PEARSON

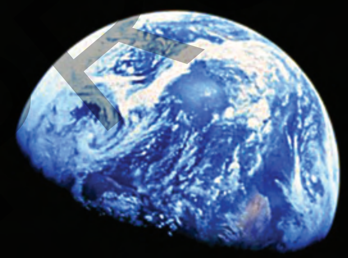
Science

STUDENT BOOK | 3RD EDITION

7

TOPIC 2 Systems in space: The Earth, Sun and Moon

In this topic you will learn about the Earth, Sun and Moon systems, and how their interactions are experienced on Earth, such as the changing seasons, eclipses and tides.



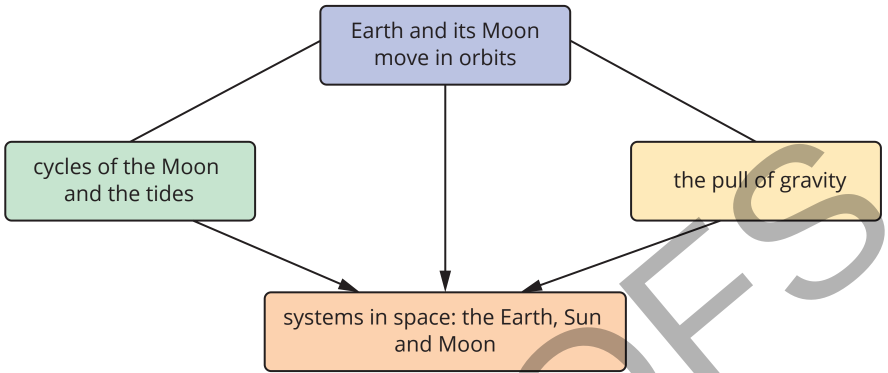
Learning intentions

The learning intentions for this topic are:

- ☐ To understand the structure of the Earth, Sun and Moon system **xx**
- ☐ To understand how the position and motion of Earth causes seasons **xx**
- ☐ To be able to use equipment to model the effect of the angle of the Sun on surface temperatures **xx**
- ☐ To understand seasonal calendars used by First Nations Australians **xx**
- ☐ To understand how the position of Earth and the Moon causes tides **xx**
- ☐ To understand how information about tides is used in society **xx**
- ☐ To understand the phases of the Moon **xx**
- ☐ To be able to create and use a model to describe the phases of the Moon **xx**
- ☐ To understand the cause of a lunar eclipse **xx**
- ☐ To be able to explore the influence of cultural perspectives on scientific knowledge about lunar eclipses **xx**
- ☐ To understand the cause of a solar eclipse **xx**
- ☐ To be able to explain how a range of factors have influenced the exploration of the Moon **xx**

2 Systems in space: The Earth, Sun and Moon

The key concepts that you will use in this topic:



The following prior knowledge questions will help to support your learning in the topic and can be attempted before the first lesson.

Earth and the Moon move in orbits

1 How long does it take Earth to spin (rotate) once?
2 Describe the motion of Earth around the Sun.

The pull of gravity

3 Describe the force of gravity acting between Earth and the Moon.

Cycles of the Moon and the tides

4 Describe the daily cycle of the tides.
5 Explain the main cause of the tides in Earth's oceans.
6 How is the Moon's motion related to the phases of the Moon seen from Earth?
7 How did the cycles of the Moon and the tides help people survive in the distant past?

2.1 The Earth, Sun and Moon system

Lesson overview

Earth, the Sun and the Moon are connected in space by the pull of gravity. They all journey through space, and their movements create observable effects from your vantage point on Earth.

Throughout the year, the length of days become longer or shorter during the seasons and you can see changes in the phases of the Moon and night sky. Earth, the Sun and the Moon interact in a predictable way. This is known through observations and knowledge of gravity and the relative sizes and distances between these objects. In this lesson, you will learn about the Earth, Sun and Moon system and how these objects interact in space.

Learning intention

To understand the structure of the Earth, Sun and Moon system

Success criteria

SC 1: I can describe the relative positions and sizes of Earth, the Sun and the Moon.

SC 2: I can describe the relative motion of Earth, the Sun and the Moon.

SC 3: I can explain the role of gravity in the movement of Earth, the Sun and the Moon.

SC 1 I can describe the relative positions and sizes of Earth, the Sun and the Moon

The **Sun** is the centre of the **solar system**. The solar system includes all objects that travel around the Sun: the eight **planets**, smaller bodies such as dwarf planets, meteors, comets and asteroids, and natural satellites such as the **Moon**. The force of **gravity** is responsible for the attraction between objects and keeps these objects, including Earth, travelling around the Sun.

KEY TERMS

Sun a massive, luminous ball of hot gas located at the centre of the solar system. It emits light, heat, and energy that reach Earth and other planets.
solar system the Sun and all the planets, satellites, asteroids, comets and other bodies revolving around it
planet roughly spherical ball of rock or gas that orbit (move around) the Sun. They do not generate their own light.
gravity the force of attraction between any two objects
Moon a natural satellite that orbits Earth

Earth, the Sun and the Moon in space

Thinking about distance and size in **space** can be very difficult because everything is very far apart and some objects in the solar system are so much larger than Earth. It helps to consider how other objects in space relate to Earth.

How big is Earth?

The diameter of Earth at the equator is 12 756 kilometres.

FIGURE 2.1.1 Earth's mass is approximately 83 times larger than the Moon's mass.

KEY TERMS

space the immense and limitless area beyond Earth's atmosphere, containing stars, planets, galaxies, and other cosmic matter
mass the amount of matter in a substance or object; measured in grams (g), kilograms (kg) or tonnes (t)

How big is the Moon?

The Moon is smaller than Earth (Figure 2.1.1) and much smaller than the Sun. It has a diameter of 3480 km which is less than a third of Earth's diameter. The Moon's mass is only about 1.2% of Earth's mass. On average, the distance between Earth and the Moon is 384 400 km.

How big is the Sun?

The Sun is very large, much bigger than Earth, and represents most of the mass in the entire solar system. The image in Figure 2.1.2 gives you an idea about the size of the Sun compared to Earth and the other planets. The Sun's diameter is about 1.392 million kilometres, which is at least 109 times wider than the diameter of Earth, so you could fit 109 Earths across the Sun. The mass of the Sun is about 333 000 times the mass of Earth.

The distance between the Sun and Earth is approximately 150 million kilometres.

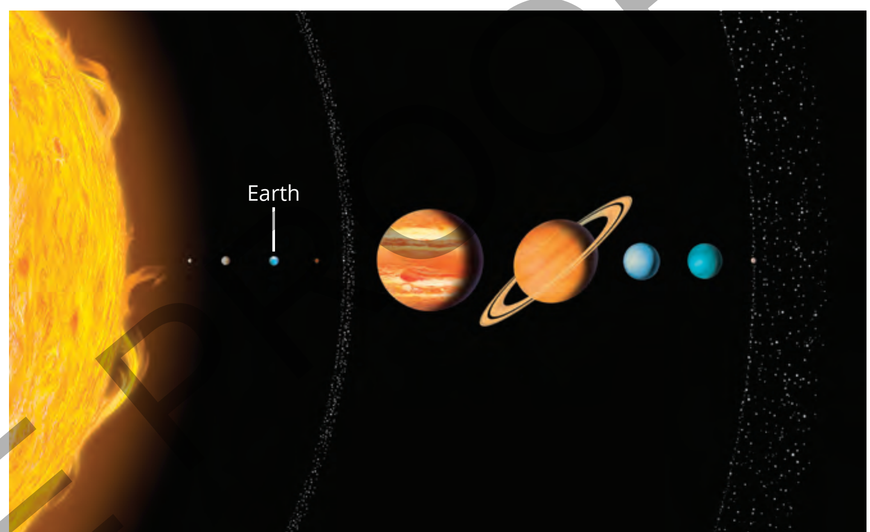


FIGURE 2.1.2 The Sun's mass is about 333 000 times the mass of Earth.

Scifile

Scientific notation

Scientific notation is a method used to express very large or very small numbers in a more compact and manageable form. It is especially useful in fields like science and engineering where these types of numbers are common.

For example, the number 1 000 000 can be written as 1×10^6.

The mass of Earth in scientific notation is 5.972×10^{24} kg

10^{24} written in expanded form is a 1 followed by 24 zeros

$= 5.972 \times 1\,000\,000\,000\,000\,000\,000\,000\,000$

$= 5\,972\,000\,000\,000\,000\,000\,000\,000$

This number is 5.972 septillion!

Now compare Earth's mass with the Moon and the Sun:

The mass of the Moon is 7.342×10^{22} kg

The mass of the Sun is 1.988×10^{30} kg

The Earth, Sun and Moon system

In space, the Moon and Earth are relatively close together compared to their distance to the Sun. The Sun and the Moon also differ greatly in size, as the Sun is about 400 times larger than the Moon. The Sun also happens to be almost 400 times farther away from Earth than the Moon, and this causes the Sun and the Moon to look the same size from your perspective on Earth.

Scifile

Distance in space

The average distance from Earth to the Moon is about 384 400 kilometres. That is like travelling around Earth's equator almost 10 times! Despite this distance, the Moon's gravity still affects Earth. The Moon looks small in the sky due to how far away it is. It is actually slightly smaller in diameter than Australia, about a third of Earth's diameter.

SC 1 CHECK YOUR UNDERSTANDING

Rank Earth, the Sun and the Moon on their size (from smallest to largest) and the Sun and the Moon on their distance from Earth (from closest to most distant).

SC 2 I can describe the relative motion of Earth, the Sun and the Moon

Everything in the solar system is always on the move. The forces between the Sun, Earth and the Moon cause movements that can be observed from Earth.

Orbits

The force of gravity can cause objects in space to revolve around others in an **orbit**. An orbit is a curved path like a circle, an ellipse or a symmetrical oval. Earth travels in an almost circular orbit around the Sun.

It takes Earth 365 and $\frac{1}{4}$ days, or one year, to orbit the Sun. A normal calendar year has 365 days – which does not quite match Earth's orbit. So, to keep the calendar year aligned with the time it takes Earth to revolve around the Sun, an extra day is added to the calendar every four years which creates leap years. Leap years have 366 days.

While Earth is travelling around the Sun, the Moon orbits around Earth. It takes the Moon 27.3 days to orbit Earth. Figure 2.1.3 shows both these motions and how long each of them takes.

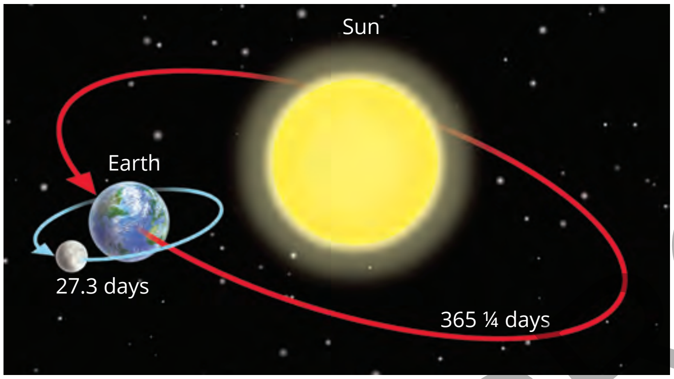


FIGURE 2.1.3 The orbit of Earth around the Sun defines one year; in this time the Moon completes many orbits of Earth.

Rotation

While Earth and the Moon are travelling in orbits in space, the Sun, Earth and the Moon are also constantly spinning. This spinning motion is called **rotation** and occurs around an axis. An axis is an invisible line that objects rotate around. You can imagine **Earth's axis** as a line through the middle of Earth from the North Pole to the South Pole (Figure 2.1.4).

Day and night

Earth's rotation on its axis results in a cycle of daylight and darkness, or day and night, every 24 hours. As Earth rotates, the side of Earth facing the Sun receives light and experiences day. The other side of Earth which faces away from the Sun is in darkness and experiences night. As Earth rotates, it seems like the Sun is moving across the sky, but it is really Earth that is moving. It is said that the Sun rises and sets at the beginning and end of each day but it is Earth's rotation that makes it look like the Sun is appearing or disappearing over the horizon (Figure 2.1.5).

SC 2 CHECK YOUR UNDERSTANDING

Identify the object that Earth orbits around.

KEY TERMS

orbit curved path a planet takes around a star, or that a moon or artificial satellite takes around a planet; orbits can be circular or elliptical
rotation spinning motion of an object around a central line, called an axis of rotation
Earth's axis the line connecting the North Pole with the South Pole; Earth rotates around this axis

FIGURE 2.1.4 It takes Earth 24 hours, or one day and night, to complete a full rotation on its axis; the Sun and the Moon take about 27 days to complete a full rotation.

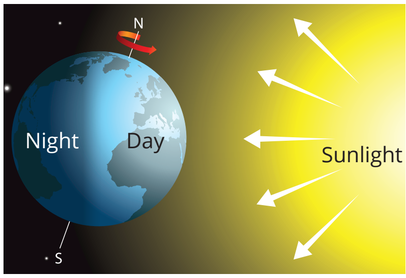


FIGURE 2.1.5 When you are on the part of Earth where you see light from the Sun, you call it daytime. When you are in the shadow of Earth, you call it night. So, the experience of day or night depends on your position on Earth.

SC 3 I can explain the role of gravity in the movement of Earth, the Sun and the Moon

Gravity is the force that attracts objects to each other in space. Any object with mass will attract any other object with mass. The Sun, the Moon and Earth all exert gravitational forces, pulling objects toward their centre. Objects with more mass have a stronger gravitational pull, but the force of gravity also decreases with distance. So, the farther you travel away from an object, the weaker the force of gravity you will experience.

Gravity and orbits

Earth, and all other objects in the solar system, have a very strong gravitational attraction to the Sun due to its immense mass. Even though the distance between the Sun and Earth is very large, the Sun's gravitational pull is strong enough to keep Earth in its orbit around the Sun.

The Moon and Earth are relatively close to each other in space. Earth has much more mass than the Moon. Earth's gravity keeps the Moon in its orbit around Earth. The diagram shown in Figure 2.1.6 is not to scale but will help you to visualise the relationship between the Moon, Earth and the Sun.

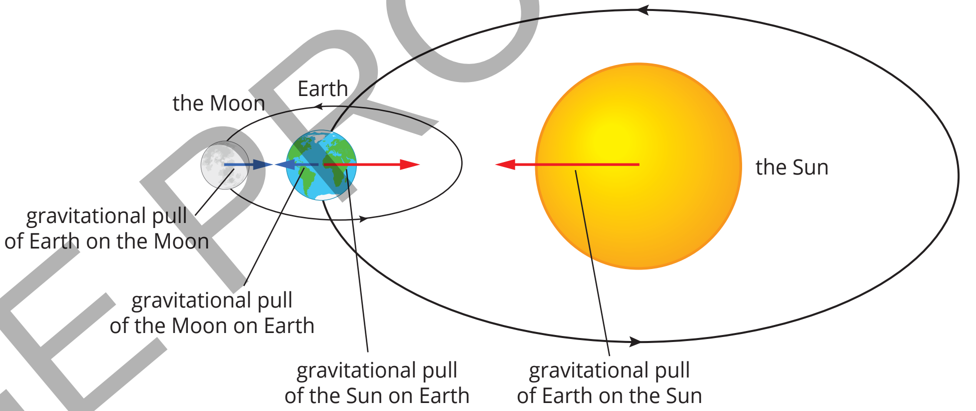


FIGURE 2.1.6 The force of gravity acting on Earth due to the Sun keeps Earth in its orbit around the Sun. The gravitational forces between Earth and the Moon are also shown and it is the pull of Earth on the Moon that keeps the Moon in its orbit around Earth.

Keeping steady

Stable orbits happen when the force of gravity is combined with an object moving at the right speed through space. For example, the Moon is travelling at a speed which would ordinarily cause it to travel through space in a straight line, but Earth's force of gravity pulls on the Moon keeping it in an orbit.

The Moon's speed also stops the Moon from being pulled to the centre of Earth and crashing down on us. The combination of the Moon's speed and Earth's gravity keeps the orbit steady (Figure 2.1.7).

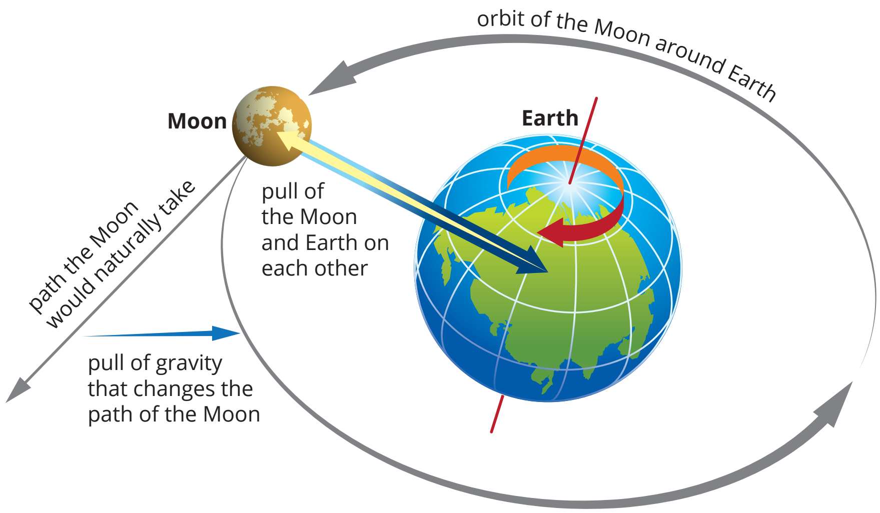


FIGURE 2.1.7 The pull of gravity of the Moon and Earth on each other keeps the Moon in orbit around Earth.

Satellites

The Moon is Earth's natural satellite. A satellite is a body in orbit around another body. Many artificial satellites are created to orbit Earth. Something that scientists must consider when they launch satellites into orbit is their speed. As shown in Figure 2.1.8, if a satellite is moving too fast, Earth's gravity won't be strong enough to keep the satellite in orbit and it will move into space (such as Satellite B). If the satellite is moving too slowly, Earth's gravity will pull the satellite back down to Earth (such as Satellite C). When the satellite is moving at just the right speed, it will stay in a fixed orbit around Earth (such as Satellite A).

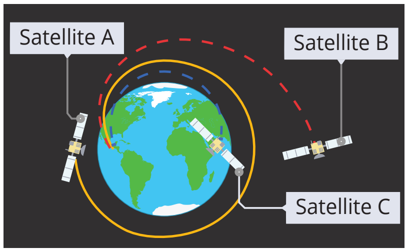


FIGURE 2.1.8 The speed of a satellite must be correct for it to stay in an orbit at a certain distance from Earth.

SC 3 CHECK YOUR UNDERSTANDING

Explain how gravity keeps the Moon in orbit around Earth.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1. Compare the sizes of Earth, the Sun and the Moon. Which one is the largest and which one is the smallest?
2. Illustrate the approximate sizes and arrangement of Earth, the Sun and the Moon using common objects (such as a basketball, a tennis ball and a marble).
3. Predict what would happen to day and night if Earth did not rotate on its axis.
4. Contrast the motion of Earth around the Sun with the motion of the Moon around Earth.
5. Describe what would happen to Earth's orbit if the Sun's gravity suddenly disappeared.

2.2 Causes of seasons

Learning intention

To understand how the position and motion of Earth causes seasons

Success criteria

SC 1: I can explain why different parts of Earth experience different seasons at different times of the year.

SC 2: I can suggest why Earth's tilt on its axis causes different parts of Earth to experience different light intensity.

SC 3: I can predict the season at a particular place on Earth based on Earth's tilt relative to the Sun.

Lesson overview

Seasonal changes are an important part of life on Earth. As seasons change there are changes in the lengths of day and night, temperature, weather patterns and the environment. The seasons are caused by the movement of Earth in space throughout the year. Different seasons are recognised in different ways, in different places on Earth. In this lesson you will learn how Earth's motion and position in space causes seasonal changes.

SC 1 I can explain why different parts of Earth experience different seasons at different times of the year.

Earth's axis

Each day Earth completes a full rotation on its axis – the imaginary line through the North and South poles. Figure 2.2.2 shows how Earth's axis is not completely upright; it is tilted at an angle of about 23.5° with the axis always pointed in the same direction in space.

This tilt means that Earth travels around the Sun at an angle, so the way sunlight reaches different places on Earth changes throughout the year.

As Earth completes an orbit around the Sun, either the Northern or Southern Hemisphere becomes tilted toward the Sun (Figure 2.2.1). The part of Earth that is tilted toward the Sun receives more direct sunlight and longer hours of daylight. Meanwhile, the part of Earth tilted away from the Sun receives less direct sunlight and shorter hours of daylight.

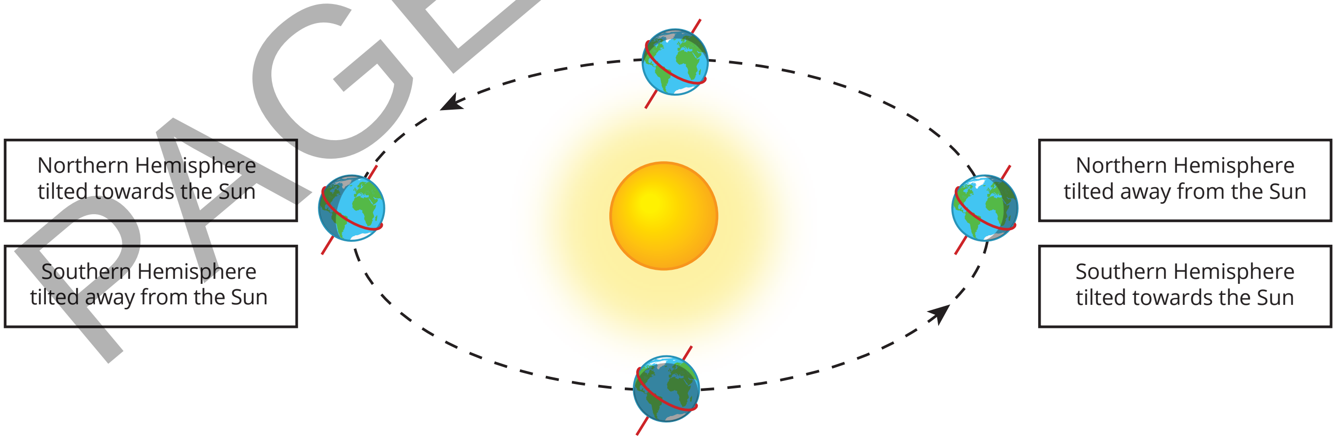


FIGURE 2.2.1 Earth's seasons are caused by its orbit and the tilt of its axis of rotation.

During an Australian summer, the South Pole is tilted toward the Sun and the Sun's path appears higher in the sky. In summer it also takes longer for the Sun to set, creating longer daylight hours. As Earth continues to orbit the Sun, it reaches a point in autumn and again in spring during which neither the South Pole nor the North Pole is tilted toward the Sun. This causes the length of day and night to be equal. During an Australian winter, the South Pole tilts away from the Sun so the Sun appears lower in the sky and sets faster, creating shorter days.

If Earth's axis were not tilted and Earth travelled around the Sun in an upright position, there would be no seasonal changes on Earth because light would reach each place on Earth in the same way all year round. It is important to remember that Earth's seasons are not caused by changes in distance to the Sun. If seasons were caused by the proximity of Earth to the Sun, then both hemispheres would experience the same season at the same time.

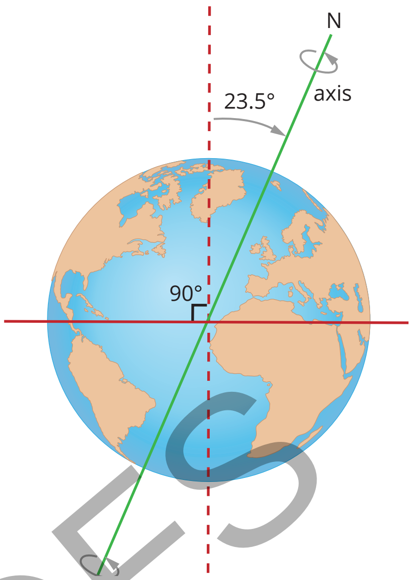


FIGURE 2.2.2 Earth's axis is tilted in space at a fixed angle of 23.5°.

Earth's seasons

Changes in weather, temperature and daylight are noticeable throughout the year (Figure 2.2.3). These changes occur regularly each year and are known as **seasons**. Depending on where you live, you probably recognise the seasons as summer, autumn, winter and spring, with summer being the hottest season with the longest daylight hours and winter being the coldest season with shortest daylight hours. The seasonal changes that a location on Earth experiences depends on that place's position in relation to the Sun's rays.

KEY TERM

seasons on Earth, summer, autumn, winter, spring; caused by the tilt of a planet's axis

Summer in Australia

Australia is in the Southern Hemisphere. When the Southern Hemisphere is tilted toward the Sun, the Southern Hemisphere experiences summer (Figure 2.2.3). Summer in Australia occurs between December and February. The Sun is higher in the sky during this time and above the horizon for a longer duration, creating higher temperatures and longer hours of daylight.

At the same time, the Northern Hemisphere is tilted away from the Sun and experiences winter. So, if you were to visit North America during the Australian summer holidays, then you would need to pack warm clothes for winter.

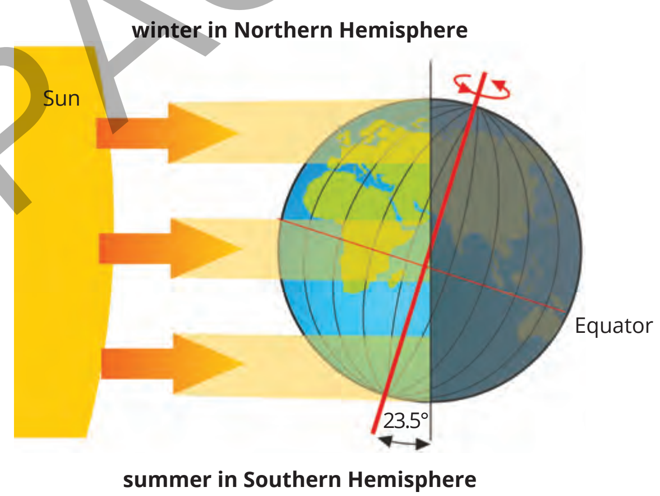


FIGURE 2.2.3 Earth's position during Southern Hemisphere summer and Northern Hemisphere winter.

Winter in Australia

When the Southern Hemisphere is tilted away from the Sun, the Southern Hemisphere experiences winter (Figure 2.2.4). Winter in Australia occurs between June and August. The Sun is lower in the sky during this time and remains above the horizon for a shorter time, creating lower temperatures and shorter hours of daylight. At the same time, the Northern Hemisphere is tilted toward the Sun and experiences summer.

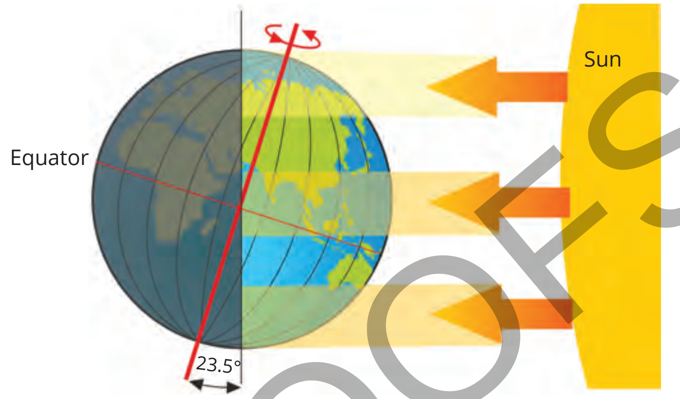


FIGURE 2.2.4 Earth's position during Northern Hemisphere summer and Southern Hemisphere winter.

Autumn and spring in Australia

Spring is the season that follows winter and is caused by the changing orientation of Earth's tilt toward the Sun. In spring, the hours of daylight and temperature begin to increase. Spring occurs between September and November in Australia.

Autumn is the season that follows winter and is caused by the changing orientation of Earth's tilt away from the Sun. In autumn the hours of daylight and temperature begin to decrease. Autumn occurs between March and May in Australia.

During mid-spring and mid-autumn there is a time when the number of hours of daylight and night are equal and neither of Earth's hemispheres tilt more toward the Sun. Temperatures are moderate in spring and autumn.

The season experienced in the Southern Hemisphere is the opposite of the season experienced simultaneously in the Northern Hemisphere. When it is spring in Australia, it is autumn in North America.

SkillBuilder

Graphing seasonal data

Patterns in data

- A pattern is a repeated occurrence or sequence in data. The data is repeated, so patterns can be used to predict observations.
- A trend is when the results are changing in one direction during the time of the recording of data.

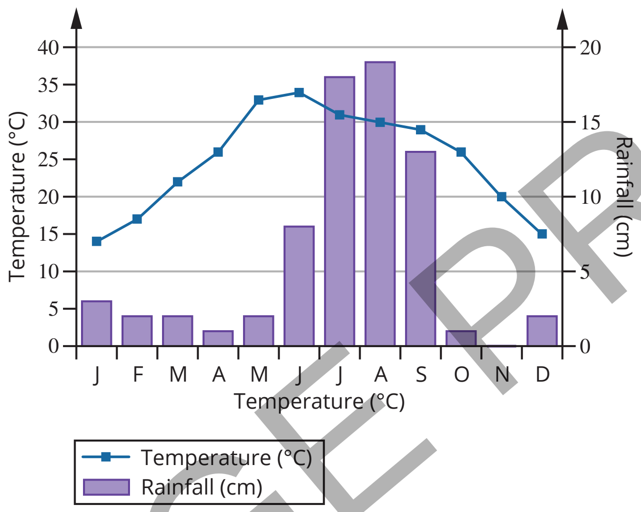
Describing patterns from graphs

1. Look at the overall pattern shown by the changes to the data on the graph.
2. If the change is all in one direction, then the pattern is called a trend.
3. Patterns that are not trends can still be used to describe events and make predictions by analysing the shape of the graph.

Seasonal patterns

1. A seasonal pattern occurs when the results are repeated over a certain amount of time, such as a year.
2. High parts of the graph are called peaks and low parts of the graph are called troughs.
   For example, Alex knows that the temperature and rainfall in one year in northern Thailand follows a seasonal pattern. By looking at the rainfall and temperature data from this year on the graph, he can predict when temperatures and rainfall will be at their highest next year. The graph shows that the temperature peaks in June at 33°C and rainfall has a major peak in August at 18 cm.

Climate graph of North Thailand



SC 1 CHECK YOUR UNDERSTANDING

Explain why it is summer in Australia when it is winter in the Northern Hemisphere.

SC 2 I can suggest why Earth's tilt on its axis causes different parts of Earth to experience different light intensity

Energy from the Sun

The Sun provides Earth with most of its energy. Solar energy from the Sun reaches Earth as light and heat.

Not all parts of Earth receive the same amount of solar energy. The amount of solar energy that a particular location receives also changes throughout the year.

KEY TERM

equator an imaginary horizontal line that divides Earth into the Northern and Southern Hemispheres. It lies equal distance between the North and South Poles

Direct and indirect sunlight

Earth receives more solar energy near the **equator** than at Earth's poles. Because Earth is round, sunlight strikes Earth more directly at the equator, specifically at an angle close to 90°. Sunlight strikes Earth at the poles indirectly, or at a much lower angle. These parts of Earth receive less solar energy.

From the equator towards the poles, sunlight reaches Earth at lower and lower angles and the amount of solar energy received decreases. This is shown in Figure 2.2.5. The amount of solar energy received at each pole also changes depending on which hemisphere is tilted toward or away from the Sun.

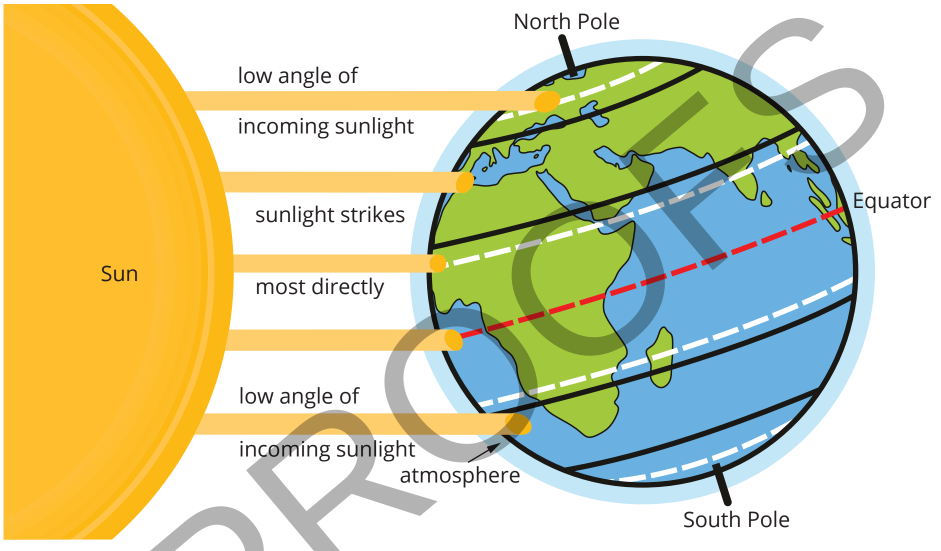


FIGURE 2.2.5 Sunlight strikes Earth's surface at different angles at different positions on Earth.

The angle of sunlight and Earth's tilt

The closer to 90° that a location on Earth is toward the Sun's rays, the more direct sunlight, or the higher light intensity it receives. When the angle of sunlight is lower the amount of the Sun's energy reaching a location is spread over a larger area. This reduces light intensity and temperature (Figure 2.2.6).

The angle of sunlight in relation to a location on Earth varies throughout the year due to Earth's tilt and orbit. As Earth completes an orbit around the Sun, each hemisphere is tilted toward or away from the Sun for part of the year.

Scifile

Solar panels

Solar panels work best when they are angled towards the Sun. By adjusting the angle to match the Sun's position, they can capture more energy and produce more electricity. This is why some solar panels can move.

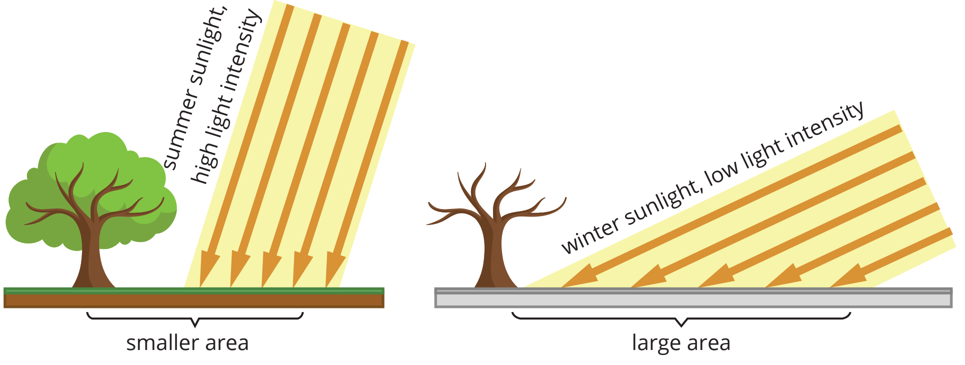


FIGURE 2.2.6 The intensity of sunlight changes throughout the year due to Earth's tilt.

Light intensity and seasons

During winter, the angle of Earth's axis causes the Sun's rays to reach a location at a lower angle, resulting in lower light intensity. In contrast, during summer, the Sun's rays hit the same location at a more direct angle (closer to 90 degrees) which leads to higher light intensity.

The angle of the Sun's rays can be related to its position above the horizon at a specific place on Earth and at a specific time of day. At midday in summer, the Sun is high in the sky, and sunlight reaches Earth at a more direct angle. In contrast, at midday in winter, the Sun appears lower in the sky, and sunlight reaches Earth at a shallower angle. Light intensity is at its peak in summer, moderate in spring and autumn and lowest in winter (Figure 2.2.7).

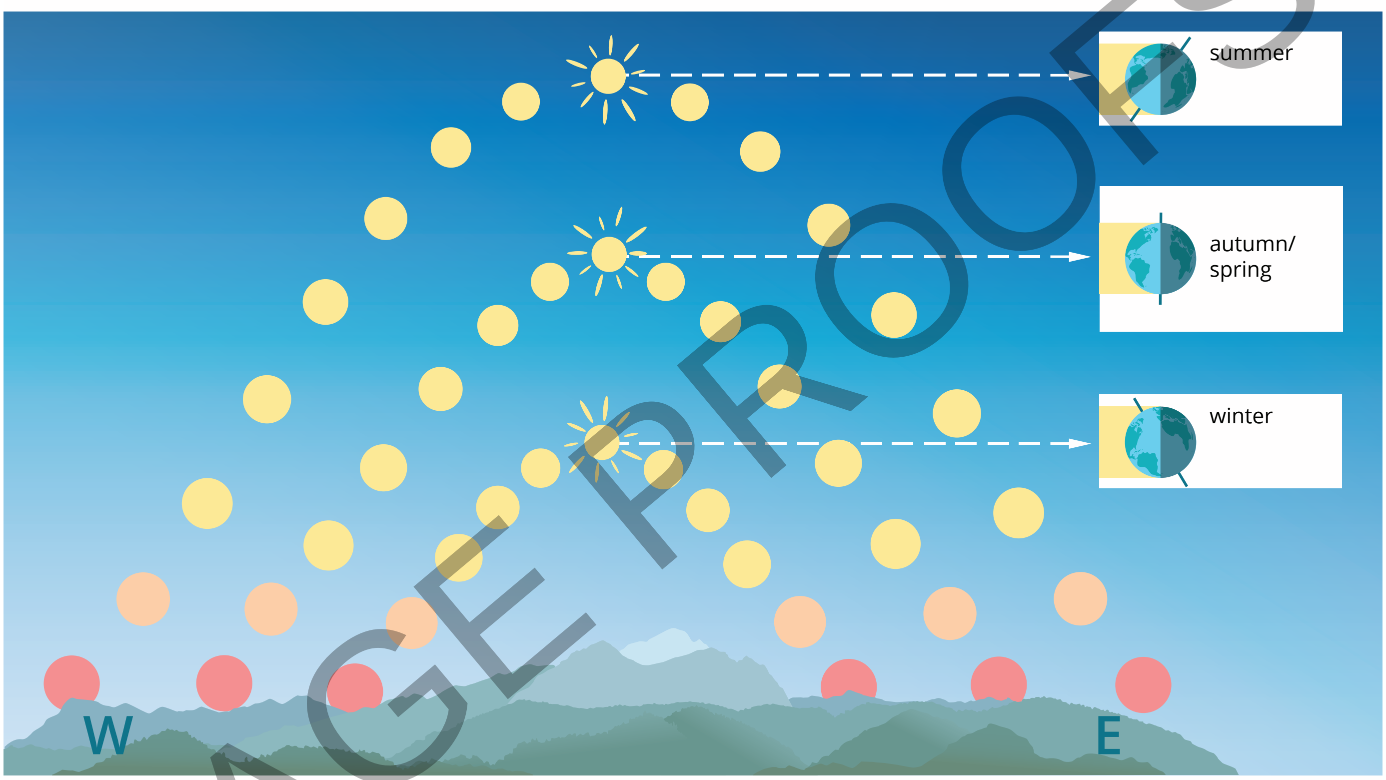


FIGURE 2.2.7 The Sun is higher in the sky in summer and lower in winter, so the light from the Sun is more intense in summer and less intense in winter.

SC 2 CHECK YOUR UNDERSTANDING

Explain how Earth's tilt affects the intensity of sunlight received at different parts of Earth.

SC 3 I can predict the season at a particular place on Earth based on Earth's tilt relative to the Sun

Earth's tilt

During Earth's orbit around the Sun, different parts of Earth experience changes in the amount and intensity of sunlight they receive due to Earth's tilt.

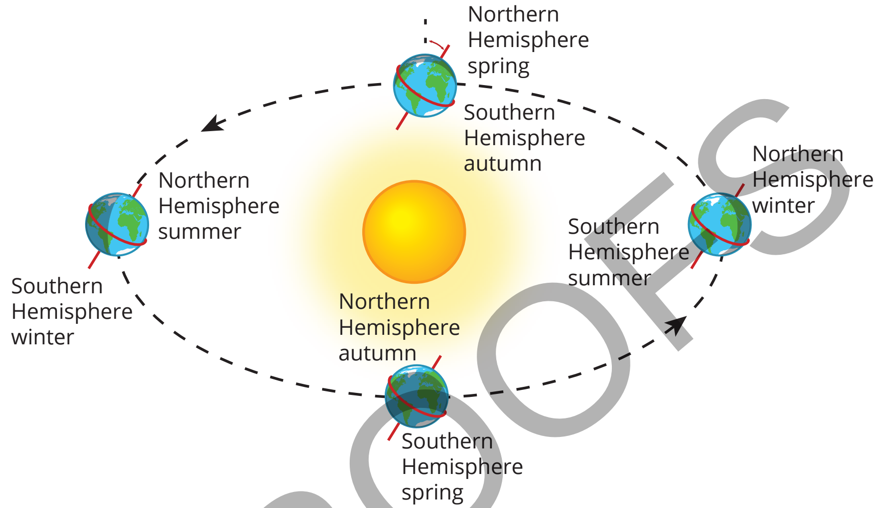


FIGURE 2.2.8 The mid-latitudes experience the greatest variation in the intensity of sunlight so the seasons are most evident there.

This tilt causes seasonal changes. In the tropics, around the Equator, every day of the year is similarly hot and there is little seasonal change. In the Arctic and Antarctica polar areas, every day is cold and there is some seasonal change. The most extreme seasonal changes are in the mid-latitudes between the poles and tropics. There are four seasons in these regions. The way in which a place experiences seasons depends on its latitude, which is its distance north or south from the equator (Figure 2.2.9).

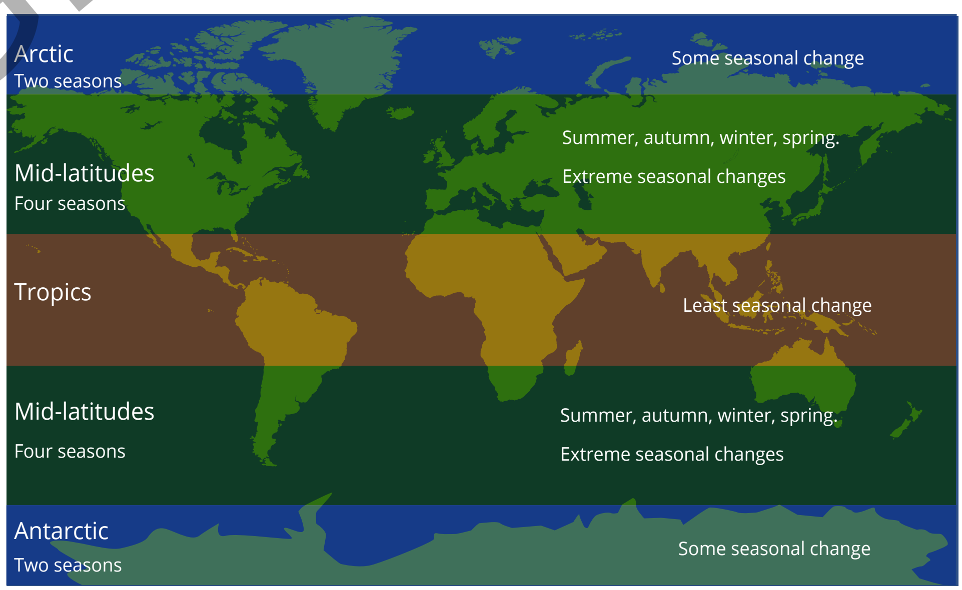


FIGURE 2.2.9 The intensity of sunlight varies with latitude, and this determines how extreme seasonal changes are throughout the year.

At the equator

The tropical regions around the equator receive the most direct, intense sunlight all year round. Earth's tilt does not greatly change the angle at which sunlight reaches the equator. As Earth completes its orbit of the Sun, the amount of sunlight reaching regions at the equator is relatively constant. Here, temperature and day length don't change much throughout the year. The typical seasons of spring, summer, autumn and winter are not representative of the seasonal changes in this region. Seasons are more often characterised by high temperatures with changing levels of rainfall in alternating wet and dry seasons.

FIGURE 2.2.10 Darwin, Australia's most northern capital city, experiences high temperatures all round with two main seasons each year characterised by rainfall as 'wet' and 'dry'.

Mid-latitudes

Mid-latitudes are regions situated between the equator and the poles. These areas experience distinct seasons – summer, autumn, winter and spring – each marked by changes in day length, light intensity and temperatures (Figure 2.2.8).

FIGURE 2.2.11 The same tree during all four seasons.

Recall that, when the Northern Hemisphere tilts toward the Sun, mid-latitude places in that hemisphere, like North America, Europe and Asia, experience summer. Meanwhile, in the mid-latitudes of the Southern Hemisphere, including Australia, South America and New Zealand, the tilt away from the Sun leads to winter. After six months, this situation reverses: the Southern Hemisphere enjoys summer as the Northern Hemisphere has winter.

At the poles

Polar regions, the Arctic in the Northern Hemisphere and Antarctica in the Southern Hemisphere, are dramatically affected by Earth's tilt and experience extreme changes in day length throughout the year. The polar regions only experience two seasons – winter and summer. Polar summers have less light intensity and lower temperatures than summers in the mid-latitudes.

FIGURE 2.2.12 During winter in Antarctica the constant darkness is known a polar night.

When the North Pole is tilted toward the Sun in the middle of its summer, the Arctic experiences continuous sunlight because the Sun does not drop below the horizon. At the same time, the South Pole is tilted away from the Sun during its winter. The Sun does not rise above the horizon and Antarctica experiences continuous darkness. So, in summer at the poles, the Sun does not set, and in winter the Sun does not rise. This situation is reversed six months later when it is winter in the Arctic and summer in the Antarctic.

Temperatures are always low throughout the year at both poles, even in summer, as the poles receive very little direct light and sunlight strikes at a very low angle.

SC 3 CHECK YOUR UNDERSTANDING

Identify the season in the Northern Hemisphere when

a the Northern Hemisphere is tilted towards the Sun

b the Southern Hemisphere is tilted towards the Sun.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 Consider the causes of Earth's seasons.

- **a** Explain how Earth's tilt affects the seasons.
- **b** Describe what happens to the seasons when Earth orbits the Sun.

2 Compare the seasons experienced in the Northern Hemisphere to those in the Southern Hemisphere.

3 If Earth's axis were not tilted, what would happen to the seasons?

4 Compare light intensity at different latitudes.

- **a** How does the light intensity at the equator compare to that at the poles?
- **b** How does light intensity change with the seasons at mid-latitudes?
- **c** Figure 2.2.9 shows how the different latitude ranges experience differing seasonal patterns. Predict which latitude ranges will be most affected by rising global temperatures if the areas most affected will be those which experience the most direct sunlight.

2.3 Investigating the changing angle of the Sun

Introduction

The angle of the Sun will change throughout the day due to Earth's rotation. The angle at which sunlight hits the surface of Earth also varies throughout the year because Earth is tilted on an axis. This is shown in Figure 2.3.1. In winter, the Sun never gets as high in the sky as it does in the summer months.

In this practical investigation, you will explore how Earth's changing tilt can be simulated through experiments to understand the varying warming effects of sunlight at different angles.

Learning intention

To be able to use equipment to model the effect of the angle of the Sun on surface temperatures

Success criteria

SC 1: I can set up an experiment that models the changing angles of sunlight.

SC 2: I can make accurate measurements with a thermometer.

SC 3: I can analyse data to test a cause-and-effect relationship.

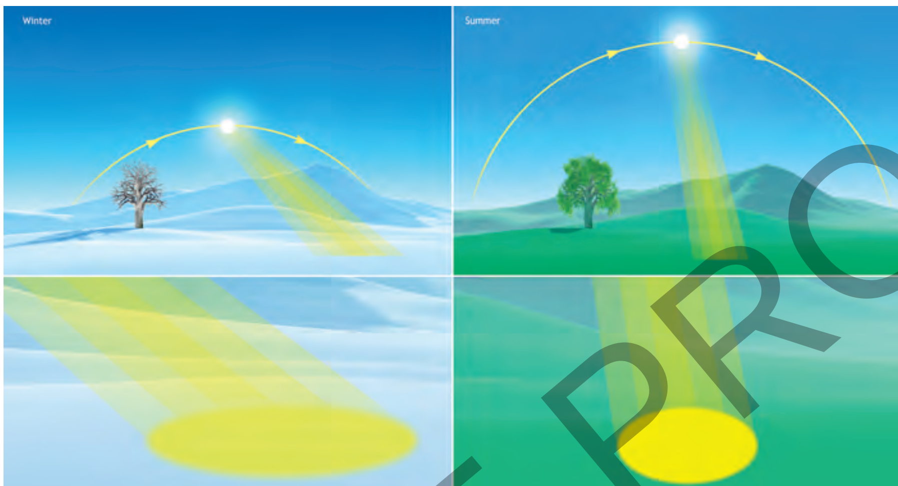


FIGURE 2.3.1 When the Sun is higher in the sky, sunlight is more intense.

Background

The position of the Sun in the sky will change both during the day and during the year. The angle at which sunlight hits Earth can be measured by imagining a straight line drawn from the Sun to a place on the surface of Earth. The angle is measured between this line and Earth's surface.

Note that the angle of sunlight at the equator is larger (more direct) throughout the year than the angle of sunlight hitting Earth's surface at the poles (Figure 2.3.2).

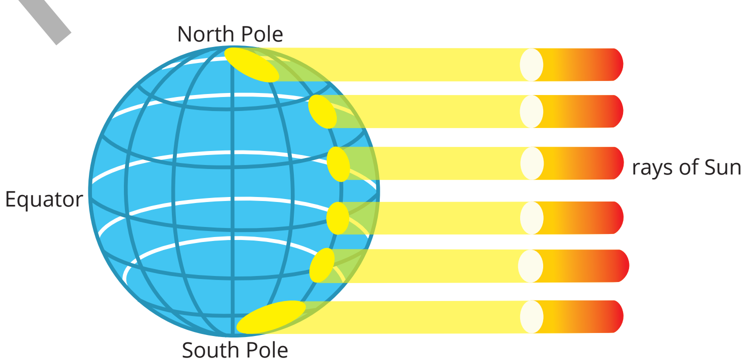


FIGURE 2.3.2 Sunlight hits Earth's surface at 90 degrees in some places and at smaller angles in others.

Aim

To use a model to test whether the angle at which sunlight hits Earth affects the surface temperature on Earth.

GO TO
SkillBuilder: Writing a hypothesis in your Skills Toolkit, page XX.

Hypothesis

Write a hypothesis for your investigation.

Prediction

Read the method and write a prediction in your notebook for what will be observed in the experiment.

Materials

SAFETY NOTE

- The lamp will get very hot so avoid touching it.

- warm lamp (such as a microscope lamp)
- 2 thermometers
- 2 blocks of wood
- black plastic
- sticky tape

Assessment of risk

Ensure you are aware of the risks of this practical investigation and have considered how safety can be improved before carrying out this activity.

Method

1. Construct a results table like the table below to record your results.
2. Cut out two small identically sized sheets of black plastic and tape them onto wooden blocks so that they make pockets.
3. Secure a thermometer in each pocket, ensuring that it is touching the plastic sheet. Tape the thermometer to the board to secure it.
4. Place the two blocks the same distance from the lamp as shown in the diagram in Figure 2.3.3.
   - Block A: Lay one block flat on the desk so that the light from the lamp falls on it at an angle.
   - Block B: Use some books to position the other block at an angle to the desk so that the light falls directly on it.

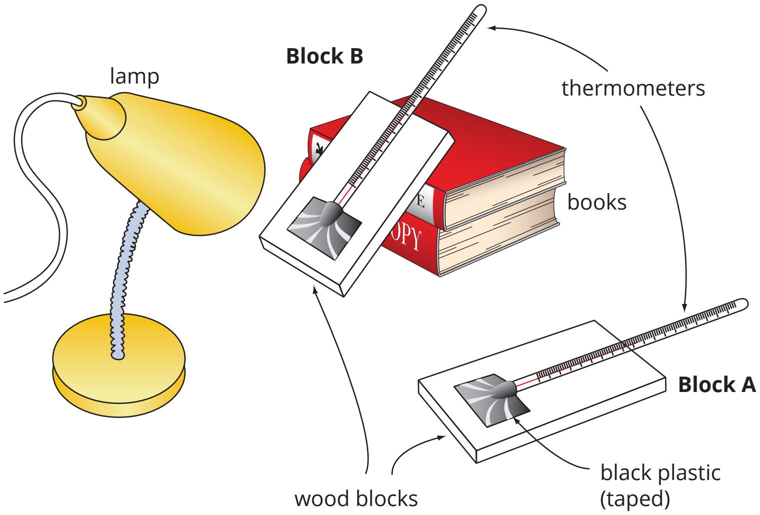


FIGURE 2.3.3 The materials setup for the investigation

5 Estimate the angle of the light to the blocks of wood.

6 Turn on the lamp and record the temperature at each block for at least 5 minutes.

Results

Record your results in a table like this.

Time (minutes)	Block A	Block B
	Angle of light = indirect	Angle of light = direct
	Temperature, *T* (°C)	Temperature, *T* (°C)
1		
2		
3		
4		
5		

Conclusion

Write your conclusion by answering the following questions.

1 Identify which block (A or B) modelled the surface of Earth in summer and which block modelled the surface in winter.

2 Describe whether the results of this experiment support the idea that there is a cause-and-effect relationship between the angle of sunlight and the temperature of the surface of Earth.

GO TO
SkillBuilder: Cause-and-effect relationships in your Skills Toolkit, page XX.

Evaluation

Describe how you were able to ensure the accuracy of your measurements in this experiment.

GO TO
SkillBuilder: Improving accuracy in your Skills Toolkit, page XX.

2.4 Seasonal calendars

Learning intention

To understand seasonal calendars used by First Nations Australians

Success criteria

SC 1: I can describe how a group of First Nations Australians organise their seasonal calendar.

SC 2: I can explain how a group of First Nations Australians use a seasonal calendar to make predictions.

Lesson overview

First Nations Australians have long held local knowledge about **Country**. Country, in this context, signifies the importance and status First Nations communities give to the land. It is not just land to be bought and sold; it is a living, breathing entity. Country talks to us, and you can hear its messages if you know how to connect appropriately.

Seasonal changes are just one example of this communication from Country (Figure 2.4.1). Over many generations, First Nations groups have developed calendars of seasonal changes that use their relationship with the natural environment, observation of the night sky and understanding of plant and animal cycles. In this lesson you will learn about the development of First Nations calendars and how they are used.

KEY TERM

Country the land that First Nations peoples have a cultural connection to through their ancestry

SC 1	I can describe how a group of First Nations Australians organise their seasonal calendar

Seasonal calendars

Different places on Earth experience different seasons. A Western model of spring, summer, autumn and winter, for example, does not reflect the seasons experienced in tropical regions near the equator. The Top End of Australia has a consistent temperature throughout the year with large seasonal rainfall variation. Here, it makes sense to describe only two seasons: wet and dry. Elsewhere in Australia, First Nations seasonal calendars are localised to different regions and are shaped by the patterns in the environment and climate in that region.

FIGURE 2.4.1 Natural cycles, such as the flowering of plants, provide evidence of changing seasons.

Specifically, the seasonal calendars of First Nations Australians are informed by environmental events, such as changes in weather, water supply, animal behaviour and plant life cycles. They are also influenced by the appearance of certain **constellations** in the night sky. First Nations peoples have been observing the sky for tens of thousands of years, allowing them to understand associations between astronomical changes and changes in the landscape on Earth. This knowledge is passed down through generations through storytelling.

KEY TERM

constellation a group of stars which form a recognisable pattern in the night sky

Indigenous astronomy

Kirsten Banks is a Wiradjuri **astrophysicist** and **science communicator** who studies Indigenous astronomy. Through her work she has learned about Indigenous Knowledge systems and how different constellations can be used for navigation, to identify what food is available and to recognise when the weather is going to change. Kirsten uses storytelling and contemporary mediums, like video, to share Indigenous Knowledge with a wide audience. One of the constellations that first inspired Kirsten's work was the Emu in the Sky.

Emu in the Sky

One of the most significant constellations to many First Nations groups across Australia is the Celestial Emu (sometimes called the 'Emu in the Sky'). This constellation is made up of the dark spaces in the Milky Way, rather than its stars, and its position in the night sky is linked to many **Creation stories**. The alignment and visibility of the Celestial Emu changes throughout the year. According to many First Nations groups, these changes align with the emu's life cycle on Earth, providing information about the best time to harvest eggs for food.

Breeding season

When the Celestial Emu is seen rising in the sky during April and May (Figure 2.4.2), this indicates the start of the emu breeding season. Breeding season is the best time to sustainably harvest eggs that have just been laid. Not all eggs from a nest are collected; some are left to ensure future generations of emu.

Nesting season

In June and July, the constellation appears horizontal in the sky (Figure 2.4.3), indicating that male emus are sitting on eggs in the nests. Chicks have developed in the eggs by this time and therefore harvesting ceases.

KEY TERMS

astrophysicist a scientist who studies the behaviour and physical properties of objects and events in space

science communicator a person who informs others who are normally non-experts about scientific findings, often with the aim of raising public interest in science

Creation stories stories that explain the origins of the universe, the rules for living and the relationship of people to each other and the environment; also known by many as Dreaming stories

FIGURE 2.4.2 The Celestial Emu rises in the east.

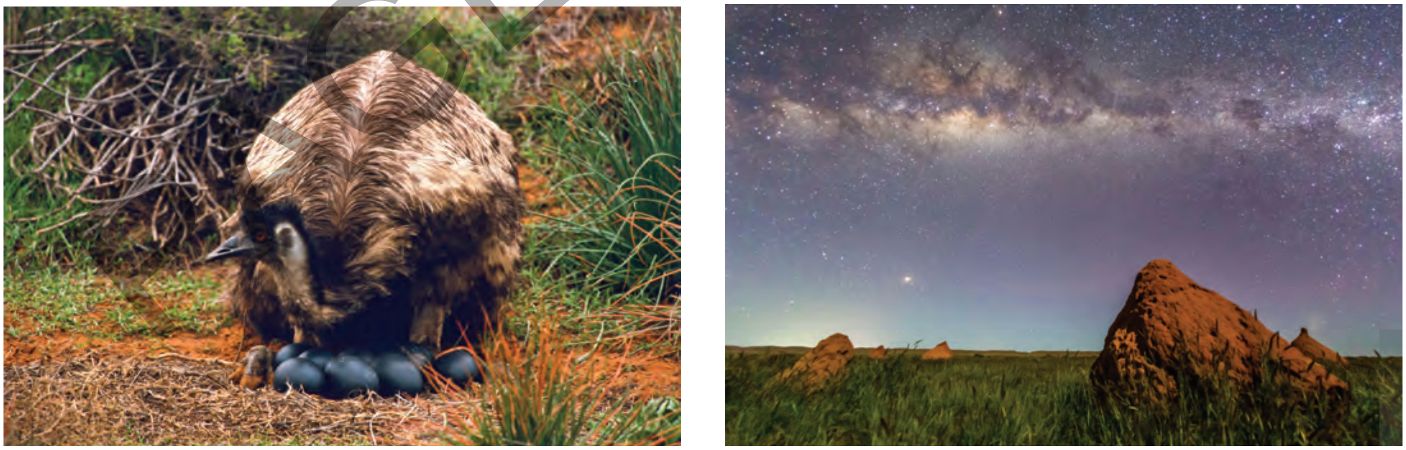


FIGURE 2.4.3 The Celestial Emu sits sideways in the sky at the time when emus sit on their eggs.

FIGURE 2.4.4 Emus hatch in spring.

Hatching season

From August to September, the Celestial Emu shifts to a vertical position in the sky, which signifies the male emus rising from the nests and the chicks hatching (Figure 2.4.4). The male emus rear the chicks at this time and so there are no eggs to collect.

SC 1 CHECK YOUR UNDERSTANDING

Describe some of the environmental knowledge or observations that were used by First Nations people to develop their seasonal calendar.

SC 2 I can explain how a group of First Nations Australians use a seasonal calendar to make predictions

Fire and seasons calendar

Different seasons and seasonal calendars are important to different groups of First Nations Australians because they provide local information about their environment. This information includes the best times to do, or not do, certain things such as use fire, travel, hunt, fish and collect food and other resources. They are developed through detailed observation of the environment and night sky over a long period of time and knowledge is passed down from generation to generation.

For example, members of the Banbai Nation, 35 kilometres north-east of Guyra in northern New South Wales, use a calendar to divide the year into seasons for fire management. Fire is critical to the sustainability of the landscape and the ability to predict when to take certain fire management actions is essential in caring for Country. Cool burning or cultural burning is a management practice that typically involves lighting small fires, and monitoring them on foot, to clear undergrowth and protect the tree canopy (Figure 2.4.5). Cool burning needs to happen in the right place at the right time of year. If burning is implemented when it is too hot and windy, fires will become too intense and get out of control, destroying the tree canopy; if it is too cold, burning won't be possible.

FIGURE 2.4.5 First Nations Australians used cool burning to manage the landscape.

KEY TERM

ecological a description of something that relates to ecosystems or interactions between living things and their environment

The Banbai Fire and Seasons calendar

The Banbai Fire and Seasons calendar was developed using long-term Indigenous Knowledge of local **ecological** and cultural seasonal events, as well as recent ecological research.

Culturally significant changes in nature signify when the seasons are changing and when it is a good time to burn.

The calendar draws on various indicators, including animal migration, breeding and activity; plant flowering and fruiting events; availability of bush tucker species for harvest; and changes in weather patterns. A simplified version of the Banbai Fire and Seasons calendar is presented in Table 2.4.1.

TABLE 2.4.1 The Banbai fire seasons

Season	Weather and fire conditions
Wildfire time (November to March)	Wet and hot, becoming warm Wildfires occur naturally; a dangerous time to burn.
Grass cures (dries out) (April to May)	Dry, becoming cool Once grass cures it is easier to burn.
Burning time (May to June)	Dry and cold to frosty Low intensity fire time; a good time to burn.
Too cold (July)	Freezing and windy Too cold to burn.
Burning time (August to September)	Cold, becoming warm Low intensity fire time; a good time to burn if it is not windy.
Risky time (October)	Hot and windy Getting too hot and windy, a risk that fires won't go out.

SC 2 CHECK YOUR UNDERSTANDING

Identify some activities that First Nations people would have done based on their seasonal calendar.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 Describe a seasonal calendar like those used by First Nations Australians. Include a description of how they can be used.

2 What are the differences between the seasonal calendar of a group of First Nations Australians and the Western calendar used today?

3 Think about how a seasonal calendar is organised.
- **a** Why do First Nations Australians use a seasonal calendar?
- **b** How does a seasonal calendar help First Nations Australians in their daily lives?
- **c** Explain how the seasonal calendar is linked to environmental changes.

4 Consider the example of the emu and how First Nations Australians were able to predict their behaviour and breeding cycle.
- **a** What were the observations that could be made at night that let First Nations people know what emus would be doing?
- **b** How could the observations you described in the previous question be used?
- **c** What other observations might you look for if you were not able to see the night sky due to long periods of cloudy weather?

2.5 Tides

Learning intention

To understand how the position of Earth and the Moon causes tides

Success criteria

SC 1: I can describe how the rotation of the Moon relates to its orbit around Earth.

SC 2: I can explain how the forces of gravitational attraction of the Moon and Sun affect water in Earth's oceans.

SC 3: I can explain the cause of neap and spring/king tides.

Lesson overview

If you put your towel close to the water's edge when spending a day at the beach, you may have to move it later in the day to stop your towel going under water. This is because of the changing tide; the level that the sea rises and falls over the course of a day (Figure 2.5.1). The changing tides are caused by the gravitational pulls and the rotations of the Moon, the Sun and Earth. In this lesson you will learn how the positions and interactions of Earth, the Sun and the Moon cause tides.

FIGURE 2.5.1 High and low tide on a rocky shore.

SC 1 I can describe how the rotation of the Moon relates to its orbit around Earth.

The Moon's rotation

Just like Earth, the Moon rotates on an axis. However, the Moon's rotation is much slower than that of Earth. It takes the Moon just over 27 days to complete a full rotation on its axis whereas Earth's rotation takes place in one day, or 24 hours.

The Moon's orbit

The Moon orbits Earth as Earth orbits the Sun. The Moon's orbit takes about the same time as its rotation, a little over 27 days. As the rotation and orbit time is the same, it results in the same side of the Moon always facing towards Earth. From Earth, it looks like the Moon is not spinning at all, but this is just because people on Earth only ever see one side of the Moon.

The Moon in action

You may have heard about 'the dark side' of the Moon. This expression isn't quite accurate as both sides of the Moon experience the same amount of time in sunlight. Figure 2.5.2 shows the Moon's orbit around Earth and its rotation on its axis. As the Moon orbits Earth, one side of the Moon continually faces Earth.

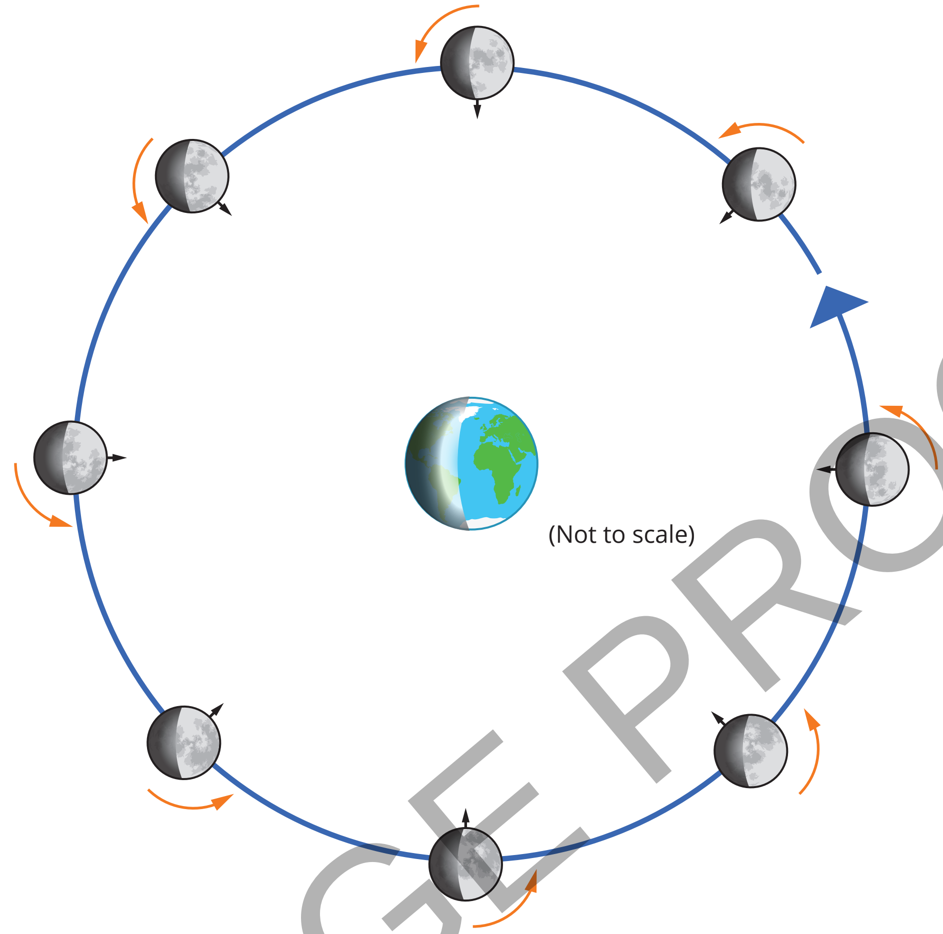


FIGURE 2.5.2 The Moon orbits around Earth approximately every 27 days and rotates once on its axis in that time, so only one side of the Moon faces Earth. During one orbit, the whole surface of the Moon spends time both in sunlight and in shadow so there is no dark side of the Moon. An arrow at one location on the Moon is shown to highlight how the Moon rotates as it orbits Earth.

SC 1 CHECK YOUR UNDERSTANDING

Explain the relationship between the Moon's rotation and its orbit around Earth.

SC 2 I can explain how the forces of gravitational attraction of the Moon and Sun affect water in Earth's oceans

KEY TERMS

tide the rising and falling of water levels in large bodies of water such as the ocean and lakes, caused by the gravitational pull of the Moon on Earth

gravitational force the force on an object due to gravity; can be described as the 'weight' of object

Tides are the regular rise and fall of the level of the sea at a certain location. The sea reaches its highest level at the shore during high tide and falls to its lowest level at low tide. Figure 2.5.3 shows the same shore at high (left) and at low tide (right).

Forces and tides

Tides are caused by the **gravitational forces** between Earth, the Moon and the Sun. The Sun and the Moon both exert a gravitational force on Earth. The Moon is much closer to Earth than the Sun, so the changes made to the oceans due to the Moon's gravitational pull are more noticeable. The effect of the Moon's gravity on Earth's oceans changes with location and time of day as Earth rotates on its axis.

Ocean bulges

The gravitational force of the Moon acts across all of Earth's surface – water and land. Water is fluid, so it is more easily moved by gravity than solid masses of land. The Moon's gravitational force is strongest at the side of Earth facing the Moon. Water is pulled toward the Moon causing the water in oceans on the side of Earth nearest the Moon to bulge outward (a high tide).

There is also a bulge (high tide) in the ocean on Earth's surface on the side opposite the Moon. The Moon's gravitational force is weakest at that point. Earth's surface hasn't been pulled as close to the Moon here as on the side closest to the Moon.

Frequency of tides

Most coastal areas on Earth experience two tidal cycles per day, two high tides and two low tides. A location on Earth experiences a high tide bulge once when the location is closest to the Moon and again when it is furthest away from the Moon (Figure 2.5.3).

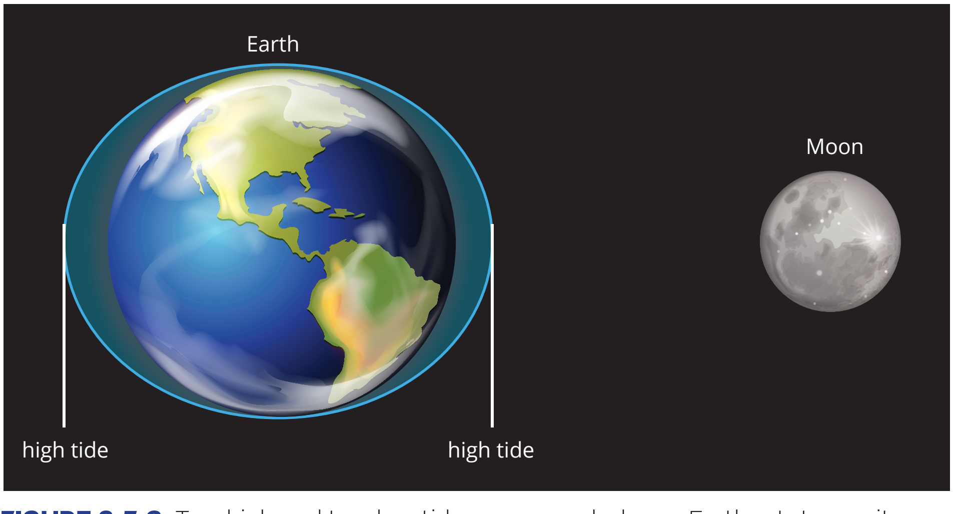


FIGURE 2.5.3 Two high and two low tides occur each day as Earth rotates on its axis, caused by the gravitational force of the Moon.

Between each high tide, a location will experience a low tide. High tide and low tide are not at the same time each day at the same location. This is because the length of a full tidal cycle is slightly longer than a day (about 24 hours and 50 minutes).

SC 2 CHECK YOUR UNDERSTANDING

Consider the causes of tides.

a How does the Moon's gravity create tides?

b Describe the effect of the Sun's gravity on tides.

SC 3 I can explain the cause of neap and spring/king tides

The Moon's gravitational force creates bulges of water on each side of Earth causing **lunar** tides. The Sun also exerts a gravitational force on Earth's water, causing bulges or **solar** tides. The Sun's gravitational pull is only about half as strong as the Moon's because the Sun is so much farther away from Earth.

When Earth, the Sun and the Moon are aligned in space, the gravitational forces of the Sun and the Moon are combined causing more extreme bulges. This results in extreme high and low tides called spring tides. When the positions of the Sun, Earth and the Moon form a right angle, their gravitational forces counteract each other, resulting in moderate tides called neap tides.

KEY TERMS

lunar related to the Moon

solar related to the Sun

new moon the phase of the moon where most of the moon seen from Earth is not illuminated by the Sun and only a very thin crescent of the moon's illuminated surface can be seen

full moon the phase of the Moon when the whole of the Moon seen from Earth is illuminated by the Sun

Spring tides

Spring tides, or king tides, occur twice a month when the Moon lines up with Earth and the Sun (Figure 2.5.4). This happens during a **new moon**, when the Moon is positioned between Earth and the Sun, and during a **full moon**, when Earth is positioned between the Sun and the Moon. The combined gravitational forces of the Sun and the Moon cause greater changes in ocean levels: higher high tides and lower low tides. A spring tide is not related to the season spring; its name refers to the *springing forth* of the tide.

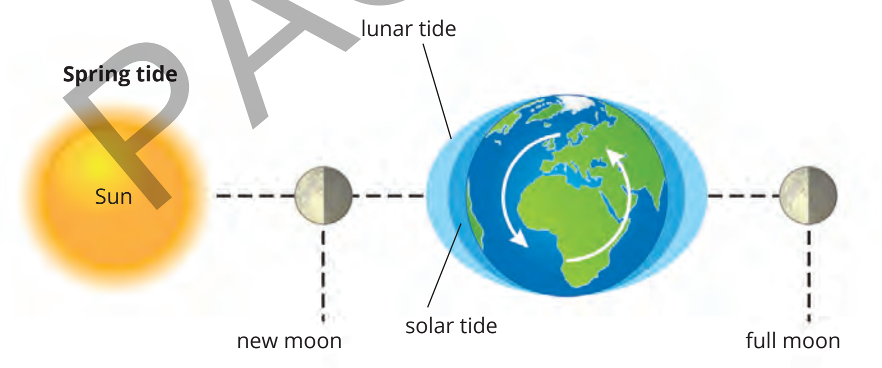


FIGURE 2.5.4 Spring tides occur at full and new moons; at these times, the gravitational attraction of the Sun and the Moon combine to increase the difference between low and high tide.

Neap tides

During the periods between spring tides, neap tides occur. Neap tides happen about seven days after spring tides, twice a month when the gravitational attraction of the Moon and the Sun act at right angles to each other (Figure 2.5.5). This occurs when the Moon is either in its first or third quarter and the gravitational forces of the Moon and the Sun are working in different directions. The opposing forces of the Sun and the Moon cause less change in ocean levels and a smaller difference between high and low tide.

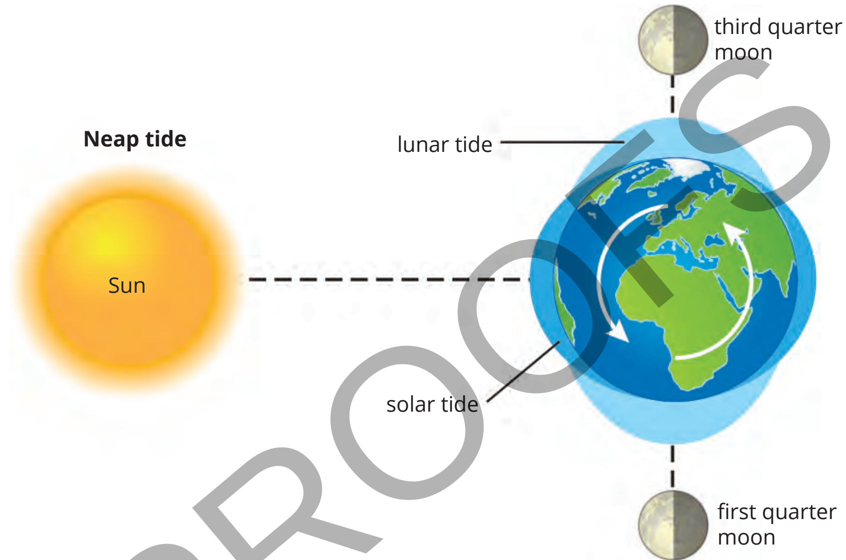


FIGURE 2.5.5 Neap tides occur when the Moon's gravity pulls at right angles to the Sun's.

SC 3 CHECK YOUR UNDERSTANDING

Consider the types of tides.

a What are spring tides and when do they occur?

b Describe the conditions that lead to neap tides.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 Compare the Moon's rotation and orbit around Earth with Earth's rotation and orbit around the Sun.

2 Describe what you would observe if the Moon did not rotate on its axis.

3 Compare the size of the Moon's gravitational force that acts on Earth's oceans to cause the tides, to that of the Sun. Include how distance and mass affect the size of the force acting.

4 Explain why neap tides are less extreme than spring/king tides.

2.6 Effects of tides

Lesson overview

The movement and position of Earth, the Sun and the Moon cause predictable tidal changes. Tides refer to the rising and falling of water levels in large bodies of water, such as oceans and lakes. Tides are mostly caused by the Moon, though the Sun has an influence too. As the Moon orbits Earth, its gravitational pull affects the water, causing it to ‘bulge’ on the side of Earth closest to the Moon, as well as on the side furthest away.

Tides play a crucial role in marine and coastal ecosystems, influencing various events along coastlines. Recording data, observing tidal patterns and making predictions help society to plan activities at sea and on the shore. In this lesson, you will learn about observing tidal data, the effects of tides and their impact on society.

Learning intention

To understand how information about tides is used in society

Success criteria

SC 1: I can use patterns in tidal data to make predictions.

SC 2: I can describe ways people use information about tides in society.

SC 3: I can describe how a group of First Nations Australians use tidal patterns to predict the best time for foraging and fishing activities.

SC 1 I can use patterns in tidal data to make predictions

Tidal data

As the position of Earth, the Sun and the Moon change, the gravitational forces acting on Earth’s oceans change with them. The result can be seen as variations in the levels of sea water or tidal changes. The movement of Earth, the Sun and the Moon, and their influence on Earth’s oceans, is regular and predictable. This allows us to calculate the times and heights of tides at a particular location. Other factors such as the shape of a shoreline and local wind and weather conditions also affect tides, so actual tide measurements are used to establish patterns as well (Figure 2.6.1).

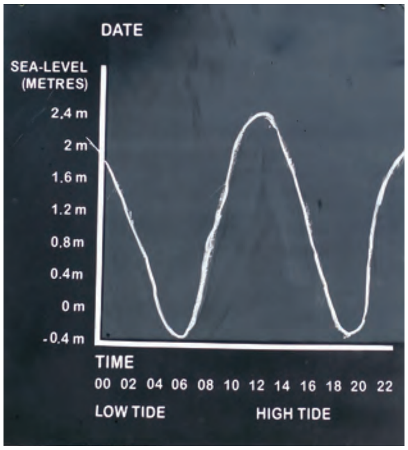


FIGURE 2.6.1 The tides cause the surface of the ocean to rise and fall twice a day.

Tide levels

Generally, four different tides occur within a day, two high tides and two low tides. Neap and spring tides occur every moon cycle, about twice every month. The positions of Earth, the Sun and the Moon determine the times when these tidal changes occur.

High tides and low tides

High tide and low tide refer to the periodic rising and falling of water levels in large bodies of water, such as oceans and seas, caused by the gravitational forces of the Moon and the Sun on Earth. The specific timing and **magnitude** of these tides can vary based on geographical location, local **topography** and other factors.

KEY TERMS

magnitude a measure of the size or strength of something

topography the hills, valleys, rivers and other physical features of the landscape

KEY TERM

lunar cycle the period of 27.3 days that it takes for the Moon to orbit Earth

Neap tides and spring tides

The terms 'neap' and 'spring' can be misleading, as neap tides are not weaker in the spring season, nor are spring tides stronger in spring. In fact, these terms refer to the increased or decreased gravitational forces exerted by the Sun and the Moon on Earth's oceans during specific stages of the **lunar cycle**.

Table 2.6.1 explains the key features of these daily and monthly tides.

TABLE 2.6.1 Features of tides

Tide	Features
High tide	• High tide occurs when the gravitational pull of the Moon is strongest on the side of Earth facing the Moon, leading to higher water levels along the coastline. • The gravitational force of the Sun contributes to high tide when it is aligned with the Moon. • High tide occurs approximately twice a day, roughly every 12 hours and 25 minutes, which corresponds to the time it takes for a location to complete a full rotation relative to the Moon.
Low tide	• Low tide occurs at the locations on Earth not experiencing a high-tide bulge. • The reduced gravitational pull causes a temporary recession of the sea, exposing more of the shoreline. • Low tide also occurs approximately twice a day, between the periods of high tide.
Neap tide	• Neap tides occur during the first and third quarters of the lunar cycle when the Sun, Earth and the Moon form a right angle. • The gravitational forces of the Sun and the Moon partially cancel each other out, resulting in weaker tides. Neap tides are characterised by lower high tides and higher low tides. • Neap tides occur about seven days after spring tides.
Spring tide	• Spring tides occur during the new moon and full moon phases when the Sun, Earth and the Moon are aligned. • The gravitational forces of the Sun and the Moon combine, resulting in stronger tides. Spring tides are characterised by higher high tides and lower low tides. • Spring tides occur about twice a month, around the times of the new moon and full moon.

Tidal range

The difference between high tide and low tide is called the tidal range (Figure 2.6.2).

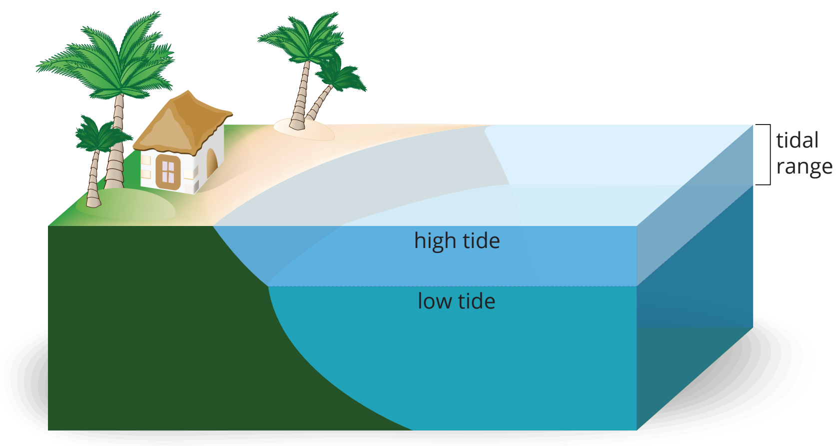


FIGURE 2.6.2 The tidal range in ocean tides.

Seeing patterns in the daily tides

The graph below in Figure 2.6.3 shows the time and height of two high tides and two low tides that occur at a single location over the course of 24 hours. As you can see, high tide in the morning occurs at 01:04 am at a height of 1.77 m; low tide in the morning occurs at 08:13 at a height of 0.49 m. High tide in the afternoon occurs at 2.18 at a height of 1.31 m; low tide during the night occurs at 7.42 at a height of 0.77 m.

From this example, you can see that two low tides and two high tides occur. The exact time between tides varies with location and over time. As the Moon orbits Earth, the tide time gets later with each passing day.

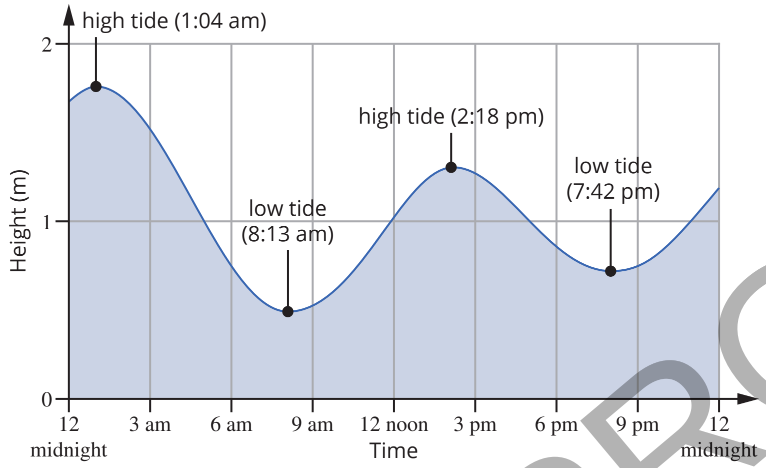


FIGURE 2.6.3 A graph of the height of the ocean's surface over 24 hours.

Tides across the month

The graph in Figure 2.6.4 shows the height of high tides and low tides over 28 days for a single coastal location.

Spring tides are shown by the largest tidal range between high and low tides in a day. Neap tides are shown by the smallest tidal range between high and low tides in a day.

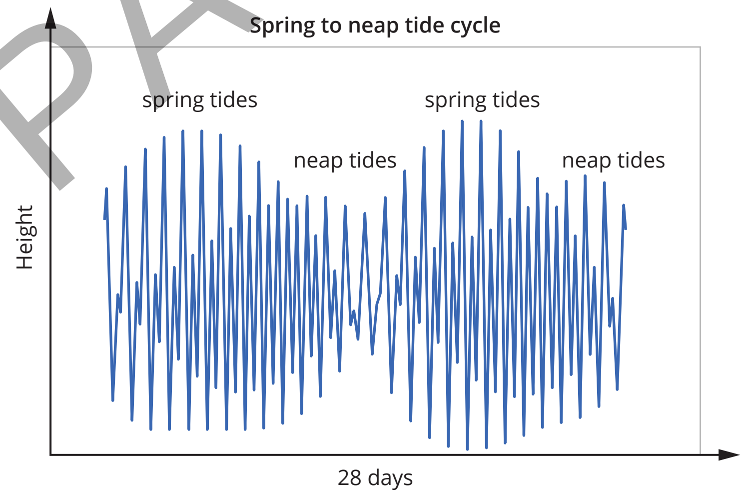


FIGURE 2.6.4 A graph of the variations in the height of the ocean's surface over 28 days.

Tide charts

Tide charts, or tide tables, are used to predict daily times and heights of tides for a specific location. For most coastal locations, tide charts are publicly available online, in newspapers and in local radio and television broadcasts. Tide charts always include the date, times and heights for low tides and high tides for a particular site, though the chart format and units may vary.

The tide chart in Table 2.6.2 shows tide times and heights over three days at Fort Denison, a ferry terminal in Sydney Harbour. It provides the times and heights for the first high tide, the first low tide, the second high tide and the second low tide each day.

TABLE 2.6.2 Tide times at Fort Denison, Sydney Harbour in May 2023

Sydney (Fort Denison) LAT 33°51′S LONG 151°14′E		
Date	**Time**	**Height (m)**
12 May 2023, Friday	1:04 am	1.77
	8:13 am	0.49
	2:18 pm	1.31
	7:42 pm	0.77
13 May 2023, Saturday	2:15 am	1.72
	9:15 am	0.48
	3:27 pm	1.38
	9:00 pm	0.75
14 May 2023, Sunday	3:26 am	1.70
	10:11 am	0.46
	4:26 pm	1.48
	10:13 pm	0.69

SC 1 CHECK YOUR UNDERSTANDING

Read Table 2.6.2 and predict the approximate time and height of the first high tide on 15 May.

SC 2 I can describe ways people use information about tides in society

KEY TERMS

ecology the study of how organisms interact with each other and their non-living environment.

economy a system in which goods and services are produced and sold

commerce buying and selling goods or services

Tides and ecology

Tides play an important role in the **ecology**, culture and **economy** of coastal locations. Predicting tides and interpreting tidal information is essential for anyone who uses the sea for travel, research, recreation, livelihood or **commerce**. Some of the ways people use information about tides are discussed below.

SCIENCE IN SOCIETY

Protecting Australia's coastlines

The position of Earth and the Moon causes tides, which have a significant impact on coastal management. Tides influence the shape and stability of coastlines, affecting erosion, sediment transport, and the formation of coastal features like beaches and estuaries. Coastal managers use knowledge of tides to plan and implement measures that protect coastal areas from erosion and flooding. For example, in Australia, the New South Wales Government has developed a Coastal Management Program that includes strategies for managing the impacts of tides and sea-level rise.

Understanding tides is also crucial for the construction of coastal infrastructure, such as ports, marinas, and sea walls. Engineers need to consider tidal patterns when designing these structures to ensure they can withstand the forces of the sea (Figure 2.6.5). Accurate tidal predictions help in planning construction activities, such as dredging and piling, which need to be carried out at specific tidal conditions. By understanding how the positions of Earth, the Moon and the Sun cause tides, coastal managers and engineers can make informed decisions that protect coastal communities and ecosystems.

FIGURE 2.6.5 Coastal structures and barriers like these concrete and rock walls need to be designed using a detailed knowledge of the tides. Similarly, submerged structures would need to withstand the forces exerted by the tides.

Navigation and operations

Tides affect the flow and depth of water at the coast. Ships and boats require enough water to stay afloat without getting stuck on the ocean floor. Therefore, navigating ports with shallow waters must ensure vessels arrive and leave at high tide to stop them from running aground. Ports with bridges also use tidal information to ensure that ships can pass under the bridge safely (Figure 2.6.6). In some ports, large ships are only able to fit under a bridge at low tide.

FIGURE 2.6.6 This cargo ship is passing under the bridge at low tide to ensure there is enough clearance.

Fishing

Tidal currents are the movement of water due to the tides. Tidal currents can influence fish activity, so it is important to observe the tides, currents and trends in fish behaviour to optimise fishing efforts (Figure 2.6.7). Fishing at the wrong time can mean wasting time and resources, resulting in a small catch.

The best time to fish depends on the target species, tide and location. In some places, it may be best to fish for large species between high tide and low tide when the tidal current increases the movement of small fish and crustaceans, attracting larger fish.

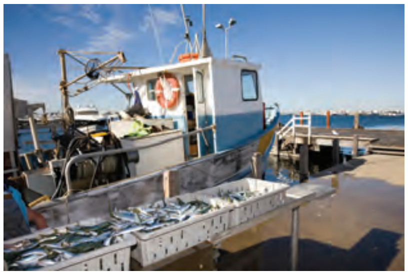


FIGURE 2.6.7 Tides can affect fishing conditions.

Recreation

FIGURE 2.6.8 The best time for recreational activities at the beach is affected by the tides and tidal currents.

Tides affect many recreational activities at the beach such as surfing, diving, swimming and exploring rock pools (Figure 2.6.8). The optimal tide conditions depend on your location and the activity you want to do. For snorkelers and divers, the depth and accessibility of a dive site may change between high and low tides. Visibility will improve with reduced tidal currents. Tide information is also important for safety. Some areas of the shore may be accessible at low tide but are cutoff at high tide. Tidal changes can also cause dangerous currents.

KEY TERMS

ecosystem a system formed by organisms interacting with each other and their nonliving surroundings

organism a living thing

renewable energy source source of energy that can be replaced after it is used, such as solar or wind energy

Ecology

Tides affect marine **ecosystems**, influencing the types of **organisms** found in the sea and on the shore. Tidal environments are regularly submerged and exposed during the tidal cycle. Native organisms are specially adapted to these changing conditions. Disruption of tidal influences, for example, those caused by storms (Figure 2.6.9), can therefore have a significant effect on such organisms, which rely on the tidal cycles for breeding or growth.

Energy

Because of their predictability, tides have the potential to be used as a **renewable energy source**. The flow of ocean water between high tide and low tide generates force that can be converted into electricity. Generating electricity from tidal energy involves using turbines, like wind turbines, that are moved by tidal current (Figure 2.6.10). These turbines are like the propellers of an aeroplane but they are moved by the water and used to generate electricity. Using tidal turbines is an extremely clean, sustainable and efficient way to generate energy.

FIGURE 2.6.9 Storm surge damage and a sand bank washed away just metres from homes in Sydney

FIGURE 2.6.10 Tidal currents can turn turbines which are used to generate electricity.

SCIENCE IN SOCIETY

Tides and renewable energy

Tidal power harnesses the energy of moving water caused by tides to generate electricity (Figure 2.6.11). This form of renewable energy is predictable and reliable, as tides follow regular and measurable patterns. In Australia, the potential for tidal energy is being explored in areas with strong tidal currents, such as the Kimberley region in Western Australia and the Torres Strait in Queensland.

Tidal energy projects require detailed information about tidal patterns, including the height and timing of tides. Engineers use this information to design and position tidal turbines and other infrastructure. By understanding tides, they can maximise the efficiency of tidal power systems and reduce the environmental impact. Tidal energy has the potential to contribute to Australia's renewable energy mix, providing a clean and sustainable source of electricity.

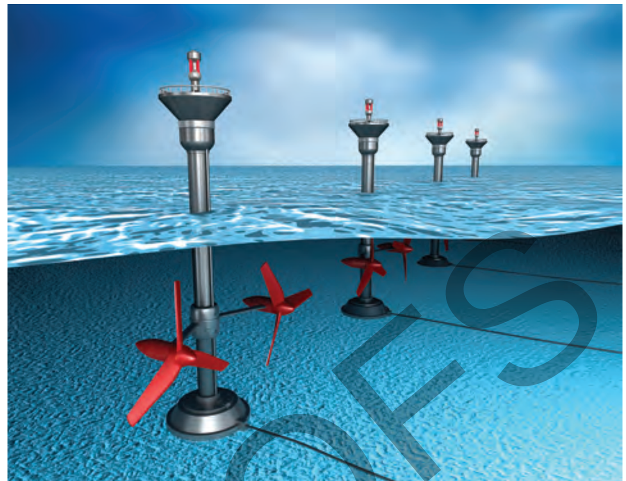


FIGURE 2.6.11 The energy in the movement or water can be transformed into electricity using tidal turbines like those shown. As the movement of water changes direction, the turbines change direction to continue to transform the energy of moving water into electricity

SC 2 CHECK YOUR UNDERSTANDING

Describe two ways that people use tidal information when planning activities in coastal areas.

KEY TERM

forage to search for something over a wide area in order to obtain it. Foraging usually refers to the search for food in the environment

SC 3 I can describe how a group of First Nations Australians use tidal patterns to predict the best time for foraging and fishing activities

Knowledge of tidal patterns

First Nations Australians have a strong and long-standing connection to the sea and tidal environments. Their knowledge systems also link the changing phases of the Moon to the changing tides. The Yolngu people of East Arnhem Land, for example, have noticed that the Moon appears to fill up and empty as it moves across the horizon. According to their teachings, tides reach their peak when the Moon is full or new, setting or rising. In contrast, tides are at their lowest when the Moon is near its zenith (high in the sky), aligning with the gravitational effects of the Moon on Earth.

Bardi Peoples of the Dampier Peninsula

The Bardi peoples of Western Australia (Figure 2.6.12) use their knowledge of the tides to travel between islands. During neap tides, these journeys are safe to make as the tidal range is reduced. At low tides, they are also able to **forage** for and collect food, such as fish, and other resources like pearls from around the peninsula.

FIGURE 2.6.12 Map showing the Bardi peoples' traditional lands, a First Nations community near Derby, in Western Australia.

FIGURE 2.6.13 Fish traps constructed by the Tommeginer people

KEY TERMS

intertidal zone the area of land on a coastline between high and low tides

weir a low barrier built across a river which can be used to raise the level of water upstream and control the flow of the river

estuarine a description of something related to an estuary where a river joins the sea

The Tommeginer People

In north-west Tasmania, the Tommeginer People have constructed tidal fish traps in coastal areas. A low wall of boulders is built in the **intertidal zone** so that when it is high tide the boulders are submerged and fish can swim over them. As the tide goes out, the boulders become visible and the fish become trapped in the shallow waters that remain where they are more easily caught (Figure 2.6.13).

Brewarrina Fish Traps

The Brewarrina Fish Traps, are a series of interconnected stone **weirs** and pools, that rely on tidal movements in the Barwon River to trap and catch fish during different seasons. As high tide approaches, fish move into the traps in the **estuarine** section of the river, following the natural flow of water. When the tide recedes, the fish become confined within the weirs and pools, making them easier to catch.

These fish traps are believed to have a history dating back 40 000 years. Their ingenuity lies in the way they cause minimal disruption to the river's flow, so that they can remain in place permanently. The continuous construction and upkeep of these traps over many centuries showcases the technological expertise of First Nations communities in this region (Figure 2.6.14).

FIGURE 2.6.14 Brewarrina Fish Traps

SC 3 CHECK YOUR UNDERSTANDING

Describe how you would use tidal charts to plan a foraging trip along the coast.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 What is tidal data?

2 Think about using tidal data to make predictions.
- **a** Why is it important to analyse tidal data?
- **b** How can patterns in tidal data help make predictions?
- **c** Explain the process of using tidal data to predict future tides.

3 Compare different uses of tidal information.
- **a** How is tidal information used differently in navigation and coastal management?
- **b** What are the benefits of using tidal information for navigation and coastal management?
- **c** What makes tidal information important in society?

4 Think about the role of tidal patterns in traditional practices of First Nations Australians.
- **a** Why are tidal patterns important for foraging activities?
- **b** How do tides affect the availability of marine resources?
- **c** Explain how understanding tidal patterns benefits First Nations Australians.

2.7 Phases of the Moon

Learning intention

To understand the phases of the Moon

Success criteria

SC 1: I can name and describe the appearance of the key phases of the Moon.

SC 2: I can explain what causes the phases of the Moon.

SC 3: I can predict the phase of the Moon for a given configuration of Earth, the Moon and the Sun.

KEY TERMS

lunar phase the appearance of the Moon from Earth as it changes over the course of a month
waxing the lunar phases after a new moon where the illuminated portion of the Moon is increasing
waning the lunar phases after a full moon where the illuminated portion of the Moon is decreasing
crescent moon a phase of the Moon where less than half is illuminated
gibbous moon a phase of the Moon where more than half is illuminated

Lesson overview

The Earth, Sun and Moon systems create different phenomena that are observable from Earth, including the changing appearance of the Moon throughout the month.

In this lesson you will learn about the different phases of the Moon and how they are produced.

SC 1	I can name and describe the appearance of the key phases of the Moon

Appearance of the Moon

Sometimes when looking at the Moon in the night sky you can see the whole round face of the Moon. Other times, you might see a small slice of the Moon, or perhaps you will not be able to see the Moon at all.

The different shapes or views of the Moon from Earth are called **lunar phases**, or moon phases. The Moon does not emit its own light, but its surface is good at reflecting light from the Sun.

Waxing and waning

It is called **waxing** as more and more of the Moon is visible after a new moon. It is called **waning** as less and less of the Moon is visible after the full moon.

Crescent and gibbous

When less than half of the Moon is visible (or illuminated), it is called a **crescent moon**. When more than half of the Moon is visible it is called a **gibbous moon**.

Lunar phases

There are eight key phases of the Moon during the Moon's 27-day orbit around Earth. The Moon changes slightly each day as it gradually progresses through the cycle (Figure 2.7.1). Table 2.7.1 explains the eight phases of the Moon as observed from the Southern Hemisphere. (Note that the view from the Northern Hemisphere is upside down compared to the view from the Southern Hemisphere.)

TERMINOLOGY TIP

A first quarter moon refers to the Moon being a quarter of the way through its cycle, not how much of the moon is visible (or illuminated). A first quarter moon is sometimes called a 'half moon' because half of the moon is visible. A third quarter moon refers to the Moon being three quarters of the way through its cycle. A third quarter moon will have the opposite half illuminated when compared to a first quarter moon.

FIGURE 2.7.1 The phases of the Moon depend on the location of the Moon with respect to Earth and the Sun. This shows the phases of the Moon as seen from the Southern Hemisphere.

TABLE 2.7.1 Eight Moon phases as observed from the Southern Hemisphere.

New moon	The new moon is the first phase in the lunar cycle, and in this phase the Moon is not visible. The side of the Moon facing Earth is not lit up by the Sun at all.
Waxing crescent	Only a small, curved section, or crescent of the Moon is visible during this phase. Most of the side of the Moon facing Earth is not illuminated. The amount of the Moon that is illuminated increases each day during the waxing phases.
First quarter	The Moon is a quarter of the way through the cycle at this point and half of the side of the Moon facing Earth is lit up.
Waxing gibbous	During this phase, more than half of the side of the Moon facing Earth is lit up. The visible section of the Moon continues to increase each day.
Full moon	The entire side of the Moon facing Earth is illuminated.
Waning gibbous	During this phase, more than half of the side of the Moon facing Earth is lit up. The visible and lit section of the Moon decreases each day during waning phases.
Third quarter	The Moon is three quarters of the way through the lunar cycle and the half opposite to that of the first quarter is lit up and visible from Earth. A third quarter moon is also known as a last quarter moon.
Waning crescent	The Moon has nearly completed the lunar cycle and only a small crescent opposite to that of the waxing crescent is visible. The amount of the Moon that is visible and lit up continues to decrease each day. After this phase, the cycle reaches the new moon phase again.

SC 1 CHECK YOUR UNDERSTANDING

List the eight key phases of the Moon.

SC 2 I can explain what causes the phases of the Moon

What is visible from Earth?

The Moon does not have its own light source. Moonlight is the reflection of sunlight off the Moon's surface. Half of the Moon is always illuminated by the Sun. The half of the Moon that is illuminated is not always visible from Earth.

The view of the Moon from Earth changes as different portions of the Moon lit up by the Sun are visible. The same side of the Moon always faces Earth but the amount of sunlight on the side of the Moon facing Earth changes. The amount of the Moon that is visible, or the phase of the Moon, depends on the relative positions of the Moon, Earth and the Sun (Figure 2.7.2).

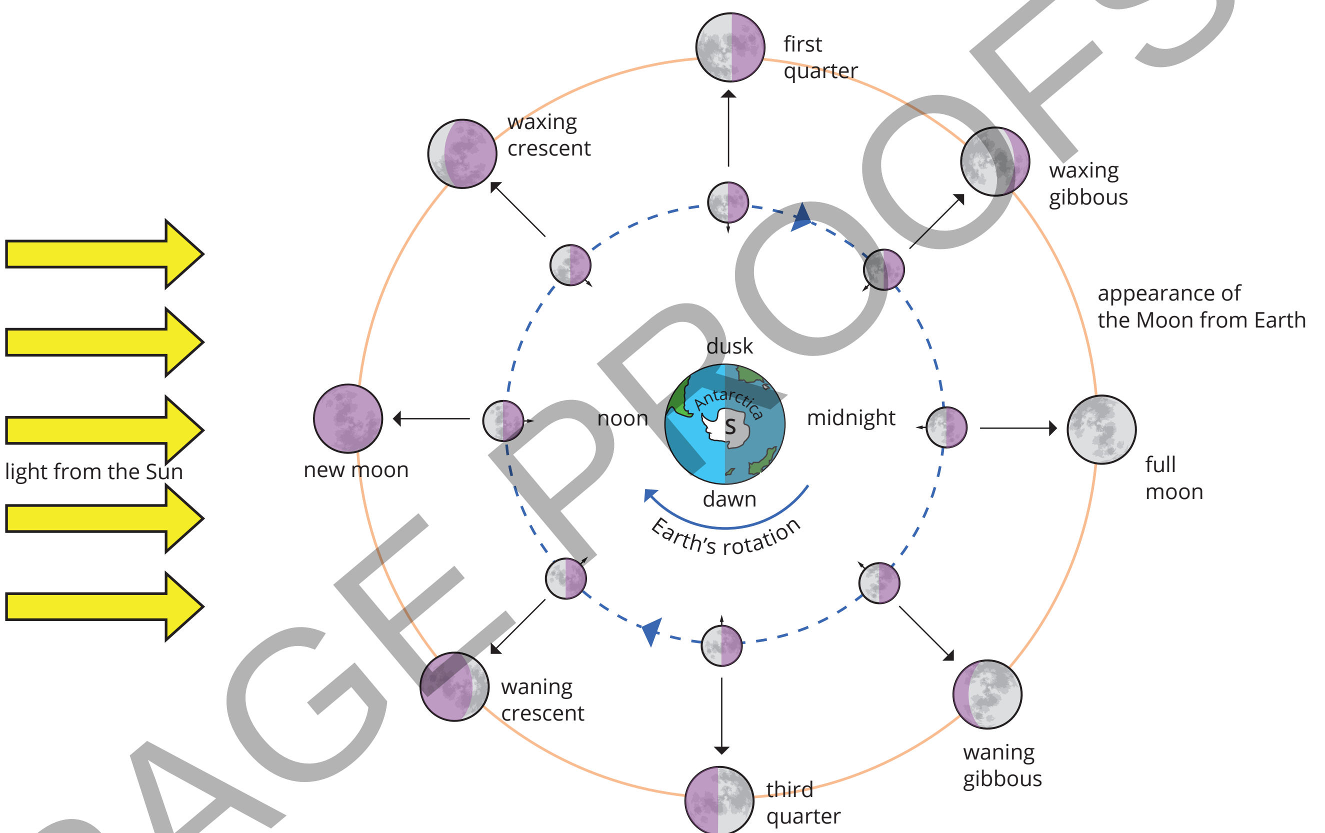


FIGURE 2.7.2 The view of the Moon changes as it orbits around Earth leading to different phases of the Moon visible from Earth. The positions of the Moon are shown on its orbit and the outer diagrams show the Moon's appearance from Earth in the Southern Hemisphere.

The Moon orbits Earth as Earth orbits the Sun, so the alignment of the Moon, Earth and the Sun changes over time. To predict how the Moon looks from Earth you need to imagine yourself standing on Earth where you can see the Moon at a specific location. For some phases this is simple. For example, when you see a third quarter Moon you are somewhere between midnight and noon on the surface of Earth and the sunlit part of the Moon appears on your right. For other phases it is much more complicated to understand. Try it for yourself and then check your prediction using Figure 2.7.2. Choose a time of day and along the Moon's orbit you can see when the Moon will be visible at this time.

Then, imagine standing on Earth looking at the Moon in that position. Does your prediction of what it looks like match the diagram around the outside showing how the Moon appears?

SC 2 CHECK YOUR UNDERSTANDING

Identify the cause of the Moon's phases.

SC 3 I can predict the phase of the Moon for a given configuration of Earth, the Moon and the Sun

A gradual change

The relative position of Earth, the Moon, and the Sun determines the amount of light reflected by the Moon to Earth and the corresponding moon phase.

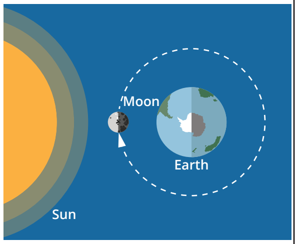
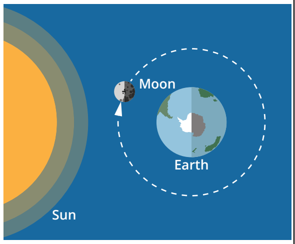
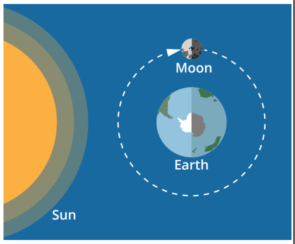
The phases of the Moon change gradually throughout the Moon cycle. As the Moon orbits Earth, it slowly moves into a new position in the sky and the Sun illuminates different parts of the Moon's surface.

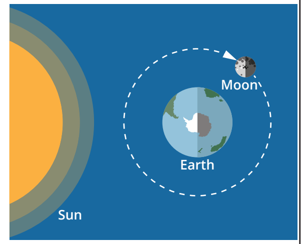
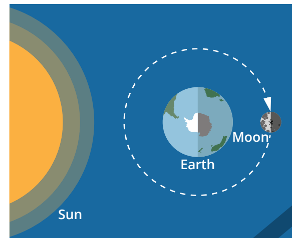
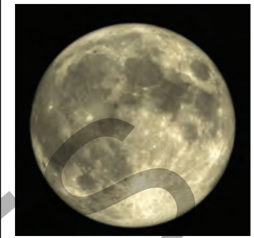
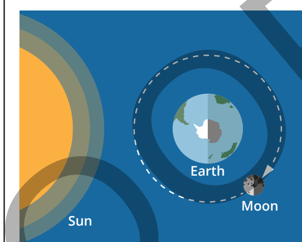
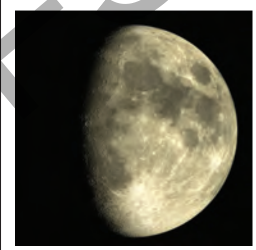
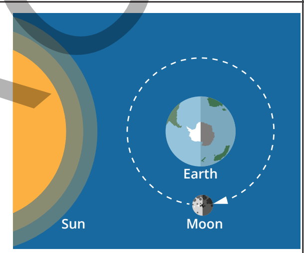
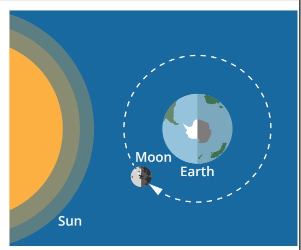
The images in Table 2.7.2 explain each of the phases of the moon. Look carefully at the alignment of the Moon, Earth and Sun to predict what can be seen from Earth. The images on the right show the view of the Moon from Earth.

DISCOVER MORE

The Moon takes 27.3 days to orbit Earth. However, it takes 29.5 days for the Moon to cycle from a new moon to a full moon and back to a new moon again. This difference occurs because the orbit of the Moon around Earth is not aligned with the orbit of Earth around the Sun. This affects how the sunlight appears on the Moon when viewed from Earth.

TABLE 2.7.2 This table shows the positions of Earth, the Moon and the Sun as well as the appearance of the Moon from Earth.

Moon phase	Alignment	What is visible from Earth	Arrangement of the Sun, Earth, and the Moon	View of the Moon from Earth
New moon	The Moon is in the middle with the Sun and Earth on either side. The Moon, the Sun, and Earth are aligned.	Difficult to see; near the Sun in the sky; the side facing Earth is in shadow.		
Waxing crescent	The Moon moves out of alignment with the Sun and Earth.	A small and increasing portion of the Moon is illuminated.		
First quarter	The Sun, Earth, and Moon form a right angle. The Moon is one quarter of the way through its orbit.	Half of the visible side of the Moon is illuminated.		

Waxing gibbous	The Moon moves toward alignment with the Sun and Earth.	More than half of the Moon is illuminated.		
Full moon	The Moon and the Sun are on opposite sides of Earth. The Moon, the Sun, and Earth are aligned.	The visible side of the Moon is fully illuminated.		
Waning gibbous	The Moon moves out of alignment with the Sun and Earth.	More than half of the Moon is illuminated, but the lit portion is decreasing.		
Third quarter	The Sun, Moon and Earth form a right angle.	Half of the Moon is illuminated.		
Waning crescent	The Moon is moving to realign with the Sun and Earth.	Less than half of the Moon is illuminated, and the lit portion is decreasing.		

SC 3 CHECK YOUR UNDERSTANDING

Predict the phase of the Moon if the Moon is at a 90-degree angle to the line between Earth and the Sun.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 Consider the phases of the Moon.
- **a** What is the phase called when the Moon appears dark?
- **b** What phase comes after the full moon?
- **c** Describe the appearance of the first quarter moon.

2 Describe the positions of Earth, the Sun and the Moon when the Moon is full.

3 Explain how the positions of Earth, the Moon and the Sun create the new moon phase.

4 Explain how you can predict the Moon's phase based on its position relative to Earth and the Sun.

2.8 Modelling the phases of the Moon

Introduction

In the field of science, a model can be a representation of ideas, objects or processes that occur in real life. Models are a useful way to visualise something that is difficult to see or understand, such as the changing positions of the Sun, Earth and the Moon in space.

In this practical investigation you will create a model to represent the position of the Moon in relation to Earth and the Sun to understand why different phases of the Moon are visible from Earth.

Background

The Moon does not emit light, but it reflects light from the Sun. From Earth, the appearance of the Moon changes because different portions of the Moon are illuminated by the Sun at different times during the Moon's orbit around Earth. The changes in the appearance of the Moon are called phases.

This experiment uses a model of the Moon, the Sun and Earth to investigate the relationship between the position of the Moon in relation to Earth and the Sun and the appearance of the Moon as seen from Earth.

Aim

To model the movement of the Moon in relation to the Sun and Earth to understand why the appearance of the Moon changes and why Moon phases occur.

Materials and safety

Write a materials list and safety notes for your investigation. You will need items to represent Earth, the Moon and the Sun in space and a way to record what you see.

Method

1 Place your light source, or 'Sun', on a table or desk that you can stand nearby.

2 Turn on your 'Sun' (light source).

3 Darken the room by turning off all other lights and closing all curtains or blinds.

4 Face toward the 'Sun' and hold your 'Moon' out in front of you.

5 Record the amount of light you can see on the side of the 'Moon' that faces you in this position – Position 1 in your results table. You can take a photo or complete a drawing.

6 Slowly start turning clockwise, to your right, and stop when you have turned $\frac{1}{8}$ of the way around the circle.

Learning intention

To be able to create and use a model to describe the phases of the Moon

Success criteria

SC 1: I can select appropriate materials to create a model that demonstrates the phases of the Moon.

SC 2: I can use a model to communicate an understanding of the phases of the Moon.

SC 3: I can evaluate a model that represents the phases of the Moon.

HINTS

- You can use your own head to represent Earth.
- You will need a light source to represent the Sun.
- If you can place the item that represents the Moon on a stick it will be easier to see.

HINT

Copy the results table into your notebook or construct a digital table in which you can add photos.

HINT

Remember your head is 'Earth'.

7 Record the amount of light you can see on the side of the 'Moon' facing you in this position.

8 Continue turning clockwise and stop every $\frac{1}{8}$ of a turn to record the amount of light you can see on the side of the 'Moon' facing you in each position.

Results

Record your results in your copy of this table.

	Position							
	1	2	3	4	5	6	7	8
View of the 'Moon'								

Conclusion

Write your conclusion to this investigation. Include answers to the following questions.

1 What happened to the amount of light you could see on the 'Moon' between position one and position five?

2 What happened to the amount of light you could see on the 'Moon' after position five?

3 How would you describe the relative position of 'Earth', the 'Moon' and the 'Sun' at position five?

4 Compare the results of position three and position seven and describe what you observed.

5 Figure 2.7.1 shows a 2D visual model of the phases of the Moon and relative positions of Earth, the Sun and the Moon. The phases of the Moon are labelled. Match the phases in the image with each position of the 'Moon' from your experiment. Identify each phase for positions one to eight.

Evaluation

Evaluate your practical investigation by answering the following questions.

1 Name each of the objects used in the experiment to represent the Sun, Earth and the Moon and explain why each was used.

2 Explain the purpose of using a model in this experiment.

3 Consider limitations of the model and any changes you could make to give a more accurate representation of the real system in space.

2.9 Lunar eclipses

Lesson overview

Usually, when the Moon is visible in a clear sky, it appears bright white, and the phase of the Moon is recognisable. Other times the Moon looks very different; it may be covered or partially covered by Earth's shadow, and it changes colour.

In this lesson you will learn how the relative positions of Earth, the Sun and the Moon cause lunar eclipses which then change the appearance of the Moon from Earth.

SC 1 I can describe what the Moon will look like during a lunar eclipse

Lunar eclipse

A lunar eclipse occurs when the Moon passes through Earth's shadow and Earth temporarily blocks the Sun's light from reaching the Moon. A lunar eclipse only occurs during the full moon phase when the Moon appears as a full circle in the sky.

During a lunar eclipse, the appearance of the Moon from Earth changes depending on which part of Earth's shadow the Moon passes through.

Figure 2.9.1 shows the two parts of Earth's shadow:

The penumbra – a diffuse, outer portion of the shadow which extends away from Earth at an angle.

The umbra – the dark, inner portion of the shadow directly behind Earth.

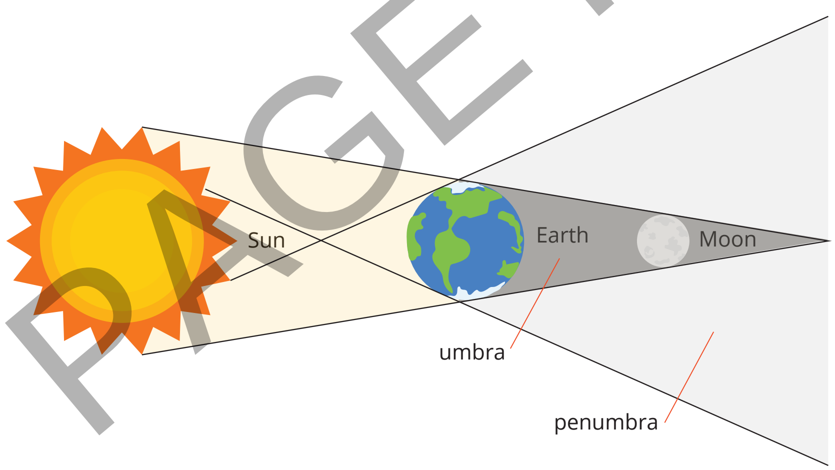


FIGURE 2.9.1 The arrangement of the Sun, Earth and the Moon during a lunar eclipse and the regions within Earth's shadow.

Penumbral lunar eclipse

A penumbral eclipse occurs when the Moon only moves through the penumbra of Earth's shadow and not through the umbra. The penumbra of Earth's shadow is very faint, and the appearance of the Moon doesn't change much during a penumbral lunar eclipse. A penumbral eclipse is hard to detect because the brightness of the Moon will only be subtly reduced.

Learning intention

To understand the cause of a lunar eclipse

Success criteria

SC 1: I can describe what the Moon will look like during a lunar eclipse.

SC 2: I can describe the relative positions of Earth, the Moon and the Sun during a lunar eclipse.

SC 3: I can explain, using a two- or three-dimensional representation, how Earth casts a shadow on the Moon during a lunar eclipse.

Scifile

Ancient explanations

Many ancient cultures had their own explanations for lunar eclipses. Some believed that a dragon or other creature was eating the Moon, while others thought it was a sign from the Gods.

FIGURE 2.9.2 Part of the Moon is covered by Earth's umbra during a partial lunar eclipse

FIGURE 2.9.3 The phases of a lunar eclipse

FIGURE 2.9.4 The orange colour of an eclipsed moon

Partial lunar eclipse

During a partial lunar eclipse, the Moon is only partly covered by Earth's shadow and some direct sunlight is still able to reach the Moon. Only part of the Moon moves through the dark inner shadow (the umbra), the rest of the Moon is in the faint shadow (the penumbra). The part of the Moon under the umbra appears dark and the rest of the Moon under the penumbra still reflects light (Figure 2.9.2).

A partial lunar eclipse can look a bit like the phases of the Moon during which some of the side of the Moon facing Earth is in darkness. A partial lunar eclipse only lasts for a short amount of time, less than two hours, and occurs only during the full moon phase.

Total lunar eclipse

During a total lunar eclipse, the Moon is completely covered by Earth's umbra and no direct sunlight reaches the Moon. The Moon is still visible during a total eclipse because some sunlight still reaches the Moon indirectly through Earth's atmosphere. The image in Figure 2.9.3 shows a time lapse of the full progression of a total lunar eclipse beginning and ending with a partial eclipse and reaching a total eclipse in the middle.

Colour of the Moon

During some stages of a lunar eclipse, the Moon can change to a reddish orange colour. This is caused by sunlight interacting with Earth's atmosphere which filters and scatters different wavelengths of light. Blue light wavelengths are filtered out by particles in the atmosphere more than red light wavelengths. Therefore, the sunlight falling on the Moon's surface is mostly orange to red, so that's the colour the Moon appears to us.

A total lunar eclipse is sometimes referred to informally as a 'blood moon' due to the Moon's change in colour (Figure 2.9.4).

Viewing a lunar eclipse

A lunar eclipse can be seen by anyone on the night side of Earth so long as their view of the Moon isn't obstructed by physical objects on Earth or clouds in the sky. The number of lunar eclipses per year is not always the same but the average is two per year. A lunar eclipse can last up to two hours.

SC 1 CHECK YOUR UNDERSTANDING

Describe how you would identify a total lunar eclipse in the night sky.

SC 2 I can describe the relative positions of Earth, the Moon and the Sun during a lunar eclipse

When the Sun, Earth and the Moon align

A lunar eclipse can only occur when the Sun, Earth and the Moon are aligned with the Sun and the Moon on opposite sides of Earth (Figure 2.9.5). This formation only occurs during the full moon phase. A full moon occurs every moon cycle which is about once a month.

FIGURE 2.9.5 The Sun, Earth and the Moon are directly aligned during a full moon and a lunar eclipse.

Not every full moon

Lunar eclipses can only occur during the full moon phase, but they do not happen every full moon.

This is due to the direction of the Moon's orbit around Earth. The Moon's orbit is slightly tilted at about 5° to the plane (an imaginary flat surface) of Earth's orbit. The tilt of the Moon's orbit is shown in Figure 2.9.6.

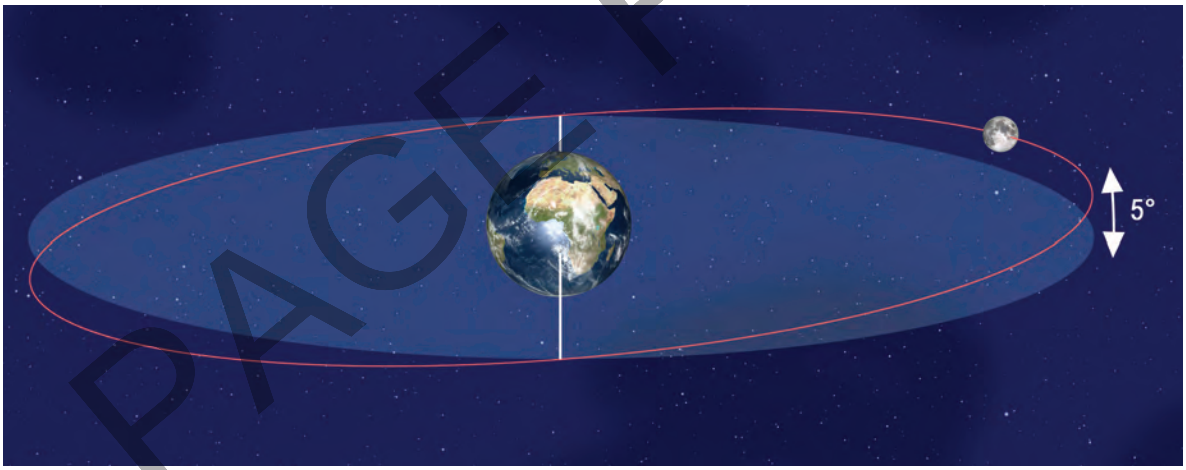


FIGURE 2.9.6 The Moon is only aligned with Earth's shadow occasionally due to the tilt of its orbit, so lunar eclipses do not happen often.

As Earth and the Moon travel around the Sun, the tilt of the Moon's orbit causes it to appear above or below the Sun when observed from Earth.

At times this means that the Moon might be slightly above or below Earth in space during the full moon phase and will orbit Earth without passing through Earth's shadow.

Geometry of a lunar eclipse

When the Moon's orbit is directly aligned in the same plane as Earth's orbit and the Sun, the Moon passes through Earth's shadow.

First, the Moon passes through the penumbra, and a penumbral then partial lunar eclipse occurs. Then, the Moon moves directly behind Earth through the umbra, and a total lunar eclipse occurs. The diagram in Figure 2.9.7 shows the relative positions of the Sun, Earth and the Moon during a lunar eclipse.

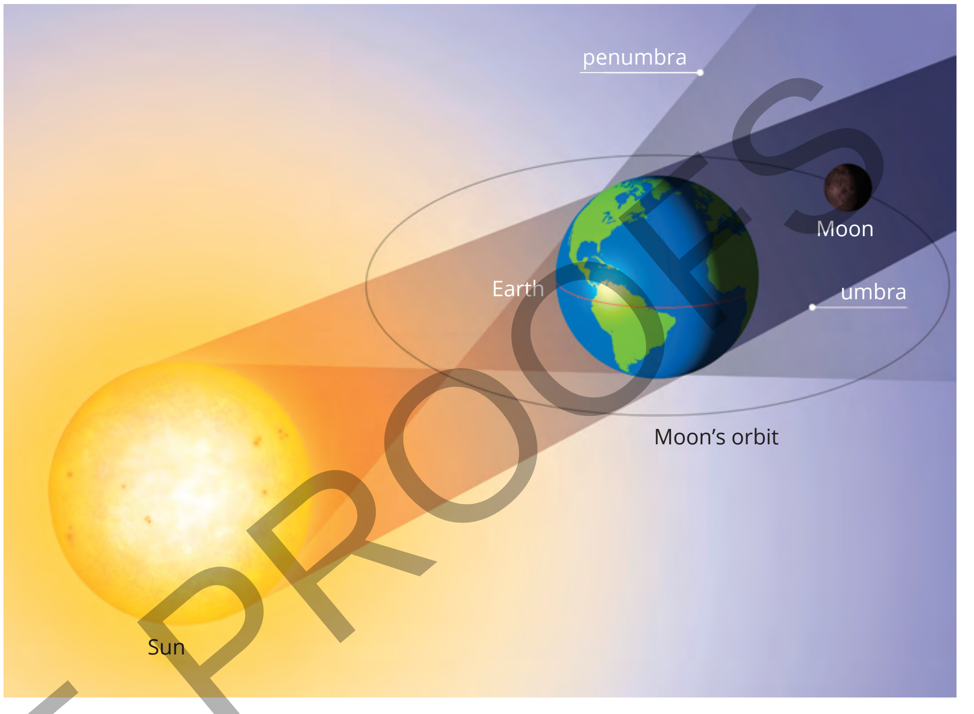


FIGURE 2.9.7 The relative positions of the Sun, Earth and the Moon during a lunar eclipse.

SC 2 CHECK YOUR UNDERSTANDING

Describe the position of the Moon relative to Earth and the Sun during a total lunar eclipse.

SC 3 I can explain, using a two- or three-dimensional representation, how Earth casts a shadow on the Moon during a lunar eclipse

Using models

Using a model is a helpful way to understand why a lunar eclipse occurs.

Lunar eclipses are not visible all the time because they only occur a couple of times a year and can only be viewed when the sky is clear. There is also only one view of the lunar eclipse from Earth's surface.

Creating a model allows for the visualisation of a lunar eclipse at any time and to see how it might look from space.

A model of a lunar eclipse should include representations of the Sun, Earth and the Moon.

2D vs 3D models

A two-dimensional (2D) model, such as a diagram or illustration, is a flat representation of Earth, the Sun and the Moon. Arrows can be used to explain movement and direction.

A three-dimensional (3D) model, such as that in Figure 2.9.8, uses physical objects to represent Earth, the Sun and the Moon and can include physical movement.

FIGURE 2.9.8 A 3D model of the Sun-Earth systems.

Scale

When making a model, the elements are ideally made to scale and are the right sizes and distances in relation to each other, but this is not always practical. When making 2D or 3D models of Earth, the Sun and the Moon, the sizes and distances of the objects are too extreme to be made to scale.

In a lunar eclipse model, it is most important to ensure:

- the Sun is bigger than Earth
- Earth is bigger than the Moon
- Earth is closer to the Moon than it is to the Sun.

Light

All the Sun's rays cannot be drawn in a 2D model, but the direction of light must be represented. Light and shadow can be represented by colour, shading or lines radiating out from a light source. In a 3D model, actual light sources that emit visible light and create shadows can be used.

SkillBuilder

Using models in Earth and space science

Models in science

Scientific models can be used to describe or explain things that are either too small or too big to be seen directly by humans.

Models can be 2D diagrams, 3D models, computer simulations, or even just thoughts or ideas.

What makes a good scientific model?

A scientific model should be based on correct science. For example, light travels in straight lines and planets orbit around the Sun.

A scientific model can be used to make predictions.

Modelling systems in space: Dealing with scale

When scaling down from the vast scale of space, keep relative sizes and times as close to reality as possible. For example:

- keep Earth bigger than the Moon.
- keep the distance of Earth to the Sun much larger than the distance to the Moon.
- keep the time for Earth to orbit the Sun much longer than the time for the Moon to orbit Earth.

For example, Fabrice was asked to draw a 2D model that shows the orbital motion of the Moon and Earth around the Sun. They were told that Earth's orbit around the Sun takes 365 days and that the Moon's revolution around Earth takes 27 days. Fabrice's diagram looked like the one depicted in Figure 2.9.9.

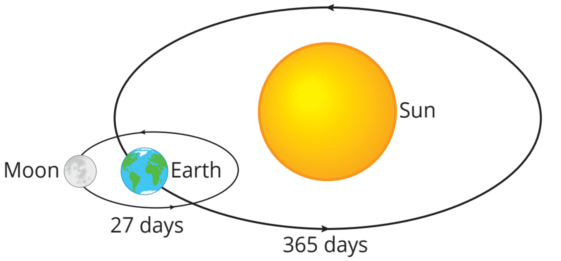


FIGURE 2.9.9 A 2D model of the Sun, Earth and Moon systems.

Worked example

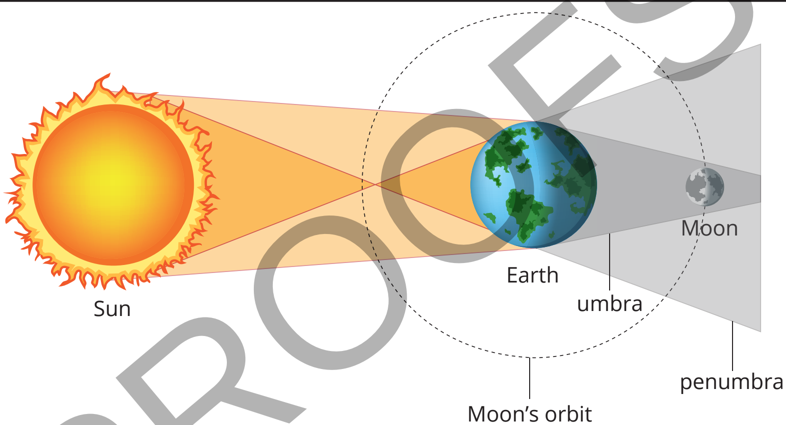
Using models in Earth and space science

Problem

Use the following information to make a 2D model of a lunar eclipse.

A lunar eclipse occurs when the Sun, Earth and the Moon are aligned, with the Sun and the Moon on opposite sides of Earth. The Moon moves into Earth's shadow during its orbit, blocking out direct light from the Sun. The Moon first travels through the lighter outer shadow (the penumbra), then through the darker inner shadow directly behind Earth (the umbra).

Solution

Thinking	Working
List the elements you need to represent with your model.	Sun Earth Moon sunlight shadow
Consider the placement of the Sun, Earth and the Moon in relation to each other.	The Sun, Earth and the Moon are aligned, with the Sun and the Moon on opposite sides of Earth.
Consider the relative sizes of, and distances between, the objects.	The Sun is bigger than Earth and Earth is bigger than the Moon. The distance between the Moon and Earth is smaller than the distance between Earth and the Sun.
Draw or make the model.	 To model a lunar eclipse, the Sun, Earth and the Moon must be arranged in this way.

Try yourself

Create an annotated sketch to plan how you would go about making a 3D model of a lunar eclipse.

SC 3 CHECK YOUR UNDERSTANDING

Describe how you would use a 3D model to show the positions of Earth, the Moon, and the Sun during a lunar eclipse.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1. If you observe the Moon gradually darkening and then turning red, what type of eclipse are you witnessing?
2. Compare different types of lunar eclipses.
   a. How does the Moon's appearance differ during a partial and a total lunar eclipse?
   b. What are the similarities between partial and total lunar eclipses?
   c. Evaluate the visual impact of a total lunar eclipse compared to a partial lunar eclipse.
3. Explain why a lunar eclipse does not occur every full moon.
4. Compare different representations of a lunar eclipse in terms of their strengths and weaknesses.
   a. How does a 2D diagram compare to a 3D model when explaining a lunar eclipse?
   b. Evaluate which model (2D or 3D) might be more effective for different learning objectives.

2.10 Cultural influence on knowledge about lunar eclipses

Learning intention

To be able to explore the influence of cultural perspectives on scientific knowledge about lunar eclipses

Success criteria

SC 1: I can describe the work and cultural context of acclaimed female scholar, Wang Zhenyi.

SC 2: I can explain how culture influenced the study of lunar eclipses.

SC 3: I can describe how Wang Zhenyi used experimentation to study lunar eclipses.

Introduction

Culture and context have an important influence on scientific research and discovery (Figure 2.10.1). The eighteenth-century Chinese scholar Wang Zhenyi was an important influence in the field of astronomy. Zhenyi studied the movements of the Sun, the Moon and planets and described lunar eclipses.

In this inquiry you will be able to explore how Wang Zhenyi's cultural perspectives influenced her knowledge about lunar eclipses.

FIGURE 2.10.1 Astronomers in China in the 18th century.

Background

Wang Zhenyi was a Chinese scientist of the 18th century from the Qing dynasty (1636–1912). She was very influential for her time which was unusual for a female. Wang Zhenyi's involvement in science was not typical as women were expected to play a limited role in society at that time. Women could not own property and had to obey male members of their family. Opportunities for careers and education for women were restricted. It was culturally unusual for women to be interested in science and to have an education. Despite the culture, Wang Zhenyi's family valued education and encouraged her to follow her interests in science and poetry. Zhenyi was influenced by her grandfather who was her teacher of astronomy, her grandmother who taught her poetry and her father who taught her medicine, geography and mathematics. At the age of 18, Zhenyi focussed on teaching herself astronomy and wrote many articles including *The Explanation of a Lunar Eclipse*.

Aim

To explore Wang Zhenyi's cultural context (historical and social background in which she lived including the values and beliefs of her society), and how these influenced her work on lunar eclipses.

Plan

1 Investigate the cultural context surrounding Wang Zhenyi. Consider where her passion for astronomy originated. Where did she learn about the stars and planets? What were her contributions in the field of astronomy? What barriers did she face as a woman studying astronomy in the 18th century?

2 Describe or draw an image of how a lunar eclipse occurs.

Design

1 Research how Wang Zhenyi made a model to prove her theory about lunar eclipses.

2 Design a model that takes inspiration from Zhenyi's experiment.

Conduct

Using your design, create a model of a lunar eclipse, drawing inspiration from Wang Zhenyi's model.

Improve

Consider the model you have created.

1 What parts of your model worked well?

2 What parts of your model needed improvement?

3 How could you modify your model of a lunar eclipse to make it better?

Evaluate

1 What aspect of culture were you investigating in this inquiry activity?

2 In this activity, you planned and conducted an inquiry about lunar eclipses, drawing inspiration from Wang Zhenyi. What skills did you use during this activity?

2.11 Solar eclipses

Learning intention

To understand the cause of a solar eclipse

Success criteria

SC 1: I can describe what the Sun will look like during a solar eclipse.

SC 2: I can describe the relative positions of Earth, the Moon and the Sun during a solar eclipse.

SC 3: I can explain, using a two- or three-dimensional representation, how the Moon casts a shadow on Earth during a solar eclipse.

KEY TERM

solar eclipse when the Moon blocks sunlight from reaching Earth

Lesson overview

Every so often the Moon briefly obstructs the view of the Sun. If you are in the right place at the right time, you can observe this from Earth.

In this lesson you will learn how the relative positions of Earth, the Sun and the Moon cause solar eclipses which change the appearance of the Sun from Earth.

SC 1 I can describe what the Sun will look like during a solar eclipse

Solar eclipse

A **solar eclipse** occurs when the Moon passes between the Sun and Earth. The Moon temporarily blocks the Sun and casts a shadow on a part of Earth's surface. A solar eclipse only occurs during the new moon phase when the Moon appears dark in the sky and is not visible from Earth. The Moon is smaller than Earth, so it only casts a shadow on a small part of Earth's surface.

During a solar eclipse, the appearance of the Sun from Earth changes depending on which part of the Moon's shadow is cast over a particular location.

As with lunar eclipses, the shadows cast by the Moon on Earth have two distinct parts: the penumbra (the diffuse, outer portion of the shadow) and the umbra (the dark, inner portion of the shadow). The penumbra and umbra of a solar eclipse are shown in Figure 2.11.1.

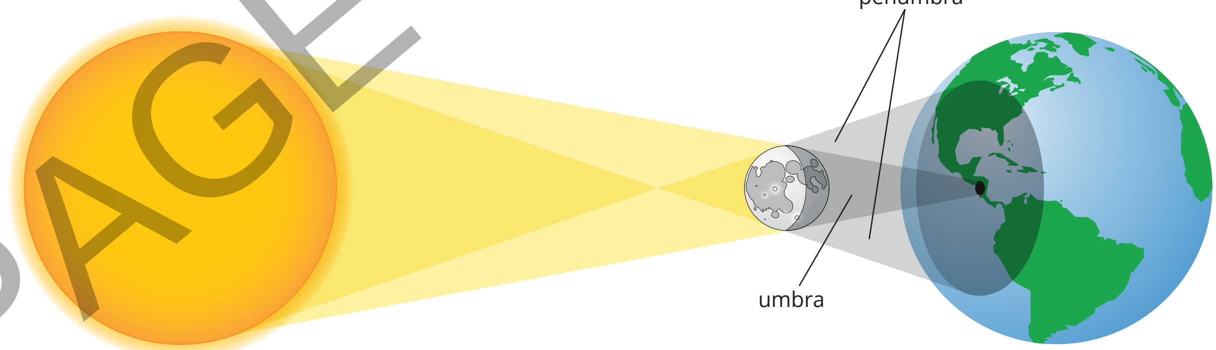


FIGURE 2.11.1 The shadow of the Moon on Earth has a darker area where all light from the Sun is blocked (umbra) and lighter areas where some of the light from the Sun is blocked (penumbra).

FIGURE 2.11.2 A partial eclipse during sunrise.

Partial solar eclipse

During a partial solar eclipse, the Sun is only partly covered by the Moon (Figure 2.11.2). Only the outer part of the Moon's shadow, the penumbra, is cast over part of Earth's surface. Part of the Sun is covered by the Moon and the Moon's penumbra falls on Earth.

Total solar eclipse

During a total solar eclipse, the Sun is completely blocked by the Moon (Figure 2.11.3). The sky darkens and the Sun cannot be seen. Only the glow of the Sun's outer atmosphere is visible. A total solar eclipse can only be seen from the part of Earth that is in the path of the Moon's umbra – the narrow dark shadow directly behind the Moon.

FIGURE 2.11.3 A time series of the full progression of a total solar eclipse beginning and ending with partial eclipses and reaching a total eclipse in the middle.

Annular solar eclipse

The word annular comes from the Latin word for ring. During an annular solar eclipse, the Moon moves directly in front of the Sun, but the Moon doesn't completely cover the Sun (Figure 2.11.4). The Moon appears as a smaller disk over the top of the disk of the Sun.

An annular solar eclipse happens when the Moon is at its farthest point from Earth during its orbit. The Moon's orbit is an ellipse (oval-shaped) so it can be slightly closer or farther from Earth depending on where it is in its orbit. When the Moon is farther away, it appears smaller in the sky and doesn't completely cover the Sun.

FIGURE 2.11.4 An annular eclipse.

Viewing a solar eclipse

Solar eclipses can't be seen from all places on Earth. They are only visible from the part of Earth in the path of the Moon's shadow. Most solar eclipses are only viewed as partial eclipses because the penumbra falls on a larger area. Only a small area of Earth falls under the umbra. Only locations falling within the umbra will see a total solar eclipse. On average, there are two to five solar eclipses each year. Whether you can see the eclipse depends on where you are on Earth.

Solar eclipse safety

Safety is an important consideration when viewing a solar eclipse. Looking directly at the Sun can cause eye damage, so always view the Sun through a filter, such as eclipse glasses (Figure 2.11.5), or a projection like a pinhole camera.

FIGURE 2.11.5 You can view the Sun safely using eclipse glasses.

SC 1 CHECK YOUR UNDERSTANDING

Identify the phase of the Moon during a solar eclipse.

SC 2 I can describe the relative positions of Earth, the Moon and the Sun during a solar eclipse

When the Sun, the Moon and Earth align

A solar eclipse can only occur when the Sun, the Moon and Earth are aligned, with the Sun and Earth on opposite sides of the Moon (Figure 2.11.6). This formation only occurs about once a month during the new moon phase. A new moon occurs every moon cycle.

FIGURE 2.11.6 The Moon must be directly between the Sun and Earth to cause a solar eclipse.

The Moon’s tilted orbit

Solar eclipses can only occur during the new moon phase, but they do not happen every new moon. This is due to the shape of the Moon’s orbit around Earth. The Moon’s orbit is slightly tilted at about 5° to the plane of Earth’s orbit (Figure 2.11.7). Recall that this tilt of the lunar orbit is also responsible for lunar eclipses not occurring every full moon.

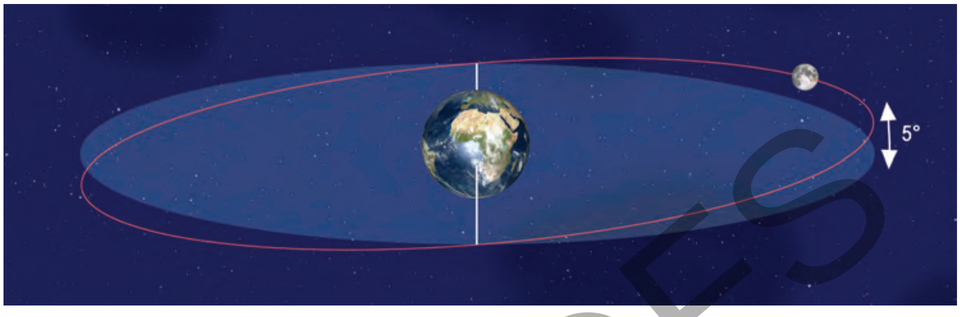


FIGURE 2.11.7 Solar eclipses do not happen often due to the tilt of the Moon’s orbit.

As Earth and the Moon travel around the Sun, the tilt of the Moon’s orbit changes direction relative to the Sun. During the Moon’s orbit, the Moon may be slightly above or below Earth during the new moon phase, so the Moon’s shadow won’t fall on Earth.

Geometry of a solar eclipse

When the Moon’s orbit is in the same plane as Earth’s orbit and the Sun, the Moon and Earth are aligned, the Moon casts a shadow on part of Earth’s surface.

A partial eclipse is observable by someone on Earth if they are located within the penumbra shadow (Figure 2.11.8). A total eclipse is observable from Earth if someone is located within the umbra. Any locations that are not in the path of the Moon’s shadow will not see a solar eclipse at all.

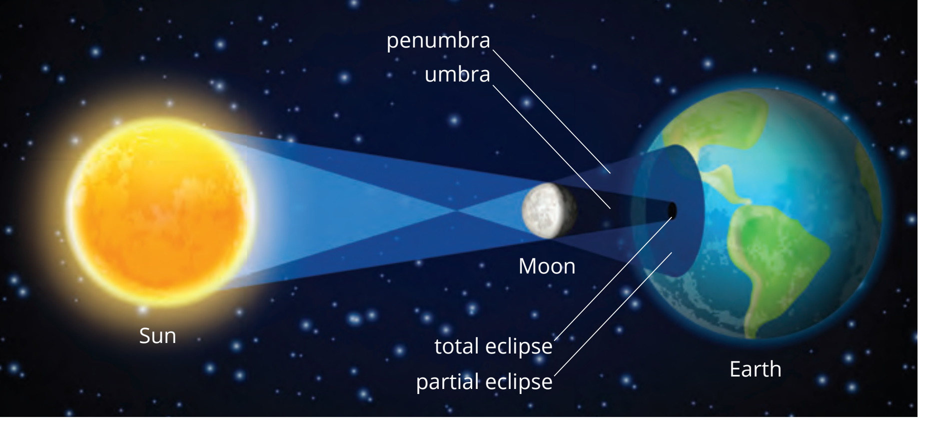


FIGURE 2.11.8 The image is a view from space of the umbra and penumbra during a solar eclipse.

SC 2 CHECK YOUR UNDERSTANDING

Explain how the alignment of Earth, the Moon and the Sun causes a solar eclipse.

SC 3 I can explain, using a two- or three-dimensional representation, how the Moon casts a shadow on Earth during a solar eclipse

Modelling a solar eclipse

Using a model is a helpful way to understand why a solar eclipse occurs.

A solar eclipse is not always visible because solar eclipses:

- only occur a couple of times a year
- can only be viewed from places on Earth in the path of the Moon's shadow
- can only be viewed when the sky is clear.

Creating a model allows you to visualise how a solar eclipse might look from space or on Earth at any time. A model of a solar eclipse should include representations of the Sun, Earth and the Moon.

In the model shown in Figure 2.11.9 the eye of the observer represents Earth. This model only shows how the light from the Sun is blocked by the Moon.

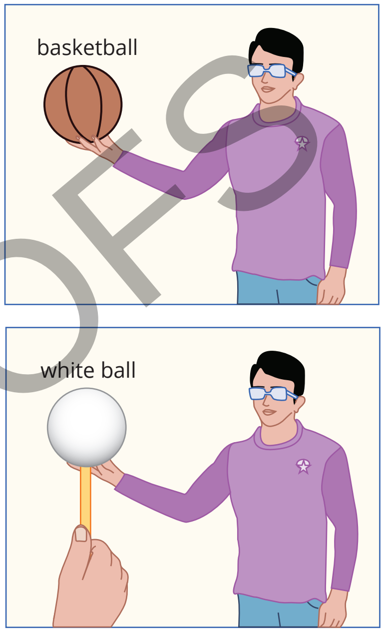


FIGURE 2.11.9 This model shows how the white ball (Moon) can block the light of the Sun (torch).

Scale

When making a model, the elements are ideally made to scale (that is, the right sizes and distances in relation to each other), but this is not always practical. When making 2D or 3D models of Earth, the Sun and the Moon, the sizes and distances of the objects are too extreme to be made to scale.

In a solar eclipse model, it is most important to ensure:

- the Sun is bigger than Earth
- Earth is bigger than the Moon
- the Moon is closer to Earth than it is to the Sun.

Altering the distance between your eye (Earth) and the Moon can make this model simulate an annular or partial eclipse.

SC 3 CHECK YOUR UNDERSTANDING

Describe features of a solar eclipse that would be more clearly shown by a 2D diagram rather than a 3D model.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 What does the Sun look like during a total solar eclipse?

2 Think about why the Sun is obscured during a solar eclipse.

- **a** Why does the Sun become obscured during a total solar eclipse?
- **b** How does the Moon's position affect the Sun's appearance during an eclipse?
- **c** Explain the difference between a partial and a total solar eclipse.

3 Compare the positions of Earth, the Moon and the Sun during a solar eclipse and a lunar eclipse.

4 Consider the shadows cast during a solar eclipse.

- **a** How does the umbra of a solar eclipse differ from the penumbra?
- **b** Describe the appearance of the Sun when viewed from the umbra of the eclipse.

5 Imagine creating a three-dimensional model of a solar eclipse.

- **a** What objects would you use to represent Earth, the Moon and the Sun?
- **b** How would you position these objects to show a solar eclipse?
- **c** What steps would you take to demonstrate the transition from penumbra to umbra?

2.12 Exploration of the Moon

Introduction

For as long as humans have gazed at the night sky, the Moon has been a focus of fascination. People have a long history of space exploration and research, specifically with the Moon.

In this inquiry you will explore how moon exploration over the last fifty years has been influenced by changing technology and economic and political factors.

Learning intention

To be able to explain how a range of factors have influenced the exploration of the Moon

Success criteria

SC 1: I can describe the historical factors that influenced the desire to send a person to the Moon.

SC 2: I can describe changes in space technologies since the Moon landings.

SC 3: I can compare the reasons for human presence on the Moon now to the time of the Apollo missions.

Background

The Space Race was a significant period in the history of space exploration, beginning in the late 1950s and continuing throughout the 1960s. During this time, the United States and the Soviet Union were in competition to be the first country to send a person to the Moon.

The Space Race led to several important achievements in space exploration, including the first human landing on the Moon in 1969.

Over the last fifty years, exploration of the Moon has changed significantly. Many technologies have been developed to support efficient and safe exploration in future landings. There are different ways that moon exploration has been carried out by scientists and space agencies. The reasons for human presence on the Moon now, as compared to fifty years ago, are very different and there are many reasons for this.

SCIENCE IN SOCIETY

Lunar exploration

The exploration of the Moon has been significantly influenced by technological advancements. The development of rockets, spacecraft, and navigation systems has made it possible to send missions to the Moon and beyond. The Apollo program, which successfully landed humans on the Moon in 1969, was made possible by innovations in engineering, computing and materials science. These technological advancements allowed astronauts to travel to the Moon, conduct scientific experiments and return safely to Earth.

The development of more powerful rockets, such as NASA's Space Launch System (SLS) and SpaceX's Starship, allows larger loads and more sophisticated instruments to be carried the Moon. Advances in robotics and artificial intelligence are enabling the design of autonomous rovers and landers that can explore the lunar surface and conduct scientific research without human intervention.

Australia is also contributing to lunar exploration through its involvement in international space missions and research (Figure 2.12.1). The Australian Space Agency collaborates with NASA and other space agencies to support lunar missions and develop new technologies for space exploration.

FIGURE 2.12.1 Australian-British astronaut Katherine Bennell-Pegg could be the first woman to walk on the Moon.

Aim

To create a presentation sharing the reasons for the human presence in space now as compared to the time of the Apollo missions.

Plan

Explore the timeline of space exploration for the following Apollo missions.

Summarise the key reasons for human presence on the Moon in the days of the Apollo missions.

Apollo 8

In 1968, Apollo 8 circled the Moon for almost a day. This mission was the first time people were able to gaze at the Moon from orbit.

Apollo 8

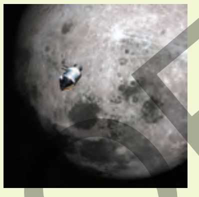


Illustration of the Apollo 8 spacecraft and the Moon in December, 1968

Apollo 10

In 1969, Apollo 10 orbited the Moon to test the Lunar Lander and the possibility of moon landings. The Lunar Module was designed to transport astronauts from the Command/Service Module in lunar orbit to the surface of the Moon and back. Many high-resolution photographs were taken detailing the Moon's surface which increased knowledge of lunar geology.

Apollo 10

An in-flight photo of Apollo 10 astronauts Thomas Stafford and John Young in May 1969

Apollo 11

In July 1969, Apollo 11 landed on the Moon and astronauts walked on the Moon for over 2 hours. They took soil samples and learnt that the Moon had once been nearly completely molten – covered in a layer of liquid rock. The astronauts found no evidence of any significant amount of water on the Moon then or in the past.

Apollo 11

Apollo 11 astronaut Buzz Aldrin on the Moon on July 21, 1969

Apollo 12

In November 1969, Apollo 12 landed on the Moon. The astronauts collected over 35 kilograms of samples which provided information about the ages of rocks and soil on the Moon's surface, especially those found in craters such as Copernicus. This information allowed scientists to create a timeline of the Moon's formation.

Apollo 12

Apollo 12 astronaut Alan Bean climbed down the ladder of the Lunar Module Intrepid for a spacewalk on the Moon's surface on November 19, 1969

Apollo 13

The Apollo 13 mission in April 1970 became a rescue mission when a panel of the service module ripped off after an in-flight explosion before the craft reached the Moon. All three astronauts returned safely after using problem-solving skills and the technology on the craft to use the limited fuel and oxygen in the Lunar Module to power them back home to Earth.

Apollo 13

Photograph of the damaged Apollo 13 service module in April 1970.

Apollo 14

On February 5, 1971, Apollo 14 astronauts collected over 43 kilograms of rocks and soil. These samples informed scientists that the Moon's crust formed over 4.4 billion years ago and confirmed that lava (semi-molten rock) flows had once covered large areas of the Moon's surface.

Apollo 14

A NASA astronaut explores the surface of the Moon as photographed by an Apollo 14 crew member in February 1971.

Apollo 15

On this mission, over 80 kilograms of samples were collected and 20% of the Moon's surface was mapped from orbit. Apollo 15 was the first mission to use a Lunar Roving Vehicle which allowed travel farther from the landing site and exploration of larger areas. It also enabled the collection of more samples so that more experiments could be carried out than previous missions.

Apollo 15

Apollo 15 astronauts deployed the first Lunar Roving Vehicle on the surface of the Moon on July 31, 1971.

Apollo 16

On this mission, the first astronomical telescope was deployed and operated on the Moon. Ancient crustal rocks were found, as well as a very strong magnetic field on the surface the Moon which was then measured.

Apollo 16

Astronaut Charles M. Duke Jr. collected lunar samples during the Apollo 16 mission in April 1972.

Apollo 17

Apollo 17 landed on the Moon on December 11, 1972. The Apollo 17 mission made several significant discoveries on the Moon. Astronauts collected a variety of rock samples and conducted several experiments to study the geological history and composition of the Taurus-Littrow Valley. New rock samples and data helped to refine estimates of the Moon's formation and early history. Orange soil was later determined to be rich in volcanic glass and other minerals. This discovery helped scientists better understand the Moon's geology and volcanic history.

Overall, the Apollo 17 mission was a significant milestone and helped expand knowledge of the Moon's geology, history and its potential as a resource for future exploration.

Apollo 17

Eugene Cernan on the Moon during the Apollo 17 mission.

Scifile

Human presence on the Moon

Today, space agencies like NASA and private companies are planning new missions to the Moon. These missions aim to establish a sustainable human presence and use the Moon as a stepping stone for further space exploration.

Design

1. Research at least two changes to space technologies related to the exploration of the Moon since the moon landings and record your key findings.
2. Research a current scientific reason for human presence on the Moon.
3. You will be creating a presentation that compares the key reasons for human presence in space now to the time of the Apollo missions. Design a way to present your findings. Map out key headings as well as the format of your presentation.

Conduct

Use your notes from the plan and design sections to create a presentation outlining the key reasons for human presence in space now compared to the times of the Apollo missions. The format of the presentation will be decided by your teacher.

Improve

Write down how you can improve your presentation by considering how well you were able to communicate your key findings to the audience.

Evaluate

Evaluate your work during this activity by describing the knowledge and skills that you gained or improved by completing the task.

2 Systems in space: The Earth, Sun and Moon

Topic summary

The key concepts included in this topic are:

- The Moon orbits Earth, and both Earth and the Moon orbit the Sun.
- Earth's axis is tilted. This means, as it orbits the Sun, one hemisphere is tilted towards the Sun, then six months later the other hemisphere is tilted towards the Sun. The hemisphere tilted towards the Sun receives more direct sunlight and experiences summer.
- First Nations Australians developed seasonal calendars to predict the seasonal availability of food and seasonal conditions.
- The gravitational pull of the Moon and Sun on Earth's oceans causes tides.
- Society uses an understanding of the tides to plan activities in coastal regions such as recreation, construction, transportation and energy generation.
- The orbit of the Moon around Earth changes how much of the lit surface of the Moon you can see and therefore the shape the Moon has from your location. These 'shapes' are called the phases of the Moon.
- A lunar eclipse is caused by the Moon travelling through the shadow of Earth.
- A solar eclipse is caused by the Moon passing between the Sun and Earth. The shadow of the Moon falls on Earth and from Earth some or all of the Sun is blocked out (eclipsed).
- The exploration of the Moon has been influenced by competition between nations and a desire to explore or understand.

Review questions

The following questions will assess your success in achieving the learning intentions for this topic.

Remember

1 Identify what causes different parts of Earth to experience different seasons.

2 Describe what a seasonal calendar is, as used by First Nations Australians.

3 What is the relationship between the Moon's rotation on its axis and its orbit around Earth?

4 Write the name of the key phase of the Moon when
   a the Moon appears round and
   b the Moon cannot be seen from Earth.

Understand

5 Explain the relative positions of Earth, the Sun and the Moon in the solar system.

6 Explain how the intensity of sunlight is responsible for a location on Earth experiencing summer and then winter six months later.

7 Phoebe was given a desk lamp, a thermometer and a protractor.
Explain how Phoebe could use this equipment on a flat surface to model the changing angles of sunlight that fall on Earth in different seasons.

8 Plan how to you could use a model to demonstrate the phases of the Moon.

9 Explain why Earth, the Moon and the Sun need to be in particular positions for a lunar eclipse to occur.

Apply

10 Describe how Earth's seasons would change if the North Pole of Earth faced directly towards the Sun in January, and then in July, Earth's South Pole faced directly towards the Sun.

11 Outline how you could use a seasonal calendar to plan agricultural activities.

12 Compare the reasons for human presence on the Moon now to the time of the Apollo missions.

Analyse

13 Compare the gravitational pull of the Moon on Earth to the gravitational pull of Earth on the Moon.

14 Compare neap tides and spring tides in terms of their causes and effects.

15 Kylie made a model to demonstrate an eclipse. Her model is shown below. Explain which type of eclipse this model would represent.

Extension: Research

16 Research and describe how the phases of the Moon affect nocturnal animal behaviour.

Topic reflection

The learning intentions for this topic are given in each lesson and at the beginning of the topic. Consider how well you have achieved them. Note down any particular areas that you are confident in, and others where you are not so sure.

2 Glossary

astrophysicist a scientist who studies the behaviour and physical properties of objects and events in space

constellation a group of stars which form a recognisable pattern in the night sky

country the land that first nations peoples have a cultural connection to through their ancestry

commerce buying and selling goods or services

creation stories stories that explain the origins of the universe, the rules for living and the relationship of people to each other

crescent moon a phase of the Moon where less than half is illuminated

Earth's axis the line connecting the North Pole with the South Pole; Earth rotates around this axis

ecological a description of something that relates to ecosystems or interactions between living things and their environment

ecology the study of how organisms interact with each other and with their non-living surroundings

economy a system in which goods and services are produced and sold

ecosystem a system formed by organisms interacting with each other and their nonliving surroundings

equator an imaginary horizontal line that divides Earth into the northern and southern hemispheres. it lies equal distance between the north and South Poles

estuarine a description of something related to an estuary where a river joins the sea

forage to search for something over a wide area in order to obtain it; foraging usually refers to the search for food in the environment

full moon the phase of the Moon when the whole of the Moon seen from Earth is illuminated by the Sun

gibbous moon a phase of the Moon where more than half is illuminated

gravitational force the force on an object caused by gravity; can be described as the 'weight' of an object

gravity the force of attraction between any two objects

intertidal zone the area of land on a coastline between high and low tides

lunar related to the Moon

lunar cycle the period of 27.3 days that it takes for the Moon to orbit Earth

lunar phase the appearance of the Moon from Earth as it changes over the course of a month

magnitude a measure of the size or strength of something

mass the amount of matter in a substance or object; measured in grams (g), kilograms (kg) or tonnes (t)

Moon a natural satellite that orbits Earth

new moon the phase of the Moon when it is near the Sun in the sky and is very difficult to see since the side of the Moon facing Earth is not illuminated

orbit curved path a planet takes around a star, or that a Moon or artificial satellite takes around a planet; orbits can be circular or elliptical

organism a living thing

planet roughly spherical ball of rock or gas that orbit (move around) the Sun; they do not generate their own light

penumbra less dense shadow of an eclipse

renewable energy source source of energy that can be replaced after it is used, such as solar or wind energy

rotation spinning motion of an object around a central line, called an axis of rotation

science communicator a person who informs others who are normally non-experts about scientific findings, often with the aim of raising public interest in science

seasons on Earth, summer, autumn, winter, spring; caused by the tilt of a planet's axis

solar related to the Sun

solar eclipse when the Moon blocks Sunlight from reaching Earth

solar system the Sun and all the planets, satellites, asteroids, comets and other bodies revolving around it

space the immense and limitless area beyond Earth's atmosphere, containing stars, planets, galaxies, and other cosmic matter

Sun a massive, luminous ball of hot gas located at the centre of the solar system. it emits light, heat, and energy that reach Earth and other planets

topography the hills, valleys, rivers and other physical features of the landscape

tide the rising and falling of water levels in large bodies of water such as the ocean and lakes, caused by the gravitational pull of the Moon on Earth

umbra full, dark shadow of an eclipse

waning the lunar phases after a full moon where the illuminated portion of the Moon is decreasing

waxing the lunar phases after a new moon where the illuminated portion of the Moon is increasing

weir a low barrier built across a river which can be used to raise the level of water upstream and control the flow of the river

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