and117.com/BT_Science_272_1

Historical attempts to model the Solar System (Take a challenge)
http://links.and117.com/BT_Science_272_2

History of the Solar System model
http://links.and117.com/BT_Science_272_3

3. Discuss and present to the class how knowledge gained through scientific research is the product of human effort to obtain rational explanations about natural phenomena.
4. Present the outcome of your group discussion using multimedia presentation.

Formative Practice 10.1

1. Name the Solar System model built by the following astronomers:
   (a) Ptolemy
   (b) Copernicus
   (c) Kepler

2. Compare and contrast the Solar System models built by Ptolemy and Copernicus.
   (a) Similarities
   (b) Differences

3. Compare and contrast the Solar System models built by Copernicus and Kepler.
   (a) Similarities
   (b) Differences

10.2 Development of Technology and its Application in Space Exploration

Development in Space Exploration

Figure 10.2 shows part of the early history of space exploration in terms of technology development and missions in space exploration.

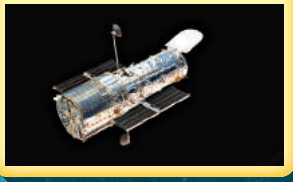
2011: Construction of International Space Station (ISS) completed

2002: National Space Agency (*Agensi Angkasa Negara*) established

2000: Malaysia's first microsatellite TiungSAT-1 launched

1996: Malaysian satellites MEASAT 1 and 2 launched

1990: US launched Hubble Space Telescope from space shuttle Discovery



1989: First Neptune flyby – US Voyager 2

1981: First flight of US space shuttle – Columbia

1973: First Jupiter flyby – US Pioneer 10

1969: First human to set foot on the Moon – Neil Armstrong, US Apollo 11

1961: First human to orbit Earth – Yuri Gagarin, aboard USSR Vostok 1

1957: First satellite – USSR Sputnik 1

1609: First telescope used in the field of astronomy by Galileo Galilei

11th century: Chinese invented gunpowder and used primitive rockets in battles

Figure 10.2 *Some of the events related to the development of technology in space exploration*

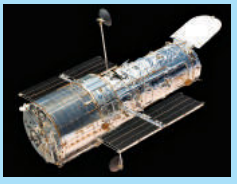
Applications of Technology in Space Exploration and their Importance

Space Telescope

Figure 10.3 shows the development of the telescope.

The astronomical **sextant** is used to measure the altitude of stars

Galileo's Telescope became the most widely used astronomical instrument



Hubble space telescope was placed in an orbit 500 km from the surface of Earth

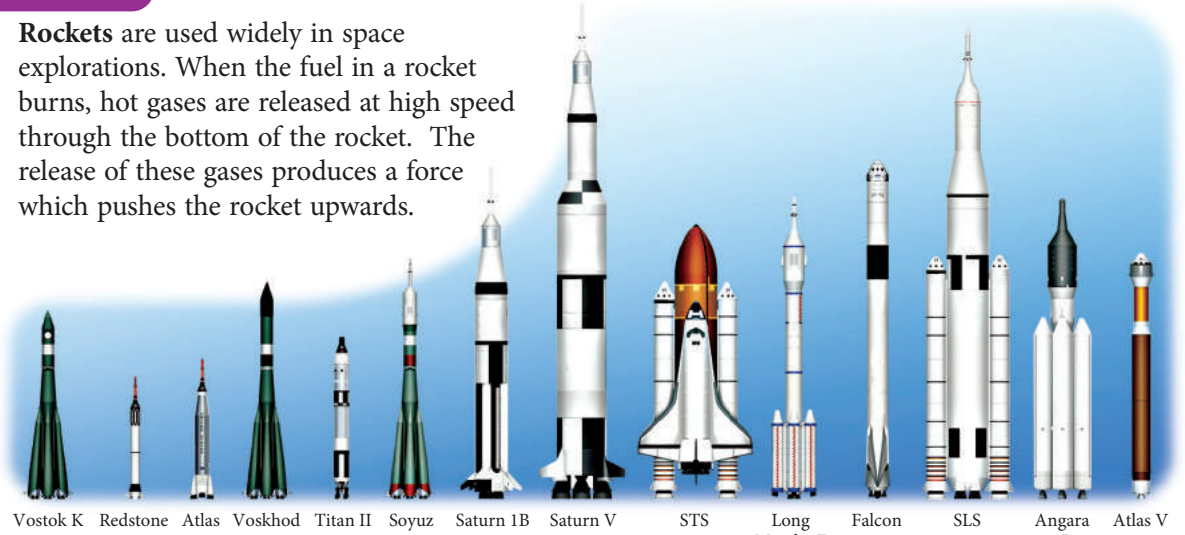
The **Spitzer space telescope** detects very distant activities in space.

Apart from optical telescopes, **radio telescopes** are also used to detect radio waves from space.

Figure 10.3 *Space telescopes*

Rocket

Rockets are used widely in space explorations. When the fuel in a rocket burns, hot gases are released at high speed through the bottom of the rocket. The release of these gases produces a force which pushes the rocket upwards.



Photograph 10.1 *Rockets used to send humans to space*

Based on Photograph 10.1, which rocket was used to send astronauts to the Moon?

Satellite

The first satellite, Sputnik 1 was sent to outer space in 1957. How many satellites are orbiting around Earth today? Which country has the largest number of satellites?

Photograph 10.2 *Weather satellite GOES-16 gathers data on solar flares*

Websites

Satellite launch

http://links.andl17.com/BT_Science_275

Space Probe

A **space probe** is a spacecraft that gathers information and sends it back to Earth. Space probes do not orbit Earth like satellites but travel further into and out of the Solar System. Space probes carry cameras and remote sensing instruments as well as radio transmitters and receivers for the purpose of communicating with scientists on Earth.

Photograph 10.3 *Space probe Cassini*

MARVELS OF SCIENCE

In 2017, space probe Cassini was still active orbiting Saturn even after 20 years in space.

Remote Sensing

Remote sensing is a method of gathering and recording information from a distance. In Malaysia, remote sensing instruments are fitted to TiungSAT-1 to receive or detect visible, ultraviolet and infrared lights produced by objects on the surface or below the surface of Earth. The information gathered by TiungSAT-1 is then sent to two data receiving stations at the National Planetarium Station, Federal Territory of Kuala Lumpur and the Mission Control Station (MCGS), Bangi, Selangor.

Photograph 10.4 shows the pattern and movement of clouds taken from TiungSAT-1's remote sensing camera. What is the use of the information obtained from this photograph?

Remote sensing technology is used in various fields in daily life as follows:

- **Agriculture** – To detect suitable regions for agricultural development
- **Geology** – To detect locations such as mineral sources, mass depletion and land depletion
- **Disaster management** – To identify pollution and forest fires
- **Defence** – To detect intrusions of enemy ships, aircraft and vehicles

Photograph 10.4 *A picture of the pattern and movement of clouds*

Activity 10.2

To understand the development of technology in space exploration

21st Century Skills
- ICS
- Discussion activity

Instructions

1. Work in groups.
2. Carry out active reading by visiting websites or going on a study tour to the National Planetarium, MACRES and National Space Agency to gather information on the development of technology in space exploration in:
   (a) early history of space exploration
   (b) the construction of rocket, satellite and space probe
   (c) remote sensing used in agriculture, geology, disaster management and defence
3. Discuss and present the development and technological applications in space exploration and their importance.
4. Present the findings of your group discussion using multimedia presentation.

Activity 10.3

To debate the issue of continual space exploration

21st Century Skills
- ISS, CPS
- Project-based activity

Instructions

1. Work in groups.
2. Gather information from the Internet, printed media and other electronic media on the importance of space exploration in the local and global context.
3. Share and discuss the gathered information.
4. Debate the issue of continual space exploration in the local and global context.

Formative Practice 10.2

1. Name the first technological device used in space exploration.

2. Study Figure 1.
   (a) What is Discovery?
   (b) What is Hape?

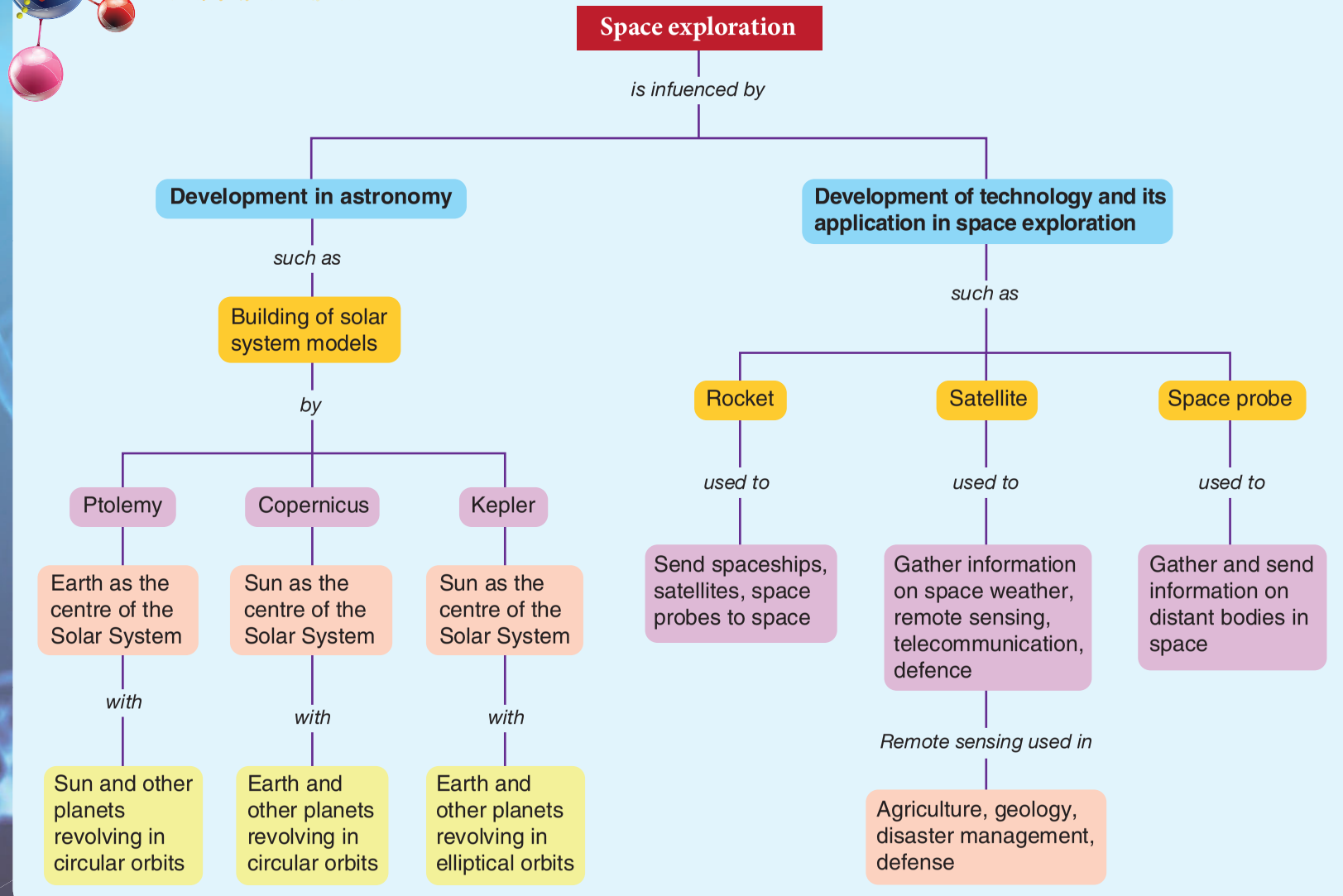
3. (a) Name the technology used to take aerial photographs.
   (b) What is the importance of taking aerial photographs during floods?

4. What is the role played by the Malaysian Remote Sensing Agency (MACRES)?

Figure 1

10.2.1 10.2.2

Summary


Space exploration
is influenced by
Development in astronomy
such as
Building of solar system models
by
Ptolemy
Earth as the centre of the Solar System
with
Sun and other planets revolving in circular orbits
Copernicus
Sun as the centre of the Solar System
with
Earth and other planets revolving in circular orbits
Kepler
Sun as the centre of the Solar System
with
Earth and other planets revolving in elliptical orbits
Development of technology and its application in space exploration
such as
Rocket
used to
Send spaceships, satellites, space probes to space
Satellite
used to
Gather information on space weather, remote sensing, telecommunication, defence
Remote sensing used in
Agriculture, geology, disaster management, defense
Space probe
used to
Gather and send information on distant bodies in space

Self-reflection

After studying this chapter, you are able to:

10.1 Development in Astronomy

☐ Explain the historical development of the Solar System model by drawing.

10.2 Development of Technology and its Application in Space Exploration

☐ Communicate the importance of the development of technology and its application in space exploration.

☐ Justify the need to continue space exploration.

Summative Practice 10

Answer the following questions:

1. Figure 1 shows the Spitzer space telescope.

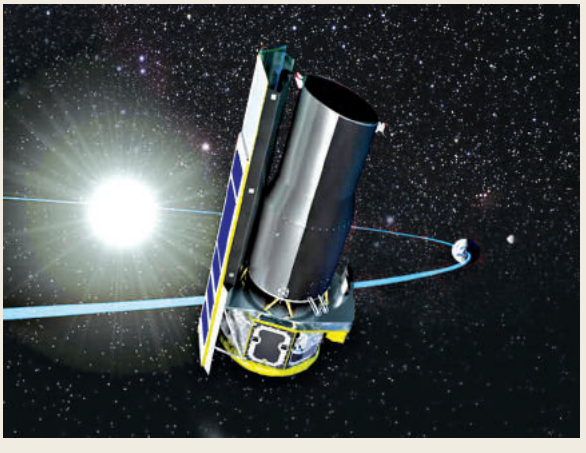


Figure 1

Mark '✓' for the correct statements and '×' for the incorrect statements.

(a) The Spitzer space telescope is located on the surface of Earth.	
(b) The Spitzer space telescope 'observes' better than ordinary telescopes.	
(c) The Spitzer space telescope is used to take photographs of Earth's surface.	
(d) The Spitzer space telescope is used as a remote sensing equipment.	

2. Match the Solar System model to the astronomer who built it.

Solar System model	Astronomer
(a) Earth is at the centre of the Solar System and the Sun revolves around Earth in a circular orbit.	Copernicus
	Kepler
(b) The Sun is at the centre of the Solar System and Earth revolves around the Sun in an elliptical orbit.	Ptolemy

3. How can knowledge about astronomy be acquired through scientific investigation?

4. Why are space probes not used to send astronauts into space?

5. Figure 2 shows a space probe sent to Saturn.

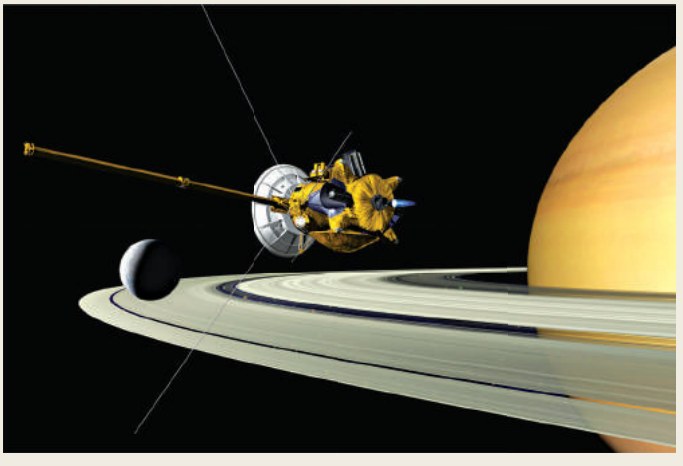


Figure 2

(a) What is the function of this space probe?

(b) State **one** example of a phenomenon that occurs on the surface of the Sun that might destroy the space probe.

(c) State the source of energy used by the space probe.

6. State **two** examples of the use of remote sensing technology in the following fields:

(a) Agriculture

(b) Geology

(c) Disaster management

(d) Defence

7. Figure 3 shows a rocket.

Figure 3

(a) What is a rocket?
(b) What is the function of rocket in space exploration?
(c) Explain **one** misuse of rocket in our daily life.

8. Astronomers have successfully discovered three planets revolving around the TRAPPIST-1 star which are suitable for all life on Earth.

As these three planets are extremely far, a special spacecraft needs to be invented to transfer life on Earth to these planets.

You are required to invent a model of the spacecraft using the following materials:

- Cardboard
- Cellophane tape
- Black plastic sheet
- Aluminium foil

ANSWERS

CHAPTER 1 Stimuli and Responses

Activity 1.1 (p. 7)

Questions

1. Stimulus: Seeing your partner let go of the ruler.
   Response: Catching the ruler using your thumb and index finger.
   This is a voluntary action because it is a conscious action and is made according to the will of the individual who received the stimulus and is controlled by the brain.
2. The distance moved by the ruler shows the time taken by the student to catch the ruler. The shorter the distance, the faster the reaction time.
3. Different students usually have different reaction time. Besides this, the reaction time of an individual is not constant.
4. In the daily life of humans, reaction time plays an important role to coordinate and control organs and body parts so that they function harmoniously and efficiently.

Activity 1.3 (p. 9)

Questions

1. Stimulus: Intensity of light that enters the eye.
   Response: Change in size of the pupil.
   This is an involuntary action because this action occurs spontaneously without any conscious control or prior thoughts.
2. The higher the intensity of light, the smaller the size of the pupil.
3. This response can help protect the eye from injury.

Brain Teaser (p. 10)

Muscular system

Formative Practice 1.1 (p. 10)

1. Central nervous system and peripheral nervous system
2. (a) Voluntary actions are conscious actions, carried out according to the wishes of a person and are controlled by the brain.
   Examples of controlled actions are reading, writing, speaking, eating, drinking, walking, running, exercising and singing.
   (b) Involuntary actions are spontaneous actions that happen without being realised or thought of beforehand.
   Examples of uncontrolled actions are heartbeat, breathing, peristalsis, secretion of saliva and sneezing.
3. Injured nerve cells in the human brain are unable to interpret impulses from affectors and cannot send impulses to effectors. Due to this, a person who sustained brain injury is unable to carry out voluntary or involuntary actions involving the brain.
4. The network of nervous system of humans functions to control and coordinate organs and body parts so as to carry out processes in the body and daily activities.

Brain Teaser (p. 15)

Excess mucus is produced when a person suffers from a cold. This excess mucus will obstruct receptors from being stimulated by chemical substances in the air entering the nasal cavity.

Brain Teaser (p. 16)

A blind person uses the sensitivity of the fingertip to read Braille and sensitivity of the hand to detect vibrations of the walking stick when it hits objects to detect any nearby obstructions.

Activity 1.6 (pp. 19, 20)

Questions

1. Tip of index finger. It has the largest number of receptors.
2. Elbow. It has the least number of receptors.
3. Touch receptor.
4. Number of touch receptors and thickness of epidermis.

Activity 1.7 (p. 21)

Questions

1. To ensure no other solutions remain and only the taste of one solution is detected during each attempt.
2. All areas of the tongue can detect all tastes of the solutions.
3. Both sides of the tongue are most sensitive towards taste because they have a large number of taste receptors.
4. The middle part of the tongue is least sensitive to taste because it has a small number of taste receptors.
5. The front part of the tongue is more sensitive to sweet taste, the sides of the tongue are more sensitive to sour and sweet tastes, the back part of the tongue is more sensitive to bitter taste and the middle part of the tongue is more sensitive to umami.

Brain Teaser (p. 22)

No. After the tongue is cleaned, the tongue will become more sensitive.

Activity 1.8 (pp. 22, 23)

Questions

1. Without the nose being pinched.
2. Taste of the cordial drink is more easily detected using a combination of sense of taste and sense of smell.
3. So that your partner does not use sense of sight to determine the taste of the cordial drink based on the colour such as purple for taste of grape, orange for taste of orange, yellow for taste of mango and red for taste of strawberry.
4. In addition to chemical substances in food which dissolve in saliva and stimulate the taste buds, chemical substances in hot food also evaporate to form vapour which enters the nasal cavity and stimulates the smell sensory cells. The combination of sense of taste and sense of smell causes hot food to taste better.

Formative Practice 1.2 (p. 29)

1. (a) Cornea
   (b) Pupil
   (c) Retina
   (d) Brain
2. Semicircular canals
3. At the upper part of the nasal cavity
4. Sweet, sour, salty, bitter, umami
5. Number of receptors and thickness of skin epidermis
6. (a) Five types of taste, touch, pain, hot objects, cold objects, and pressure.
   (b) Five types of taste can be detected by taste receptors in the taste buds of the tongue. The tongue is protected by skin that has touch, pain, heat, cold and pressure receptors. Therefore, it can detect touch, pain, hot objects, cold objects and pressure.

Experiment 1.1 (pp. 30 – 33)

A. Questions (p. 31)

1. Light
2. Shoot of the plant
3. The shoot of the plant shows positive phototropism because shoots of plants grow towards the direction of light.

B. Questions (p. 32)

1. So that light cannot influence the growth of the seedlings.
2. (a) Grow upwards against the direction of gravity.
   (b) Grow downwards in the direction of gravity.
3. Roots of plants show positive geotropism because the roots of plants grow towards the direction of gravity. Shoots of plants show negative geotropism because shoots of plants grow against the direction of gravity.

C. Questions (p. 33)

1. Water
2. Roots of the plant
3. Absorbs water and moisture in the air in beaker Y
4. The roots of the plants show positive hydrotropism because they grow towards water.

Formative Practice 1.3 (p. 35)

1. (a) Tropism is a directed response of plants towards stimuli coming from a certain direction.
   (b) (i) Thigmotropism
   (ii) Geotropism
   (iii) Phototropism
2. (a) (i) Shoots
   (ii) Roots
   (iii) Tendrils or winding shoots
   (b) Positive hydrotropism allows roots to obtain water and dissolved mineral salts to survive.
3. Similarity: Tropism and nastic response are responses of plants towards stimuli.
   Difference: Tropism is the directed response of plants towards stimuli while nastic response is the response towards stimuli without considering their direction.

Brain Teaser (p. 37)

The blind have a more sensitive sense of hearing. They make use of sound to detect location and estimate distance of nearby objects.

Formative Practice 1.4 (p. 39)

1. Stereoscopic and monocular vision.
2. Location of eyes on the head.
3. Primary consumer has monocular vision. Monocular vision has a wide field of vision and allows it to detect predators coming from various directions.
4. Stereophonic hearing allows us to determine the direction of sound accurately.
5. Azman uses his stereophonic hearing to determine the cat's location. The time and loudness of the sound made by the cat received by both of Azman's ears are the same. The brain then informs Azman the direction of the cat making the sound.

Summative Practice 1 (pp. 41 – 43)

1. (a) ×
   (b) ✓
   (c) ×
   (d) ✓
2. P: Brain
   Q: Spinal cord
   R: Peripheral nerve
3. (a) Changes in the size of the pupil of the eye.
   (b) Intensity of light which enters the eye.
   (c) The lower the intensity of light directed towards the eye, the larger the size of the pupil of the eye.
   (d) During a solar eclipse, the bright rays of the sun will enter the eye and damage the cells of the retina.
4. (a) Sound → Earlobe → Ear canal → Eardrum → Ossicles → Oval window → Cochlea → Auditory nerve → Brain
   (b) Light → Cornea → Aqueous humour → Pupil → Eye lens → Vitreous humour → Retina → Optic nerve → Brain
5. (a) X: Touch receptor
   Y: Pain receptor
   (b) Fingertip is more sensitive towards touch stimuli compared to the palm of the hand.
   Fingertip has a thinner layer of epidermis and more touch receptors compared to the palm of the hand.
   (c) Agree. The tongue is a sensory organ that has receptors known as taste buds on the surface of the tongue which is protected by skin epidermis.
6. (a) The sense of smell helps us to detect danger such as leakage of gas that might occur in the science laboratory. For example, we can detect the presence of dangerous gases such as chlorine and ammonia from their smell.
   (b) Dogs have a very sensitive sense of smell because they have more sensory cells for smell than human

and are more efficient to analyse smell than human.

7. (a) – Positive phototropism
   – Positive hydrotropism
   (b) Positive phototropism ensures shoots and leaves of plants obtain sufficient sunlight to make food through photosynthesis.
   Positive hydrotropism allows roots of plants to grow towards water so that they can absorb water to enable plants to carry out photosynthesis.
8. (a) Stereoscopic vision
   (b) The eagle is a predatory animal. Stereoscopic vision helps the eagle to hunt its prey by accurately determining the location of its prey.
9. Explanation:
   – Fill the transparent plastic bottle with water.
   – It functions as a convex lens.
   – Place it on top of the newspaper.
   – Read the newspaper through it.

CHAPTER 2 Respiration

Experiment 2.1 (pp. 50 – 52)

Question (p. 51)

– The water level in the gas jar containing inhaled air is higher.
– Composition of oxygen in inhaled air is higher than that in exhaled air.
– Burning of candle using the oxygen in the gas jar causes water to enter to fill the space originally filled with oxygen.

Question (p. 52)

– Limewater in the conical flask where exhaled air was passed through turns cloudy.
– Carbon dioxide in the exhaled air reacts with the limewater.

Formative Practice 2.1 (p. 53)

1. (a) Trachea
   (b) Bronchus
   (c) Bronchiole
2. (a) ✓
   (b) ×
   (c) ×
   (d) ×
3. To provide sufficient oxygen and eliminate carbon dioxide from the air.
4. (a) (i) Rib cage
   (ii) Diaphragm
   (iii) Trachea and bronchus
   (iv) Lungs
   (b) – A thin rubber sheet stretches more easily compared to a thick rubber sheet.
   – Therefore, a thin rubber sheet is more easily pulled downwards or pushed upwards.
   (c) (i) Breathing in or inhaling
   (ii) Exhaling
   (d) – The structure or volume of the glass jar which represents the rib cage is fixed when the thin rubber sheet is pulled downwards or pushed upwards.
   – While the structure and volume of the rib cage changes during the processes of inhaling or exhaling.

Formative Practice 2.2 (p. 56)

1. Difference in concentrations of oxygen gas in the alveolus and blood capillaries.
2. (a) When concentration of oxygen is high, haemoglobin will combine with oxygen chemically to form oxyhaemoglobin which is unstable.
   (b) When concentration of oxygen is low, oxyhaemoglobin will decompose to form haemoglobin and oxygen.
3. Glucose + oxygen $\rightarrow$ carbon dioxide + water + energy
4. Efficiency of exchanging oxygen in the human body decreases at high altitudes. Concentration of oxygen in the air at high altitudes is low. Due to this, the rate of diffusion of oxygen from the alveolus into the blood capillaries is also low.
5. – Thickness of wall of alveolus and blood capillary is one cell thick
   – The wall of alveolus is moist
   – Alveolus with large surface area
   – Dense network of capillaries covering alveolus

Brain Teaser (p. 57)

Forests help to maintain the balance of oxygen and carbon dioxide in the atmosphere.

Brain Teaser (p. 58)
Smoking endangers the health of the smoker and everyone in the vicinity of the smoker.

Brain Teaser (p. 59)
Electric buses do not emit exhaust gases. Therefore, air pollution can be reduced.

Experiment 2.2 (pp. 62, 63)
Questions
1. Cigarette tar
2. Cigarette smoke is an acidic substance because it changes the purple colour of litmus solution to red.
3. Ammonia, stearic acid, methane, butane, methanol, toluene, cadmium, arsenic, acetone

Formative Practice 2.3 (p. 63)
1. (a) Tar, pollen, haze and dust
   (b) Sulphur dioxide, carbon monoxide, nitrogen dioxide
2. Pollen
3. (a) Pain during breathing
   (b) Blood in phlegm
   (c) Frequent shortness of breath
   (d) Wheezing sound when breathing
4. Lung cancer, emphysema, bronchitis, (any two)
5. A person who does not smoke but who breathes in cigarette smoke from smokers nearby.

Formative Practice 2.4 (p. 66)
1. (a) Gills
   (b) Trachea
   (c) Moist outer skin
2. Thin outer skin of frogs, dense network of blood capillaries under the layer of skin, very permeable to respiratory gases and moist.
3. Body cells of insects have a direct connection with the respiratory surface. Oxygen that enters the tracheole diffuses directly into the cells while carbon dioxide diffuses out.
4. When we exercise, our rate of respiration increases. Higher rate of transport of oxygen to body cells and higher rate of elimination of carbon dioxide from body cells result in healthier body cells. Due to this, the health of all systems in the body especially the respiratory system is maintained.
5. Not smoking, frequent exercise

Brain Teaser (p. 67)
Organ of gaseous exchange.

Brain Teaser (p. 71)
Air is always moving from one region to another region. Therefore cooperation from the global society is required. Prevention in only one region would not be effective.

Formative Practice 2.5 (p. 72)
1. Leaves, stem, aerial roots
2. P: Guard cell Q: Stomatal pore
3. (a) Stomata open during the day. Water diffuses into guard cells through osmosis causing the guard cells to bend and open the stoma.
   (b) Stomata close at night. Water diffuses out of guard cells through osmosis causing the guard cells to straighten up and close the stoma.
   (c) Stomata are closed on hot days to prevent excessive loss of water through transpiration.
4. Polluted air will reduce the amount of sunlight reaching the plants and reduce the rate of photosynthesis. Hence, the growth and survival of plants will be jeopardised.

Summative Practice 2 (pp. 74 – 77)
1. (a) Alveolus
   (b) Bronchus
   (c) Nasal cavity
2. P: Trachea
   Q: Bronchus
   R: Alveolus
3. (a) ✓
   (b) ✓
   (d) ✓
4. (a) higher
   (b) lower
5. (a) Haemoglobin transports oxygen from the red blood cell to body cells.
   (b) Oxyhaemoglobin easily decomposes into haemoglobin and oxygen when

it reaches body cells so that oxygen can diffuse into the cells.

6. (a) Azura may be allergic to pollen. In Spring, more pollen is released from anthers. When Azura inhales air containing pollen, there is a higher risk of her getting an asthma attack.

(b) Any place that is hazy and dusty.
Examples: industrial areas, construction sites and others.
Haze and dust also cause asthma attacks in asthma patients.

7. (a) – Thickness of the wall
– Moisture of the wall
– Surface area
– Network of capillaries

(b) (i) Asthma
Symptom: Shortness of breath
Cause: Excessive release of mucus on the surface of alveolus reduces the surface area and rate of gaseous exchange in the alveolus thereby causing shortness of breath.

(ii) Bronchitis
Symptom: Shortness of breath
Cause: Inflammation of the bronchus in bronchitis patients caused by tar and irritants in cigarette smoke reduces the rate of movement of air from the nose to the lungs through the bronchus. This causes bronchitis patients to be frequently breathless.

(iii) Emphysema
Symptom: Shortness of breath
Cause: The alveolus in emphysema patients is damaged by dangerous substances in the air such as irritants in cigarette smoke. Hence, the surface area for gaseous exchange in the alveolus is reduced causing shortness of breath.

8. – Stop smoking.
To avoid harmful substances found in cigarette smoke from entering the lungs and harming the respiratory system.
– Avoid places with polluted air.
To avoid inhaling air that contains harmful substances such as cigarette tar, carbon monoxide, sulphur dioxide, nitrogen dioxide, haze, dust and pollen which are harmful to the respiratory system.
– Have proper exercise and lead a healthy lifestyle.
To maintain a healthy respiratory system.

9. Users at the waiting areas will become passive smokers if there are other users nearby who smoke. This is harmful to their health.

10. (a) Gaseous exchange is through diffusion into cells.

(b) The respiratory system of insects is more effective than the human respiratory system.

(c) Gaseous exchange through direct diffusion into the cells of insects is easier, quicker and more efficient compared to gaseous exchange through transport of gases by blood in the human body.

11. (a) Carbon monoxide

(b) When the air in a car which contains carbon monoxide is inhaled, the carbon monoxide combines with haemoglobin to form carboxyhaemoglobin. Therefore, a person in the car will not have sufficient oxygen supply which can be fatal.

12. (a) (i) 3.0 dm^3
(ii) 2.5 dm^3

(b) (i) 4.0 dm^3
(ii) 3.0 dm^3

(c) The more active the activity that is performed, the larger the maximum volume of the lungs. From the graphs

in Figures 3(a) and 3(b), the volume of air in the lungs of runners X and Y increases when they are running.

(d) Runner Y.
Cigarette smoke which damages the alveolus will reduce the maximum volume of air in the human lungs. The maximum volume of air in the lungs of runner Y is less, therefore runner Y is a smoker.

(e) Increase in the maximum volume of the lungs increases the rate of respiration because the rate of gaseous exchange in the lungs is increased.

CHAPTER 3 Transportation

Formative Practice 3.1 (p. 82)

1. The function of the transport system is to carry substances needed by cells into organisms and eliminate waste products from organisms to the outside surroundings.
2. Examples of substances needed by cells:
Oxygen, nutrients
Examples of waste products eliminated from cells:
Carbon dioxide, water, urea
3. Importance of the functions of transport system in organisms are as follows:
   – Transport system provides substances needed by cells such as oxygen and nutrients which are used to produce energy through the process of cellular respiration.
   – Transport system provides substances needed by plant cells such as carbon dioxide and water which are used to carry out photosynthesis.
   – Transport system also eliminates toxic waste products from the cells of organisms to the surroundings.
4. If the transport system of an organism cannot function well,
   – cellular respiration cannot be carried out. Without energy, living process cannot occur in the organism.
   – food cannot be made by green plants through photosynthesis. Without food, plants and animals will die.
   – toxic waste products that fail to be eliminated from the body to the outside surroundings will poison and kill the organism.

Activity 3.2 (p. 84)

Fish

– Fish has a single blood circulatory system where blood flows through the heart only once in one complete cycle to the all the other parts of the body.
– Fish's heart has one atrium and one ventricle.
– Deoxygenated blood flows out from the heart to the gills where gaseous exchange occurs in the capillaries of the gills changing deoxygenated blood to oxygenated blood.
– Oxygenated blood flows from the heart to the whole body, changes into deoxygenated blood and flows back into the heart.

Amphibians

– Amphibians have an incomplete double circulatory system where blood flows through the heart twice in one complete cycle to the whole body.
– Amphibian's heart has two atriums and one ventricle.
– Deoxygenated blood flows out from the amphibian's heart to the lungs and skin where gaseous exchange occurs in the blood capillary walls in the lungs or under the skin changing deoxygenated blood to oxygenated blood.
– Oxygenated blood flows from the heart to the brain and a mixture of oxygenated and deoxygenated blood flows to all other parts of the body except the lungs. Oxygenated blood changes into deoxygenated blood and flows back into the heart.

Reptiles

– Reptiles have an incomplete double circulatory system where blood flows through the heart twice in one complete cycle to the whole body.
– Reptile's heart has two atriums and one ventricle with a structure which divides the space in the ventricle into two separate parts.

– Deoxygenated blood flows out from the heart to the lungs where gaseous exchange occurs in the walls of the blood capillaries in the lungs changing deoxygenated blood to oxygenated blood.
– Oxygenated blood flows from the heart to the whole body except the lungs, changes to deoxygenated blood and flows back into the heart.

Mammals and birds

– Mammals and birds have a double circulatory system where blood flows through the heart twice in one complete cycle to the whole body.
– The heart of mammals and birds have two atriums and two ventricles.
– Deoxygenated blood flows out from the heart to the lungs where gaseous exchange occurs in the walls of the blood capillaries in the lungs changing deoxygenated blood to oxygenated blood.
– Oxygenated blood flows from the heart to the whole body except the lungs, changes to deoxygenated blood and flows back into the heart.

Brain Teaser (p. 91)

Systolic pressure is produced when the ventricle pumps blood out from the heart to the whole body. Blood coming out flows with high pressure. Diastolic pressure on the other hand is produced when blood flows into the heart. Blood flows with lower pressure.

Experiment 3.1 (p. 92)

Questions

1. The more active the activity, the higher the pulse rate.
2. The rate of intake of oxygen and release of carbon dioxide by body cells increases while carrying out active activity. This causes the heart to beat more frequently and increases the pulse rate to transport oxygen and carbon dioxide more efficiently.

Formative Practice 3.2 (p. 95)

1. Blood circulatory system is a special transport system in complex organisms which functions to transport nutrients, respiratory gases and waste products.
2.

Artery
Transports oxygenated blood (except the pulmonary artery)
Capillary
Connects arteries to veins and is a place of exchange of substances between cells
Vein
Transports deoxygenated blood (except pulmonary vein)

3. Type of activity, gender, age, health
4. Caring for our heart is important to ensure continuity of our life.

Brain Teaser (p. 99)

An individual who has blood type O can donate blood to all individuals irrespective of their blood type because blood type O does not have any antigens on its red blood cells.

Formative Practice 3.3 (p. 101)

1. Red blood cells, white blood cells, platelets and blood plasma
2. Blood plasma
3.

Blood group of donor	Blood group of recipient			
	A	B	AB	O
A	✓	×	✓	×
B	×	✓	✓	×
AB	×	×	✓	×
O	✓	✓	✓	✓

4. (a) To save lives
   (b) Leukaemia, haemophilia
5. (a) A person of blood group O can donate blood to any individual because the person has no A antigen and B antigen.
   (b) A person of blood group AB can receive blood from any individual because his plasma does not contain antibody Anti-A or Anti-B.
   (c) Blood bank is the place where blood is stored and retrieved.
6. (a) Hospitals, National Blood Centre
   (b) Road accidents, war
7. (a) Blood group AB
   (b) Presence of virus and other unwanted substances
   (c) Prevents clotting of blood

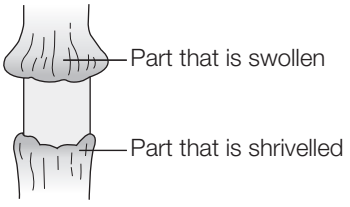
Activity 3.8 (p. 110)

Questions

1. The eosin solution stains to form a specific pattern in the leaves, stem and roots of the plant.
2. Xylem
3. Passage of water in plants is through a transport tissue, namely xylem.

Activity 3.9 (p. 111)

Questions

1. 

2. Passage of food in plants is through the phloem.

Formative Practice 3.4 (p. 112)

1. Transpiration is a process of loss of water in the form of water vapour from the surface of plants to the air through evaporation.
2. (a) vapour, liquid
   (b) xylem, phloem
3. Light intensity, air humidity, temperature, air movement
4. Passage of water in xylem can be detected with the use of dye because water is colourless.
5. P: Phloem
   Q: Xylem
   R: Xylem
   S: Phloem
   T: Xylem
   U: Phloem

Formative Practice 3.5 (p. 113)

1. Similarity: – Both are transport systems
   – Both transport water, nutrients and dissolved substances
   – Both exist in complex organisms
   Difference: Pick one of the differences shown in Figure 3.31.
2. Organisms cannot continue to live if they do not have a unique circulatory system according to their respective needs.

Summative Practice 3 (pp. 116 – 120)

1. (a) PULSE
   (b) TRANSPIRATION
   (c) CAPILLARY
   (d) PHLOEM
   (e) HEART
   (f) ANTIGEN
2. (a) ✓
   (b) ×
   (c) ×
   (d) ×
3. (a) Valve
   (b) Transport oxygenated blood
   (c) (i) Blood vessel Q has thick walls to withstand high blood pressure.
   (ii) Blood vessel R has walls which are one cell thick to increase the efficiency of exchange of substances between blood and body cells through diffusion.
4. (a) Oxygen, carbon dioxide, water, digested food, waste products
   (b) Oxygen, carbon dioxide, water
   (c) During the day, plant cells carry out photosynthesis and produce oxygen. Hence, plant cells do not need oxygen supply.
5. (a) (i) dub
   (ii) lub
   (iii) systolic
   (iv) diastolic
   (b) Systolic pressure reading is higher than diastolic pressure reading. Systolic pressure reading is reading of blood pressure which is higher when heart ventricle contracts to force blood out of the heart to be distributed to the whole body. Diastolic pressure reading is reading of blood pressure which is lower when heart ventricle slackens to facilitate blood flowing from the whole body back to the heart.
6. (a) (i) Eric, Roy
   (ii) Blood will coagulate.The victim may die.
   (b) (i) Individual 2.
   This is because she fulfils the age condition of 18 years and above but less than 60 years. She also fulfils the body mass

condition of more than 45 kg.

(ii) Pregnant women are not suitable to donate blood.

7. (a) Transports food

(b) Xylem or Y

(c) (i) The part above the ring will become swollen. Food collected here cannot be transported to the part below the ring because of the absence of X (phloem).

(ii) The plant will dry up and die.

8. Set A = $\frac{54\text{ g}}{180\text{ mins}}$ = 0.3 g/min

Set B = $\frac{36\text{ g}}{180\text{ mins}}$ = 0.2 g/min

9. (a) Badrul. He has the highest pulse rate immediately after activity.

(b) Azizah. Her pulse rate returns to its original rate after a time interval of 15 minutes after activity.

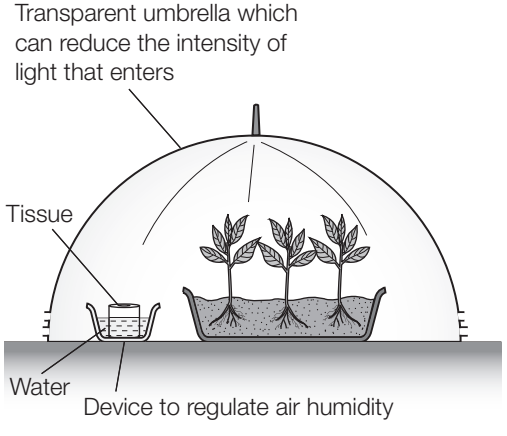
10. (a) Location B.

Location A is not suitable for the growth of herbs. This is because of the absence of light needed by herbs to carry out photosynthesis.

Location C is not suitable for the growth of herbs. High temperature in this location will increase the rate of transpiration of the herbs.

Location B is suitable for the growth of herbs. Temperature in this dim location is able to maintain the rate of transpiration of the herbs. In addition, the presence of sunlight in the bright location enables the herbs to carry out photosynthesis.

(b) Example of constructed model



CHAPTER 4 Reactivity of Metals

Brain Teaser (p. 126)

Mineralogists usually use the name bauxite, civilians such as mine workers use the name aluminium ore and scientists use the name aluminium oxide.

Activity 4.1 (pp. 126, 127)

Questions

1. Carbon dioxide

2. Flow the gas through limewater. If the limewater turns cloudy, the gas is carbon dioxide. On the other hand, if the limewater does not turn cloudy, the gas is not carbon dioxide.

3. (a) Carbon dioxide

(b) Carbon dioxide

4. (a) calcium chloride + carbon dioxide + water

(b) calcium oxide + carbon dioxide

5. Calcium, carbon, oxygen

Formative Practice 4.1 (p. 128)

1. Minerals are naturally occurring solid elements or compounds with definite crystalline structures and chemical compositions.

2. (a) Gold, silver, diamond or other mineral elements (Any one)

(b) Bauxite, hematite, galena, cassiterite, quartz or other natural mineral compounds (Any one)

3. Calcium oxide that has properties of a base is used to neutralise acidic soil. Silicon dioxide that has a high melting point is used to make glass laboratory apparatus.

Activity 4.3 (pp. 130, 131)

Questions

1. (a) Magnesium oxide

(b) Aluminium oxide

(c) Zinc oxide

(d) Iron oxide

(e) Lead oxide

2. The more reactive the metal towards oxygen, the more vigorous the reaction.

3. Magnesium → Aluminium → Zinc → Iron → Lead

Brain Teaser (p. 132)

Carbon + oxygen → carbon dioxide

Hydrogen + oxygen → water

Activity 4.4 (pp. 132, 133)

Questions

1. (a) Zinc + Carbon dioxide
(b) No change
(c) Lead + Carbon dioxide

2. Zinc and lead.
Oxides of metals which are less reactive than carbon will turn into the metals when heated with carbon.

3.

Increasing reactivity ↑

Aluminium
Carbon
Zinc
Lead

4. Metal extraction. Metals which are less reactive than carbon in the reactivity series of metals can be extracted from their ores through the reduction of the oxide of these metals by carbon.

5. (a) more
(b) less

Formative Practice 4.2 (p. 136)

1. The reactivity series of metals is an arrangement of metals according to their reactivity towards oxygen.

2. (a) Yes. Metal X is reactive towards oxygen because metal X burns with a bright flame.
(b) Metal Y is less reactive than metal X.
(c)

X
Y
Z ↓

3. (a) oxygen
(b) potassium
(c) extraction

4. (a) Potassium
(b) Gold

5. (a) Carbon and hydrogen
(b) Carbon and hydrogen can react with oxygen.

Formative Practice 4.3 (p. 141)

1. (a) Electrolysis
(b) Reduction of iron ore with carbon

2. (a) Tin
(b) (i) Iron ore, limestone, coke
(ii) Hot air
(c) (i) Slag
(ii) Molten iron

3. (a) Soil erosion. Problem of soil erosion can be solved by replanting trees.
(b) Air pollution. Air pollution can be avoided by filtering the gases produced before releasing them to the atmosphere.

Summative Practice 4 (pp. 143 – 145)

1. (a) Elements: Iron, Silver, Potassium, Tin
Compounds: Quartz, Bauxite, Galena, Hematite, Limestone
(b) Bauxite, Aluminium and oxygen

2. (a) Tin(IV) oxide
(b) Carbon
(c) Tin + oxygen → Tin(IV) oxide

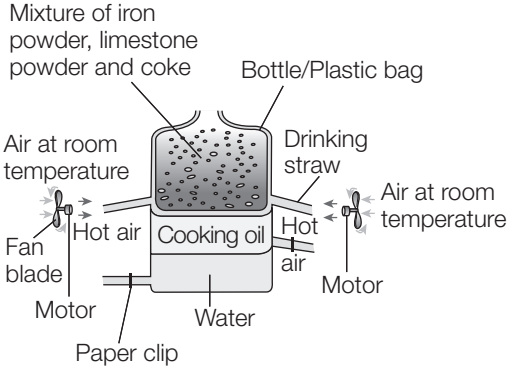
3. (b) ✓
(c) ✓

4. (a) Oxygen
(b) Potassium and sodium are very reactive metals. Paraffin prevents potassium and sodium from reacting with oxygen and water vapour in the air.

5. (a) Oxygen
(b) To provide oxygen for the reaction.
(c) Heat the powdered metal until it glows before heating potassium manganate(VII) to provide oxygen for the reaction.
(d) To construct a reactivity series of metals.

6. For metals which are more reactive than carbon, extraction of the metals is through the electrolysis method. For metals which are less reactive than carbon, extraction of the metals is through reaction of the metal ores with carbon.

7.



Explanation:

Substance	Represent
Bottle	Blast furnace
Cooking oil	Slag
Water	Molten iron
Motor	Heating device
Iron powder	Iron ore
Limestone powder	Limestone

Innovative step: Fan blade is connected in a direction opposite to the normal direction so that sucked air flows through the motor to be heated. Motor is also cooled by this flow of air.

CHAPTER 5 Thermochemistry

Experiment 5.1 (pp. 149 – 151)

Questions (p. 151)

1. (a) Release of heat is shown by the rise in thermometer reading.
(b) Absorption of heat is shown by the drop in thermometer reading.

2. (a) Thermal equilibrium
(b) When the net rate of heat transfer between the products of reaction and thermometer is zero, products of reaction and thermometer is in thermal equilibrium. Hence, the temperature reading on the thermometer is fixed at maximum value or minimum value.

3. (a) The temperature during reaction is higher than the temperature before reaction occurred.
(b) The temperature during reaction is lower than the temperature before reaction occurred.

4. – Sodium hydroxide dissolving in water
– Reaction between sodium hydroxide and hydrochloric acid (Neutralisation)

5. – Ammonium chloride salt dissolving in water
– Reaction between sodium hydrogen carbonate and hydrochloric acid

6. (a) Wrapping the polystyrene cup with cotton wool or felt cloth, using a lid for the cup.
(b) Heat insulators such as cotton wool and felt cloth and lid for cup reduces the transfer of heat to the surroundings.

Formative Practice 5.1 (p. 154)

1. (a) An endothermic reaction is a chemical reaction that absorbs heat from the surroundings.
(b) An exothermic reaction is a chemical reaction that releases heat into the surroundings.

2. Thermochemistry is the study of heat changes when chemical reactions occur.

3. The rate of respiration increases when performing vigorous physical activities, because respiration is an exothermic reaction. Heat produced by the exothermic reaction is absorbed into the body. Hence, the body temperature increases.

4. (a) Global warming
(b) Reduce burning of fossil fuels.

5. (a) Exothermic reaction.
(b) Exothermic reactions release heat into the surroundings and increase the temperature. High temperatures can relieve muscle cramp.

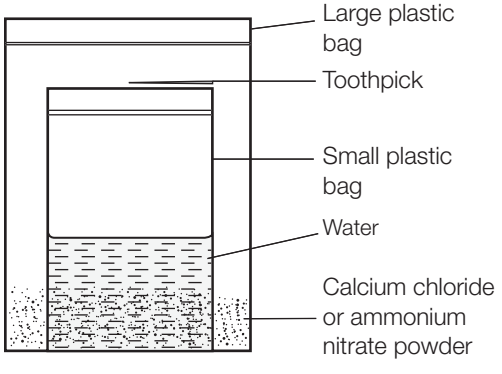
Summative Practice 5 (pp. 155 – 158)

1. (a) Exothermic reaction
(b) Endothermic reaction
(c) Exothermic reaction
(d) Endothermic reaction
(e) Exothermic reaction
(f) Exothermic reaction

2. (a) released
(b) increases
(c) hot
(d) absorbed

3. (a) THERMOCHEMISTRY
(b) PHOTOSYNTHESIS
(c) RESPIRATION
(d) THERMOMETER
(e) ENDOTHERMIC
(f) EXOTHERMIC

4. Heating of calcium carbonate is an endothermic reaction. Heat is absorbed by the chemical reaction that occurs during the decomposition of calcium carbonate.
5. The reaction between hydrochloric acid and sodium carbonate is an exothermic reaction whereas the reaction between hydrochloric acid and sodium hydrogen carbonate is an endothermic reaction.
6. Replanting of trees will increase the rate of photosynthesis. As photosynthesis is an endothermic reaction, more heat will be absorbed from the surroundings into the plants to carry out photosynthesis. Hence, the surrounding temperatures will drop.
7. (a) Thermite reaction is an exothermic reaction because heat is released into the surroundings.
   (b) In a thermite reaction, heating of iron(II) oxide, aluminium and magnesium tape produces iron and carbon dioxide through an exothermic reaction. The heat released in this reaction increases the temperature of the iron and carbon dioxide until the iron melts. This molten iron is used to repair and reconnect the broken iron railway rails.
8.



Instant hot pack:
– Use toothpick to prick a hole in the small plastic bag so that water flows out from the plastic bag and mixes with the calcium chloride powder in the large plastic bag.
– Dissolving of calcium chloride in water is an exothermic reaction which heats up the large plastic bag.
– Hence, the large plastic bag functions as an instant hot pack.

Instant cold pack:
– Use toothpick to prick a hole in the small plastic bag so that water flows out from the plastic bag and mixes with the ammonium nitrate powder in the large plastic bag.
– Dissolving of ammonium nitrate in water is an endothermic reaction which cools down the large plastic bag.
– Hence, the large plastic bag functions as an instant cold pack.

CHAPTER 6 Electricity and Magnetism

Activity 6.1 (p. 165)
Questions
1. Electric current
2. Cutting of magnetic field lines (by copper wire or coil of wire)
3. Induced current

Activity 6.2 (p. 166)
Questions
1. (b) ✓
   (c) ✓
2. Induced current is detected based on the lighting up of the LED. Induced current is produced and flows through the LED. Therefore the LED lights up.
3. Current is induced when magnetic field lines are cut.
4. Sound energy, heat energy, light energy
5. – LED lasts longer and does not burn out easily
   – LED will light up when electric current flows through as compared to filament bulb which only lights up when its filament is hot enough.

Activity 6.4 (pp. 172 – 175)
Questions
1. To show the shape of graph, direction of current and voltage change for direct current and alternating current.
2. Similarity: Magnitude of the displacement of the light spot from the zero position

in steps 6 and 8 is fixed and the same. This shows that the voltage of the battery is fixed and of the same value.

Difference: Displacement of the light spot from the zero position in step 6 is positive while displacement of the light spot from the zero position in step 8 is negative. This shows that the current in step 6 flows from positive to negative whereas in step 8 the flow of current in the C.R.O. has been reversed.

3. (a) First inference:
The different position of the straight line on the display screen in steps 7 and 9 shows that direct current is the electric current which flows in the opposite direction.

(b) Second inference:
The position of the straight line from the zero position in steps 7 and 9 which are different shows that direct current in steps 7 and 9 flow in the opposite directions.

4. Voltage produced by the power supply keeps changing. Hence, the light spot on the screen moves up and down to produce a vertical trace on the screen irrespective of the type of terminal connection to the C.R.O.

5. (a) First inference:
The shape of graph on the display screen produced by the vertical and horizontal trace made by a light spot shows continuous change in the direction of current flow and the voltage of the alternating current.

(b) Second inference:
The shape of graph on the display screen in steps 13 and 15 is the same. This shows continuous change in the direction of the current flow and the voltage of the alternating current irrespective of the type of terminal connection to the C.R.O..

6. (a) Direct current

(b) Alternating current and direct current

Formative Practice 6.1 (p. 176)

1. Renewable energy sources are energy sources that can be replaced continually and will not deplete while non-renewable energy sources are energy sources that cannot be replaced and will deplete.

2. (a) LED lights up in arrangements P and Q. In arrangements P and Q, magnetic field lines are cut by the coil of wire to produce induced current. This induced current flows through the LED causing the LED to light up.

(b) LED does not light up in arrangement R. In arrangement R, there is no cutting of magnetic field lines and no induced current flows through the LED.

3. To show the shape of graph, direction of current and voltage change for direct current and alternating current.

Experiment 6.1 (pp. 178 – 180)

Questions

1. (a) Bulb P is brighter compared to bulb S.

(b) $V_p > V_S$

(c) Step-down transformer

2. (a) Bulb S is brighter compared to bulb P.

(b) $V_p < V_S$

(c) Step-up transformer

3. If the difference between the number of turns in the primary coil and the number of turns in the secondary coil in a transformer is increased, the difference between the primary voltage and secondary voltage becomes bigger.

4. A transformer can only change the voltage of an alternating current if the number of turns of the primary coil and secondary coil is different. On the contrary, if the number of turns in the primary and secondary coil in a transformer is the same, then there is no change in the primary voltage and secondary voltage.

Formative Practice 6.2 (p. 183)

1. A transformer is a device that changes the voltage of an alternating current.

2. (a) alternating
(b) more
(c) step-up
(d) step-down

3. (a) Microwave oven, washing machine, refrigerator, television
(b) Mobile phone charger, laptop/tablet charger

4. (a) $\frac{V_p}{V_s} = \frac{N_p}{N_s}$

$\frac{240}{5} = \frac{N_p}{10}$

$N_p = 10 \times \frac{240}{5}$

$= 480$

Number of turns in primary coil, $N_p = 480$

(b) The transformer in the mobile phone charger is a step-down transformer because:
i) the output voltage is lower than the input voltage.
ii) the number of turns in the secondary coils, N_s, is less than the number of turns in the primary coils, N_p ($N_s < N_p$).

Brain Teaser (p. 187)

In one cycle, single-phase wiring has two peaks whereas three-phase wiring has six peaks. Because of this, the current supply of three-phase wiring is more stable.

Brain Teaser (p. 192)

Because most electric kettles sold in the market use 10 – 12 A current.

Formative Practice 6.3 (p. 194)

1. (a) Step-up transformer station
(b) Switch zone
(c) Step-down transformer

2. (a) increased
(b) National Grid Network
(c) Switch zone

3. (a) Fuse, earth wire, circuit breaker, lightning conductor (any three)
(b) Fuse functions as a safety component that melts and cuts off electric current supply when excessive current flows through it.

4. (a) Damaged wire insulator. Exposed live wire touches the exposed neutral wire.
(b) (i) Excessive load
(ii) Fire. Large flow of current causes wires, plugs and sockets to become so hot that they burn.

Brain Teaser (p. 199)

Can be used in Thailand but the time taken to boil water is longer.

Brain Teaser (p. 201)

No. A green building uses the concept of savings on energy, water and material consumption.

Formative Practice 6.4 (p. 202)

1. Energy efficiency is the percentage of energy input converted into useful energy output.

2. (a) Using the formula:

$P = \frac{E}{t}$

$P = \frac{180 \text{ kJ}}{2 \text{ minutes}}$

$= \frac{180\,000 \text{ J}}{120 \text{ s}}$

$= 1\,500 \text{ W}$

(b) Power of air conditioner,
$P = 1\,500 \text{ W}$

$= \frac{1\,500}{1\,000} \text{ kW}$

$= 1.5 \text{ kW}$

3. $P = VI$

$1\,200 \text{ W} = 240 \text{ V} \times I$

Electric current, $I = \frac{1\,200 \text{ W}}{240 \text{ V}}$

$= 5 \text{ A}$

4. (a) $E = Pt$

$= \frac{800}{1\,000} \text{ kW} \times \frac{30}{60} \text{ h}$

$= 0.4 \text{ kWh}$

(b) Cost of energy used by rice cooker
= Electrical energy used in kWh × cost of energy for each kWh
= 0.4 kWh × 30 sen/kWh
= 12 sen

5. (a) Star rating labelling on an electrical appliance shows the energy efficiency of the electrical appliance.
(b) At least 3 stars. The more stars on a star rating label means more energy savings.

Summative Practice 6 (pp. 204 – 207)

1. (a) True
(b) False
(c) True

2. (a) Non-renewable energy source
(b) Renewable energy source
(c) Renewable energy source
(d) Renewable energy source

3. (a) Magnetic field lines are cut
(b) Induced current
(c) LED lights up. Induced current flows through the LED. The flow of current through the LED causes the LED to light up.
(d) Generator

4. (a) Cathode ray oscilloscope
(b) Shape of graph, direction of current and voltage changes for direct current and alternating current.
(c) (i) Alternating current
(ii) Direct current

5. (a) Step-down transformer
(b) Number of turns in the primary coil is more than the number of turns in the secondary coil.
(c) To reduce eddy current and increase the efficiency of the transformer
(d) Using the formula, $\frac{V_p}{V_s} = \frac{N_p}{N_s}$

$$\frac{10}{V_s} = \frac{100}{20}$$

$$\text{Secondary voltage, } V_s = 10 \times \frac{20}{100}$$
$$= 2 \text{ V}$$

6. (a) Main fuse
(b) (i) Fuse and MCB function as safety devices that protect appliance from any excessive current flow.
(ii) When the current flowing through a fuse exceeds the value of the fuse, the fuse will melt and cannot be reused without replacing the burnt fuse wire with a new fuse wire.
An MCB is an electromagnetic switch connected to the live wire. An MCB cuts the circuit by turning off its switch when the current flowing through it exceeds its limit. The MCB can be reused by turning on the switch again without having to do any replacement.
(c) Using the formula:

$$P = VI$$
$$700 \text{ W} = 240 \text{ V} \times I$$
$$\text{Electric current, } I = \frac{700 \text{ W}}{240 \text{ V}}$$
$$= 2.9 \text{ A}$$

Fuse chosen is a 3 A fuse because the value of the fuse is slightly higher than the value of the electric current flowing through the hair dryer.

7. (a) Using the formula:

$$\text{Power (W)} = \text{Voltage (V)} \times \text{Electric current (A)}$$
$$= 230 \text{ V} \times 10 \text{ A}$$
$$= 2\,300 \text{ W}$$
$$= \frac{2\,300}{1\,000} \text{ kW}$$
$$= 2.3 \text{ kW}$$

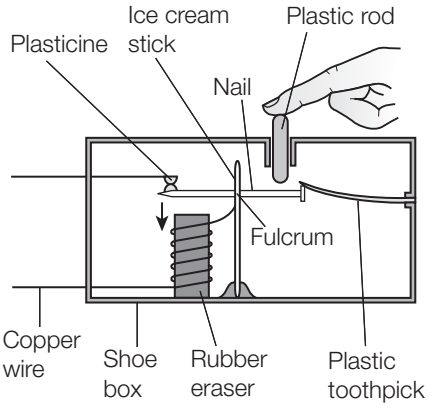
(b) 13 A fuse.
13 A fuse is the most suitable because a 13 A fuse allows a 10 A current to flow through it but does not allow a current exceeding 13 A to flow through the electric heater. A current that is too high will damage the electric heater.
(c) A 10 A current that flows through 1A, 2A, 3A and 5A fuses will melt the fuse wires. Hence, the electric heater will not be able to function.
15 A and 30 A fuses allow current which is much greater than 10 A to flow through the electric heater. This will damage the electric heater.
10 A fuse is also not suitable because most 10 A fuses normally allow maximum current of less than 10 A to flow through it. Hence, the

10 A fuse will blow if installed in the electric heater.

8. (a) An MCB is a small electromagnetic switch connected to the live wire.

(b) An MCB functions as an electric safety device. An MCB cuts off the circuit when the current flowing through it is too high or exceeds its limit value.

(c)



Contact – plasticine
Iron – nail
Fulcrum – an ice cream stick
Reset button – plastic rod
Spring – plastic toothpick
Iron core – Rubber eraser
Electric wire – copper wire

Scenario: When the electric current that flows through the MCB exceeds its limit value, the solenoid becomes a strong electromagnet.

MCB	Model of MCB
Electric wire that is mounted to the contact and iron is pulled downwards as shown in Figure 4.	Copper wire that is mounted to the plasticine and iron nail is.pulled downwards as shown in the above diagram.
The iron rotates in an anti-clockwise direction at the fulcrum.	The iron nail rotates in an anti-clockwise direction at the fulcrum on the ice cream stick.
The rotating iron pushes the spring upwards. Finally, the spring is released and it is below the iron.	The rotating iron nail pushes the toothpick upwards. Finally, the toothpick is released and it is below the iron nail.
Reset button when pushed downwards will push the iron downwards until the iron nail is below the spring again.	When the plastic rod is pushed downwards, it will push the iron nail downwards until the iron nail is below the toothpick again.

CHAPTER 7 Energy and Power

Brain Teaser (p. 210)

(a) 1 000 (or 10^3) J
(b) 1 000 000 (or 10^6) J

Brain Teaser (p. 212)

No

Activity 7.1 (pp. 214, 215)

Questions

1. (a) Frictional force
(b) Gravitational force

2. Student's answer

3. Force, displacement in the direction of the force, time

4. Student's answer

5. (a) Aeroplane that is taking off, moving ERL train.
(b) Sleep, sit

Formative Practice 7.1 (p. 215)

1. (a) Work is defined as the product of force and displacement in the direction of the force.
(b) Joule

2. Energy is the ability to do work.

3. (a) Power is defined as the rate of doing work.
(b) Watt

4. (a) $W = Fs$
$= 2\ 500\ \text{N} \times 4\ \text{m}$
$= 10\ 000\ \text{J}$
(b) Energy used = work done
$= 10\ 000\ \text{J}$
(c) Power of crane, $P = \frac{W}{t}$
$= \frac{10\ 000\ \text{J}}{1.2\ \text{minutes}}$
$= \frac{10\ 000\ \text{J}}{72\ \text{s}}$
$= 138.89\ \text{W}$

Formative Practice 7.2 (p. 221)

1. (a) Gravitational potential energy is the work done to lift an object to a height, h, from the surface of the Earth.
(b) Elastic potential energy is the work done to compress or stretch an elastic material over a displacement, x from the position of equilibrium.

2. (a) $W = Fs$
$= 40\ \text{N} \times 0.5\ \text{m}$
$= 20\ \text{J}$
(b) Gravitational potential energy
(c) Gravitational potential energy of possessed by the chair = work done on it
$= 20\ \text{J}$

3. Distance of compression of spring
= original length of spring − length of compressed spring
$= 50\ \text{cm} - 30\ \text{cm}$
$= 20\ \text{cm}$
$= 0.2\ \text{m}$
Elastic potential energy
$= \frac{1}{2} Fx$
$= \frac{1}{2} (20\ \text{N})\ (0.2\ \text{m})$
$= 2\ \text{J}$

4. (a) Kinetic energy $= \frac{1}{2} mv^2$
where m is mass
v is velocity
Even though the value of the velocity, v of a heavy vehicle is small, the value of its mass, m is big. Hence, the large mass of these heavy vehicles causes more kinetic energy.
(b) (i) Bullet fired from a pistol.
(ii) Aeroplane taking off from runway at airport.

Formative Practice 7.3 (p. 226)

1. The Principle of Conservation of Energy states that energy cannot be created or destroyed but can only be converted from one form to another.

2. (a) P, R
(b) Q

3. (a) Gravitational potential energy
$= mgh$
$= 2\ \text{kg} \times 10\ \text{m s}^{-2} \times 2.5\ \text{m}$
$= 50\ \text{J}$
(b) According to the Principle of Conservation of Energy,
Kinetic energy = Gravitational potential energy

$$\frac{1}{2} mv^2 = 50\ \text{J}$$

$$\frac{1}{2} \times 2\ \text{kg} \times v^2 = 50\ \text{J}$$

$$v^2 = 50\ \text{m}^2\text{s}^{-2}$$

$$v = \sqrt{50\ \text{m}^2\text{s}^{-2}}$$

$$= 7.07\ \text{m s}^{-1}$$

Summative Practice 7 (pp. 228, 229)

1. (a) Energy possessed by an object is due to its position or condition.
(b) Energy possessed by a moving object.

2. (a) N m
(b) Work
(c) stationary
(d) can
(e) acceleration

3. (a) $W = Fs$

= 5 kg × 10 m s^{-2} × 2 m
= 100 J

(b) Energy used by motor = work done
= 100 J

4. (a) Gravitational potential energy = mgh
where m is the object mass
g is the gravitational acceleration
h is the height

(b) Elastic potential energy = $\frac{1}{2}Fx$,
where F is the compression or stretching force
x is the displacement from equilibrium position

(c) Kinetic energy = $\frac{1}{2}mv^2$,
where m is the mass,
v is the velocity

5. (a) Work = force × displacement
= 200 N × 0.4 m
= 80 J

(b) Elastic potential energy
$= \frac{1}{2}Fx$
$= \frac{1}{2} \times 200\ \text{N} \times 0.4\ \text{m}$
= 40 J

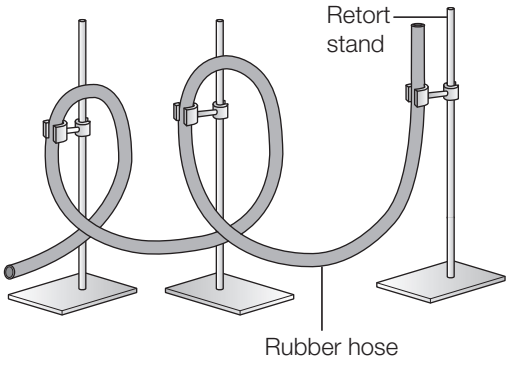
(c) Because part of the work done is used to bend the bow.

6. (a) Principle of Conservation of Energy

(b) Vertical displacement of 2.5 cm from position Y.

(c) Potential energy at X = mgh
$= \frac{40}{1\ 000}\ \text{kg} \times 10\ \text{m s}^{-2} \times \frac{5}{100}\ \text{m}$
= 0.02 J
Potential energy at Y = 0 J, so difference in potential energy
= (0.02 – 0) J
= 0.02 J

7.



Explanation: This model of a roller coaster has vertical, winding and turning loops.

CHAPTER 8 Radioactivity

Brain Teaser (p. 235)

(a) 1 Ci = 3.7 × 10^{10} Bq
(b) 1 Bq = 2.70 × 10^{-11} Ci

Formative Practice 8.1 (p. 237)

1. (a) Wilhelm Roentgen
(b) Henri Becquerel
(c) Marie and Pierre Curie

2. Radioactivity is the spontaneous decay process of an unstable nucleus by emitting radioactive radiation.

3. (a) curie (Ci), becquerel (Bq)
(b) The decay rate of an unstable nucleus.

4. Carbon-14 (C-14), Radon-222 (Rn-222), Thorium-232 (Th-232), Uranium-238 (U-238)

5. Half-life, $T_{\frac{1}{2}}$, is the time taken for the number of undecayed nuclei to be reduced to half of its original value.

Formative Practice 8.2 (p. 239)

1. According to Dalton's Atomic Theory, an atom is the smallest particle and cannot be further divided.

2. (a) When an atom loses electrons.
(b) When an atom gains electrons.

3. (a) Q and S. In Q and S, the number of protons is more than the number of electrons.
(b) R and T. In R and T, the number of electrons is more than the number of protons.
(c) P. In P, the number of protons is the same as the number of electrons.

4. (a) One electron is gained.
(b) The number of electrons in the ion increases by one.
(c) Bromide ion, Br^-

Brain Teaser (p. 243)

1 μSv/h is equivalent to 10^{-6} J of ionising radiation energy absorbed by 1 kilogram of living tissue in a time interval of 1 hour.

Formative Practice 8.3 (p. 246)

1. (a) Ionising radiation is radiation that produces positive and negative ions while passing through the air.
Examples of ionising radiation: alpha radiation, beta radiation, gamma ray and X-ray (any one)
(b) Non-ionising is radiation that does not produce ions while passing through the air.
Examples of non-ionising radiation: light (visible), infrared, radio waves

2. (a) lower, higher
(b) higher, lower

3. (a) Cosmic rays, background radiation
(b) Nuclear accidents, nuclear tests, use of radioisotopes in medical field

4. (a) microSievert/hour (μSv/h)
(b) 1 Sv is 1 Joule of ionising radiation energy absorbed by 1 kilogram of living tissue.
(c) Radiation dose less than 0.2 μSv/h

5. The higher an individual is from the surface of Earth, the stronger the cosmic rays received. Hence, an individual who is in an aeroplane at a high altitude will absorb more cosmic rays causing his ionising radiation dose to exceed the safety level.

6. Ionising radiation dose received by the student = 0.01 mSv/h × 2 h × 5
= 0.1 mSv

Formative Practice 8.4 (p. 250)

1. (a) Carbon-14 dating to determine the age of an ancient object.
(b) Cobalt-60 to treat cancer by killing cancer cells.
(c) Phosphorus-32 to determine the absorption rate of phosphate fertilisers in plants.
(d) Uranium-235 to build weapons such as atomic bombs.
(e) β-radiation to monitor the thickness of metal sheets.

2. (a) Gamma rays
(b) Gamma rays preserve food by killing the bacteria in the preserved food.

3. Boxes with thick lead walls can prevent all types of radioactive radiation emitted by radioactive sources or radioactive waste from escaping.

4. (a) Presence of radioactive substance or radioactive radiation.
(b) Hospitals, atomic research centres, X-ray rooms.
(c) Alpha radiation. It has the lowest penetration power.

5. (a) Lead (or aluminium)
(b) For lead:
Advantage – Lead is an appropriate shield from all types of radioactive radiation including gamma rays which have high penetration power.
Disadvantage – The high density of lead makes the clothing too heavy.
For aluminium:
Advantage – The lower density of aluminium makes the clothing less heavy.
Disadvantage – Aluminium is a less efficient shield from gamma rays which have high penetration power.

Summative Practice 8 (pp. 252 – 254)

1. (a) ✓
(b) ×
(c) ✓

2. Radioactive decay is a spontaneous process by which an unstable nucleus emits radioactive radiation until the nucleus becomes more stable.

3. sodium-24 (Na-24)

4. 0 hours, 32 g → 5.2 hours, 16 g → 10.4 hours, 8 g → 15.6 hours, 4 g → 20.8 hours, 2 g

Therefore the remaining mass of Pa-234 after 20.8 hours is 2 g.

5. (a) Ion formed is a positive ion because Mg atom loses two electrons to form Mg^{2+} ion.
(b) Ion formed is a negative ion because F atom gains one electron to form F^- ion.

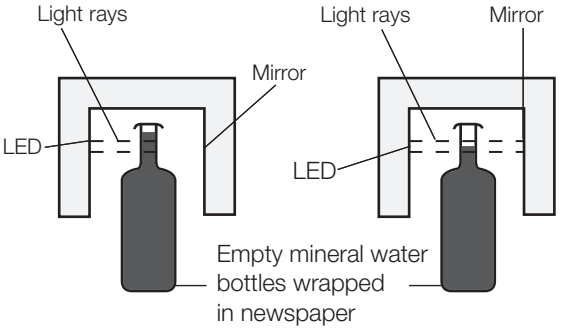
6. (a) X-ray and gamma ray:
- are ionising radiation
- have high penetration power in air
- are electromagnetic waves

(b) (i) Sample Y. This is because the strawberry in sample Y is still in good condition.

(ii) Gamma rays
(iii) Gamma rays kill bacteria in food.
(iv) Yes. This is because the radioactive radiation dose in preserved food is within the normal level or safe level.

7. (a)
- Wear appropriate protective clothing.
- Detect radioactive radiation dose found on clothing with detectors such as Geiger Müller tube which gives a warning sound if the dose detected exceeds the normal level.

(b)



Explanation:

Component in the model	Representing component in the system
LED	Beta radiation source
Light rays	Beta radiation
Mineral water bottles wrapped in newspaper	Bottles filled with drinking water
Mirror	Beta radiation detector

CHAPTER 9 Space Weather

Formative Practice 9.1 (p. 263)

1. Photosphere, chromosphere, corona
2. Prominence, solar flare, coronal mass ejection
3. Earth's magnetosphere is defined as a region in space surrounding Earth. It is a combination of the Earth's magnetic field (as the main magnetic field) and the magnetic field in the region in space.
4. Solar wind
5. Comet

Formative Practice 9.2 (p. 265)

1. Phenomena that occur on the surface of the Sun and in outer space.
2. Formation of aurora, disturbances to telecommunication, navigation system and electric power lines
3. When the number of sunspots increases, coronal mass ejections will increase.

Summative Practice 9 (pp. 266 – 267)

1. A: Convection zone
B: Chromosphere
C: Photosphere
D: Radiation zone
E: Core
F: Corona
2. 11 years
3. Sunspots
4. – Smartphone (mobile)
– Internet
– TV broadcast
– Global positioning system (GPS)
5. All living things would die. Ionising radiation in solar winds would reach Earth and be absorbed by living things at levels exceeding the safety level. Hence, the risks to the health of living things would increase and this would be fatal.
6. Sketch of model: Student's answer
Explanation:
– Green plastic bag represents 'Bow Shock'
– White thread represents magnetic field lines from other planets
– Red thread represents Earth's magnetic field
– Polystyrene cup represents a protective layer, the magnetosphere
– Convex cover represents the part of the magnetosphere that is directed towards the Sun
– Plasticine represents Earth

CHAPTER 10 Space Exploration

Formative Practice 10.1 (p. 272)

1. (a) Geocentric model
(b) Heliocentric model
(c) Modified heliocentric model according to Kepler's Law

2. (a) Similarity: In the Solar System models built by Ptolemy and Copernicus, Earth or the Sun revolve in orbits.
(b) Difference: In the Solar System model built by Ptolemy, Earth is at the centre of the orbit whereas in the Solar System model built by Copernicus, the Sun is at the centre of Earth's orbit.

3. (a) Similarity: The Solar System models built by Copernicus and Kepler are heliocentric models.
(b) Difference: In the Solar System model built by Copernicus, Earth and the planets revolve in circular orbits whereas in the Solar System model built by Kepler, Earth and the planets revolve in elliptical orbits.

Formative Practice 10.2 (p. 276)

1. Telescope

2. (a) Discovery is a space shuttle.
(b) Hape is a rocket which sent Discovery to space.

3. (a) Remote sensing technology
(b) To identify the locations hit by flood and determine the places to transfer flood victims

4. MACRES is responsible for all remote sensing projects in Malaysia.

Summative Practice 10 (pp. 278 – 280)

1. (a) ×
(b) ✓
(c) ×
(d) ×

2. (a) Ptolemy
(b) Kepler

3. Through human effort to obtain rational explanation about objects and phenomena in space based on their intellectual abilities.

4. Because space probes are not built to return to Earth.

5. (a) To gather information about Saturn to be sent back to Earth.
(b) Solar wind
(c) Solar energy

6. (a) – Oversee conditions and usage of land
– Predict yield of crops
(b) – Explore regions to search for oil and mineral sources
– Map Earth's surface
(c) – Oversee natural disasters such as floods
– Oversee forest fires, oil spills in the oceans and landslides
(d) – Detect enemy invasions from air, land and sea
– Detect nuclear tests

7. (a) A rocket is an aircraft that obtains its thrust using a rocket engine.
(b) To send astronauts, spaceships, satellites, remote sensing instruments and space probes to space.
(c) Functions as a weapon by carrying guided missiles.

8. Sketch of model: Student's answer
Explanation:

Material	Function
Aluminium foil	Shield against ionising radiations from space
Cylindrical cardboard	As a rocket
Black plastic sheet	Solar battery/ Source of energy for spaceship
Cardboard in the form of a spaceship	As a spaceship

Answer

Only selected answers are provided here

CHAPTER 1 Stimuli and Responses

Summative Practice 1

1. (a) × (b) ✓ (c) × (d) ✓

2. P: Brain
Q: Spinal cord
R: Peripheral nerve

3. (a) Changes in the size of the pupil of the eye.
(b) Intensity of light which enters the eye.
(c) The lower the intensity of light directed towards the eye, the larger the size of the pupil of the eye.
(d) During a solar eclipse, the bright rays of the Sun will enter the eye and damage the cells of the retina.

4. (a) Sound → Earlobe → Ear canal → Eardrum → Ossicles → Oval window → Cochlea → Auditory nerve → Brain

(b) Light → Cornea → Aqueous humour → Pupil → Eye lens → Vitreous humour → Retina → Optic nerve → Brain

5. (a) X: Touch receptor
Y: Pain receptor
(b) Fingertip is more sensitive towards touch stimuli compared to the palm of the hand. Fingertip has a thinner layer of epidermis and more touch receptors compared to the palm of the hand.
(c) Agree. The tongue is a sensory organ that has receptors known as taste buds on the surface of the tongue which is protected by skin epidermis.

6. (a) The sense of smell helps us to detect danger such as leakage of gas that might occur in the science laboratory. For example, we can detect the presence of dangerous gases such as chlorine and ammonia from their smell.
(b) Dogs have a very sensitive sense of smell because they have more sensory cells for smell than human and are more efficient to analyse smell than human.

7. (a) – Positive phototropism
– Positive hydrotropism
(b) Positive phototropism ensures shoots and leaves of plants obtain sufficient sunlight to make food through photosynthesis.
Positive hydrotropism allows roots of plants to grow towards water so that they can absorb water to enable plants to carry out photosynthesis.

CHAPTER 2 Respiration

Summative Practice 2

1. (a) Alveolus
(b) Bronchus
(c) Nasal cavity

2. P: Trachea
Q: Bronchus
R: Alveolus

3. (a) ✓ (b) ✓ (d) ✓

4. (a) higher (b) lower

5. (a) Haemoglobin transports oxygen from the red blood cell to body cells.
(b) Oxyhaemoglobin easily decomposes into haemoglobin and oxygen when it reaches body cells so that oxygen can diffuse into the cells.

6. (a) Azura may be allergic to pollen. In Spring, more pollen is released from anthers. When Azura inhales air containing pollen, there is a higher risk of her getting an asthma attack.
(b) Any place that is hazy and dusty. Examples: industrial areas, construction sites and others. Haze and dust also cause asthma attacks in asthma patients.

7. (a) – Thickness of the wall
– Moisture of the wall
– Surface area
– Network of capillaries

(b) (i) Asthma
Symptom: Shortness of breath
Cause: Excessive release of mucus on the surface of alveolus reduces the surface area and rate of gaseous exchange in the alveolus thereby causing shortness of breath.

(ii) Bronchitis
Symptom: Shortness of breath
Cause: Inflammation of the bronchus in bronchitis patients caused by tar and irritants in cigarette smoke reduces the rate of movement of air from the nose to the lungs through the bronchus. This causes

bronchitis patients to be frequently breathless.

(iii) Emphysema
Symptom: Shortness of breath
Cause: The alveolus in emphysema patients is damaged by dangerous substances in the air such as irritants in cigarette smoke. Hence, the surface area for gaseous exchange in the alveolus is reduced causing shortness of breath.

8. – Stop smoking.
To avoid harmful substances found in cigarette smoke from entering the lungs and harming the respiratory system.
– Avoid places with polluted air.
To avoid inhaling air that contains harmful substances such as cigarette tar, carbon monoxide, sulphur dioxide, nitrogen dioxide, haze, dust and pollen which are harmful to the respiratory system.
– Have proper exercise and lead a healthy lifestyle.
To maintain a healthy respiratory system.

CHAPTER 3: Transportation

Summative Practice 3

1. (a) PULSE (d) PHLOEM
(b) TRANSPIRATION (e) HEART
(c) CAPILLARY (f) ANTIGEN

2. (a) ✓ (b) × (c) × (d) ×

3. (a) Valve
(b) Transport oxygenated blood
(c) (i) Blood vessel Q has thick walls to withstand high blood pressure.
(ii) Blood vessel R has walls which are one cell thick to increase the efficiency of exchange of substances between blood and body cells through diffusion.

4. (a) Oxygen, carbon dioxide, water, digested food, waste products
(b) Oxygen, carbon dioxide, water
(c) During the day, plant cells carry out photosynthesis and produce oxygen. Hence, plant cells do not need oxygen supply.

5. (a) (i) dub
(ii) lub
(iii) systolic
(iv) diastolic
(b) Systolic pressure reading is higher than diastolic pressure reading. Systolic pressure reading is reading of blood pressure which is higher when heart ventricle contracts to force blood out of the heart to be distributed to the whole body. Diastolic pressure reading is reading of blood pressure which is lower when heart ventricle slackens to facilitate blood flowing from the whole body back to the heart.

6. (a) (i) Eric, Roy
(ii) Blood will coagulate.The victim may die.
(b) (i) Individual 2.
This is because she fulfils the age condition of 18 years and above but less than 60 years. She also fulfils the body mass condition of more than 45 kg.
(ii) Pregnant women are not suitable to donate blood.

CHAPTER 4 Reactivity of Metals

Summative Practice 4

1. (a) Elements: Iron, Silver, Potassium, Tin
Compounds: Quartz, Bauxite, Galena, Hematite, Limestone
(b) Bauxite, Aluminium and oxygen

2. (a) Tin(IV) oxide
(b) Carbon
(c) Tin + oxygen → Tin(IV) oxide

3. (b) ✓ (c) ✓

4. (a) Oxygen
(b) Potassium and sodium are very reactive metals. Paraffin prevents potassium and sodium from reacting with oxygen and water vapour in the air.

5. (a) Oxygen
(b) To provide oxygen for the reaction.
(c) Heat the powdered metal until it glows before heating potassium manganate(VII) to provide oxygen for the reaction.
(d) To construct a reactivity series of metals.

CHAPTER 5 Thermochemistry

Summative Practice 5

1. (a) Exothermic reaction
(b) Endothermic reaction
(c) Exothermic reaction
(d) Endothermic reaction
(e) Exothermic reaction
(f) Exothermic reaction

2. (a) released (c) hot
(b) increases (d) absorbed

3. (a) THERMOCHEMISTRY
(b) PHOTOSYNTHESIS
(c) RESPIRATION
(d) THERMOMETER
(e) ENDOTHERMIC
(f) EXOTHERMIC

4. Heating of calcium carbonate is an endothermic reaction. Heat is absorbed by the chemical reaction that occurs during the decomposition of calcium carbonate.

5. The reaction between hydrochloric acid and sodium carbonate is an exothermic reaction whereas the reaction between hydrochloric acid and sodium hydrogen carbonate is an endothermic reaction.

CHAPTER 6 Electricity and Magnetism

Summative Practice 6

1. (a) True (b) False (c) True

2. (a) Non-renewable energy source
(b) Renewable energy source
(c) Renewable energy source
(d) Renewable energy source

3. (a) Magnetic field lines are cut
(b) Induced current
(c) LED lights up. Induced current flows through the LED. The flow of current through the LED causes the LED to light up.
(d) Generator

4. (a) Cathode Ray Oscilloscope
(b) Shape of graph, direction of current and voltage changes for direct current and alternating current.
(c) (i) Alternating current
(ii) Direct current

5. (a) Step-down transformer
(b) Number of turns in the primary coil is more than the number of turns in the secondary coil.
(c) To reduce eddy current and increase the efficiency of the transformer
(d) Using the formula, $\frac{V_p}{V_s} = \frac{N_p}{N_s}$

$$\frac{10\text{ V}}{V_s} = \frac{100\text{ turns}}{20\text{ turns}}$$

$$\text{Secondary voltage, } V_s = 10\text{ V} \times \frac{20\text{ turns}}{100\text{ turns}}$$

$$= 2\text{ V}$$

CHAPTER 7 Energy and Power

Summative Practice 7

1. (a) Energy possessed by an object is due to its position or condition.
(b) Energy possessed by a moving object.

2. (a) N m (b) Work
(c) stationary (d) can
(e) acceleration

3. (a) $W = Fs$
$= 5\text{ kg} \times 10\text{ m s}^{-2} \times 2\text{ m}$
$= 100\text{ J}$
(b) Energy used by motor = work done
$= 100\text{ J}$

4. (a) Gravitational potential energy = mgh
where m is the object mass
g is the gravitational acceleration
h is the height
(b) Elastic potential energy = $\frac{1}{2}Fx$,
where F is the compression or stretching force
x is the displacement from equilibrium position
(c) Kinetic energy = $\frac{1}{2}mv^2$,
where m is the mass
v is the velocity

CHAPTER 8 Radioactivity

Summative Practice 8

1. (a) ✓ (b) × (c) ✓

2. Radioactive decay is a spontaneous process by which an unstable nucleus emits radioactive radiation until the nucleus becomes more stable.

3. sodium-24 (Na-24)

4. 0 hours, 32 g → 5.2 hours, 16 g → 10.4 hours, 8 g → 15.6 hours, 4 g → 20.8 hours, 2 g

Therefore the remaining mass of Pa-234 after 20.8 hours is 2 g.

CHAPTER 9 Space Weather

Summative Practice 9

1. A: Convection zone
B: Chromosphere
C: Photosphere
D: Radiation zone
E: Core
F: Corona

2. 11 years

3. Sunspots

4. – Smartphone (mobile)
– Internet
– TV broadcast
– Global positioning system (GPS)

CHAPTER 10 Space Exploration

Summative Practice 10

1. (a) × (b) ✓ (c) × (d) ×

2. (a) Ptolemy (b) Kepler

3. Student's answers

4. Because space probes are not built to return to Earth.

5. (a) To gather information about Saturn to be sent back to Earth.
(b) Solar wind
(c) Solar energy

Complete answers for teachers
http://links.and/17.com/BT_Science_283

Glossary

Alternating current An electric current with the direction of its flow constantly changing.

Artery A type of blood vessel which transports oxygenated blood from the heart to the whole body.

Aurora A stunning light display in the sky when charged gas particles interact with atoms and molecules in Earth's atmosphere.

Capillary A type of blood vessel which connects arteries with veins.

Carboxyhaemoglobin A stable compound formed when carbon monoxide combines chemically with haemoglobin.

Cathode Ray Oscilloscope (C.R.O.) An electronic device that can be used to show the differences in the shape of graph, direction of current and voltage change for direct current and alternating current.

Coronal mass ejection A huge cloud of plasma that erupts from the Sun and often occurs together with huge and strong solar flares.

Direct current An electric current that flows only in one direction.

Earth's magnetosphere A region in outer space surrounding Earth where the magnetic field in Earth's magnetosphere is a combination of Earth's magnetic field and the magnetic field in the region in space.

Electric current Rate of flow of electric charges through a conductor.

Electric meter A device used to measure the quantity of electrical energy used.

Energy The ability to do work.

Energy efficiency Percentage of energy input that is converted to useful form of energy output.

Exudation (guttation) Process of water loss from plants in liquid form through hydathodes found at the edges of leaves.

Fuse A short, fine wire, heats up easily and melts when the current flowing through it exceeds the value of the fuse.

Generator A device used to generate electrical energy in the form of an induced current.

Geocentric model Solar System Model with Earth at the centre and the Sun revolving around Earth.

Geotropism Directional response of plants towards the force of gravity.

Green building A building which applies the concept of energy conservation to save the cost of energy consumption and reduce the release of carbon dioxide.

Heliocentric model Solar System Model with the Sun at the centre and Earth and other planets revolving around the Sun.

Hydrotropism Directional response of plants towards water.

Involuntary action Action that occurs immediately without conscious control or prior thoughts.

Kinetic energy Energy possessed by a moving object with a given mass.

Long-sightedness A type of visual defect which causes near objects to appear blurry because the images are focused behind the retina.

Metal extraction Process of obtaining a metal from its ore.

Mineral Solid element or compound present naturally with definite crystalline structure and chemical composition.

Nastic response Response towards stimulus such as touch but does not depend on the direction of the stimulus.

Non-renewable energy sources Energy sources that cannot be replaced and will deplete.

Optical illusion An object that is seen differs from its actual state.

Oxyhaemoglobin Unstable compound formed when oxygen combines chemically with haemoglobin in the blood.

Passive smoker A person who does not smoke but inhales cigarette smoke from nearby smokers.

Phloem Component in vascular bundle which transports sucrose produced during photosynthesis to other parts of the plant.

Phototropism Directional response of plants towards light.

Power Rate of doing work.

Prominence Huge loop or arched column of glowing gases over the sunspot.

Pulse Produced by the contraction and relaxation of the muscular artery wall.

Reactivity series of metals Arrangement of metals according to their reactivity with oxygen.

Remote sensing Method of gathering and recording information from a distance.

Renewable energy sources Energy sources that can be replaced continually and will never deplete.

Short-sightedness A type of visual defect which causes distant objects to appear blurry because the images are focused in front of the retina.

Solar cycle The activity of sunspot that seems to appear and disappear according to a 11-year cycle.

Solar wind Particles in plasma such as electrons, protons and alpha particles that erupt from the Sun to outer space travelling together at high speeds.

Space probe Spacecraft that gathers information and sends the information back to the Earth.

Space weather Phenomena that occur on the surface of the Sun (such as prominences, solar flares, sunspots and coronal mass ejections) and in space (such as solar winds, solar radiation storms and geomagnetic storms).

Sunspots Dark regions seen on the surface of the Sun.

Thermochemistry A study associated with heat changes during chemical reactions.

Thigmotropism Directional response of plants towards touch.

Transformer Device that changes the voltage of an alternating current.

Transpiration Process of water loss in the form of water vapour from the surface of plants to the air through evaporation.

Tropism Directional response of plants towards stimuli such as light, water, gravity and touch from a certain direction.

Value of fuse Maximum value of current that can flow through the fuse without causing the fuse wire to melt.

Vein A type of blood vessel which transports deoxygenated blood from the whole body to the heart.

Voltage Electrical energy used to move a unit of electric charge through a conductor.

Voluntary action Conscious action and conducted under one's will.

Xylem Component in vascular bundle which transports water and dissolved mineral salts from the roots to the leaves.

Reference

David Applin (2012). *Biology*, United Kingdom: Nelson Thornes

Gareth Williams (2011). *New Biology for You, Updated*, United Kingdom: Nelson Thornes

Gary Philpott and Jennifer Clifford (2009). *Longman Physics 11-14 (2009 edition)*, England: Longman.

Ian J. Burton (2015). *Cambridge O Level Biology Revision Guide, 2nd Revision*, United Kingdom: Cambridge University Press.

Joanne Baker (2010). *50 ideas universe*, United Kingdom: Quercus Editions Ltd, London.

Karen C. Timberlake (2018). *Chemistry – An introduction to General, Organic and Biological Chemistry, 13th Edition*, United States: Pearson.

Keith Johnson (2011). *New Physics for You, Updated*, United Kingdom: Nelson Thornes.

Lawrie Ryan (2011). *New Chemistry for You, Updated*, United Kingdom: Oxford Longman, Pearson Education Limited.

Martin Redfern (2012). *50 ideas earth*, United Kingdom: Quercus Editions Ltd.

Mary Jones, Geoff Jones (2015). *Biology Coursebook*, United Kingdom: Cambridge University Press

Ooi Chong Oui, Suzita binti Mohd Resa and Umagowrie a/p Supramaniam (2012). *Sains Tingkatan 3,* Malaysia: Pustaka Sistem Pelajaran Sdn. Bhd.

Phillipa Gardom Hulme (2013). *Complete Chemistry for Cambridge*, United Kingdom: Oxford University Press.

Stephen Schneider and Thomas Arny (2015). *Pathways to Astronomy*, United States: Glencoe Science Mc-Graw Hill.

Tho Lai Hoong (1990). *Fakta Penting Fizik Moden SPM*, Malaysia: Penerbit Fajar Bakti Sdn. Bhd.

Tho Lai Hoong (1991). *Fizik Tingkatan 4 KBSM*, Malaysia: Didika Sdn. Bhd.

Tho Lai Hoong (1996). *Pure Physics Modern Certificate Guides*, Singapore: Oxford University Press.

Tho Lai Hoong, Hasnah binti Abu Samah (2012). *Sains Tingkatan 3*, Malaysia: Sasbadi Sdn. Bhd.

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