Geography Year 1

SECTION 3

EXPLORING EARTH'S SHAPE, MOTIONS AND COORDINATES

THE EARTH AND ITS NEIGHBOURHOOD

The Earth and its Features

Introduction

This section is focused on one planet, our Earth. How do we know the Earth is not flat? What shape is it and what evidence is there to prove it? You already know that the Earth is spherical from your earlier lesson. You will also know that the Earth is not a perfect sphere like a cricket ball or a football. This section is also devoted to discussions on longitudes and latitudes. These are imaginary lines on the earth's surface that are measured in degrees. As you learnt in JHS Social Studies, that lines of longitudes and latitudes help us to locate places on Earth's surface. This is an interesting aspect of geography that enlightens you on the location of places, including your school and even where you are now. You will also look at the characteristics as well as the importance of these imaginary lines.

The world you live in can be shown in different ways. For example, on a globe, Atlas, and single-sheet maps. There are particular rules you need to follow when locating a place by latitude and longitude. Building on your experiences and understanding of latitude and longitude can enhance your ability to calculate distances and determine time differences. These skills not only deepen your knowledge of geography but also have practical implications in various fields. This section explores the world of latitude and longitude and helps you understand the techniques involved in calculating distances and time.

At the end of this section, you should be able to:

- Discuss the evidence of the shape of the Earth.
- Examine the effects of the Earth's rotation and revolution
- Use latitudes and longitudes to locate places on the Earth's surface
- Calculate distances using latitudes and time using longitudes

Key Ideas

- The shape of the Earth is spherical. It flattens at the poles and bulges at the equator.
- The Earth's shape is referred to as *Geoid*.
- Some evidence supporting the Earth's spherical nature includes early sailors circumnavigating the globe, the Bedford Level Canal Experiment, the phenomena of sunrise and sunset, the gradual visibility of ships as they approach, and the circular horizon.
- Latitudes are imaginary horizontal lines on the Earth's surface measured in degrees from 0° to 90° North and South of the Equator.
- Longitudes are imaginary vertical lines on the surface of the Earth measured in degrees from 0° to 180° East and West of the Greenwich or Prime Meridian.

- Lines of latitudes and longitudes are used to locate places on the Earth's surface.
- Latitude and longitude are geographical coordinates that provide a precise location on the Earth's surface.
- Latitudes are used to calculate distances while Longitudes are used to determine the time of a place

EVIDENCE OF THE SHAPE OF THE EARTH

The shape of the Earth

The Earth is round and can be described as having a spherical shape. It is not a perfect sphere because is slightly flat at the North and South Poles which give it a nearly spherical shape called a '*geoid*'.

Activity 3.1

1. Explain, in your own words, how the shape of the Earth is different from the shape of a football or cricket ball.

   For this activity, your explanation should include the word '*geoid*' and compare the Earth, which is slightly flattened at the poles, with the more spherical shape of a cricket ball or football. You might even say that the Earth could not roll very well because of its shape.

2. Explain why looking at the moon might not be a good way to decide on the shape of our Earth.

   For this activity you might include that the moon looks like a circle rather than a sphere and although it gives the idea of a rounded shape, you cannot tell whether the shape has more than two dimensions. This might have led to early map makers drawing a flat-known world with edges where ships might 'drop off'.

CHARACTERISTICS OF THE SHAPE AND SIZE OF THE EARTH

- The Earth is spherical in shape.
- The equatorial diameter of the Earth is about 12,800km.
- The polar diameter is about 12,722km.
- The equatorial circumference is about 40,075km.

- The polar circumference is about 40,007km.
- The total surface area is about 510,000,000 sq. km.
- The Earth is slightly flattened at the poles and bulges at the equator.
- It is called '*geoid'* which means '*Earth-shaped'*.

Activity 3.2

1. Take a tennis or cricket ball. Draw two lines on the ball. One line represents the equatorial circumference of the Earth and one line the polar circumference of the Earth. You can also use rubber bands but make sure the ball is divided twice into two perfect halves or 'hemispheres'. Measure the distance round the two marks with a ruler or dressmaker's tape. Describe your mini experiment and what you found out. Explain why the ball is a sphere and not a '*geoid*'.

   For this activity, your experiment should be carefully written up including how you made sure the ball was divided exactly into two halves (hemispheres), how you measured the two lines, a data table showing the two distances which should be the same and an explanation why the ball is a sphere.

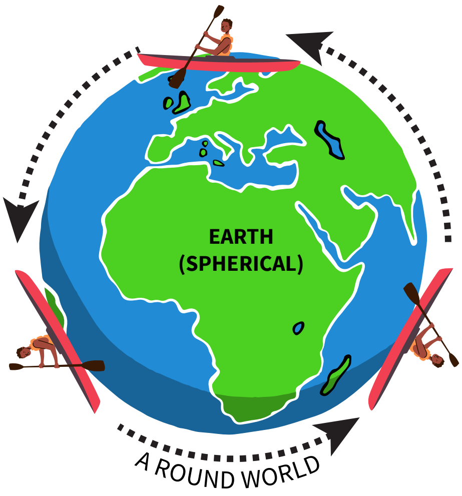
2. Compare your experimental results with the data on the equatorial and polar circumference of the Earth. Describe your findings.

   Your answer should be that the two measurements for the Earth are different but the same for the ball. One is more spherical!

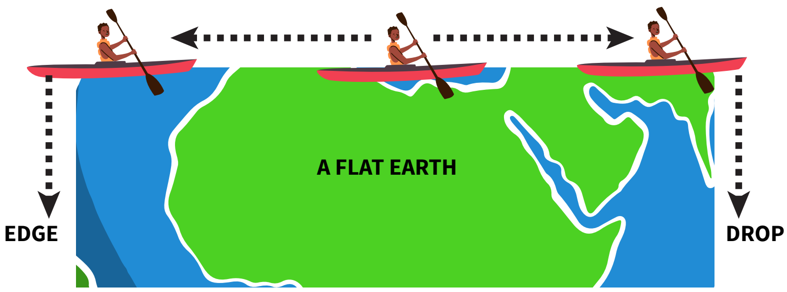
PROOF OF EARTH'S SPHERICAL SHAPE

You know that the Earth is round or spherical in shape. Below is some of the evidence that proves that the Earth is spherical in shape.

Circumnavigation of the Earth: One piece of evidence to show that the shape of the Earth is spherical is to travel around the Earth. If you travel around the whole world by air, land, sea, or ocean and in any direction, you will never reach the end but will come back to where you started. This is because spherical objects have no fixed points. If the Earth were flat, you would start somewhere and end at another place. You would have to turn around and retrace your steps to get back to the place you started. In the 16th century, Ferdinand Magellan proved the Earth was round because was able to travel and go around the world ending up back at the same place he started. He took this event between 1519 and 1522. Figure 3.1 helps to explain this point.



Circumnavigation of the earth



Abrupt drop at the edge of a table-like earth

Fig. 3.1: Difference between flat and spherical objects

If you go round the spherical object, it is possible to come back to the starting point without going through the same route but on a flat surface, you will either fall at the end or you can only come back to the starting point by going back through the same route.

Bedford Level Canal Experiment: This is an experiment done by early canal builders in an area of England called the Bedford Levels. The land here looks completely flat, a good place to build a canal. In a canal, the water is not meant to flow but there will always be some movement from high to lower levels because of the curved surface of the Earth. The engineers proved, by driving poles of equal height into the ground a long distance apart, that the land surface was curved. When three poles of equal lengths are driven into a spherical surface, you will notice that the first and the last poles would have equal lengths or appear at the same levels, with the middle pole being projected due to the curvature of the Earth. The three poles would have the same heights if the Earth had a flat surface. In Figure 3.2, compare the heights of the poles on a spherical surface as against a flat surface.

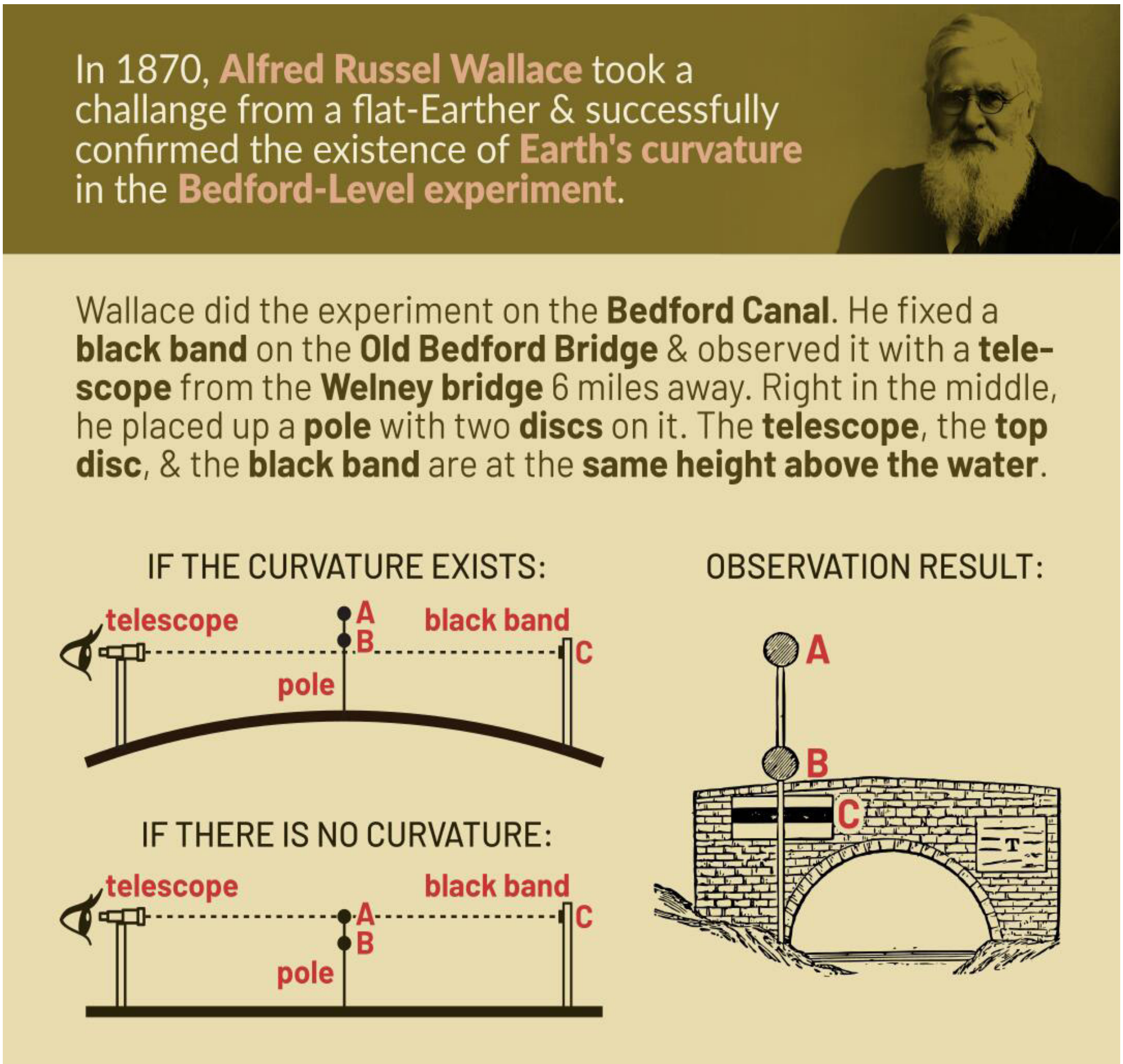
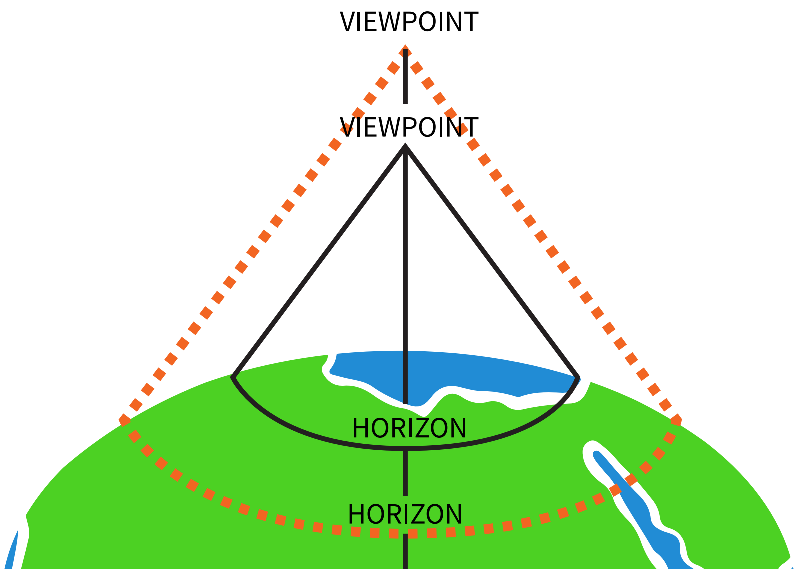


Fig. 3.2: Bedford Level canal experiments on a spherical and flat surface

Figure 3.2a depicts poles driven in the ground on a round surface as against 3.2b, those driven in the ground on a flat surface. Observe it and explain the difference. How does it help explain the spherical nature of the Earth?

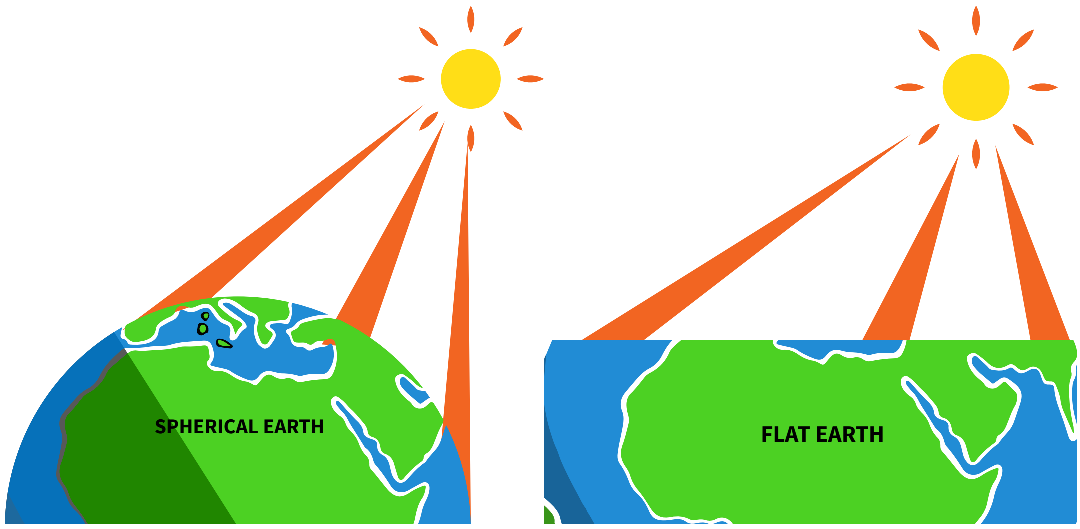
Circular horizon: This explains the curved horizon of the Earth. The horizon of the earth, viewed from any direction or elevation, such as a mountain or an airplane appears curved. This curved horizon widens as the height of the observer increases until it completely becomes circular. This curved horizon is proof that the Earth is a sphere.



Increasing altitude widens the circular horizon. Viewed from Y the horizon would be AB but from a higher viewpoint (X) a wider horizon (C, D) would be seen

Fig. 3.3: The curved horizon of the Earth

Sunrise and Sunset: Have you ever thought of why we have day and night or sunrise and sunset? It is caused by the rotation of the earth which has a link with the spherical nature of the Earth. The rotation of the Earth from the west to the east makes the sun rise from the east and set in the west. This implies that those in the east will see the sun before those in the west. This also causes day and night at different places on the earth. It indicates that the earth is spherical. If it were flat, all parts would have seen the sun at the same time. Figure 3.4 helps to explain it further.



(a) Sun rises and sun sets at different times for different places (b) The whole world will have sun rise or sun set at the same time

Fig. 3.4: Sunrise and sunset on rounded and flat surfaces

On the round surface, there is darkness and light at two different places but on the flat surface, there is light throughout.

Lunar eclipse or Eclipse of the Moon: Have you heard of an eclipse of the Moon or that of the Sun before? The eclipse of the Moon helps explain the spherical nature of the Earth. During the eclipse of the moon, the Earth comes between the sun and the moon. The shadow of the Earth, which is cast or reflected on the moon, is round. It is an indication that the Earth is circular because only circular shapes cast a round shadow.

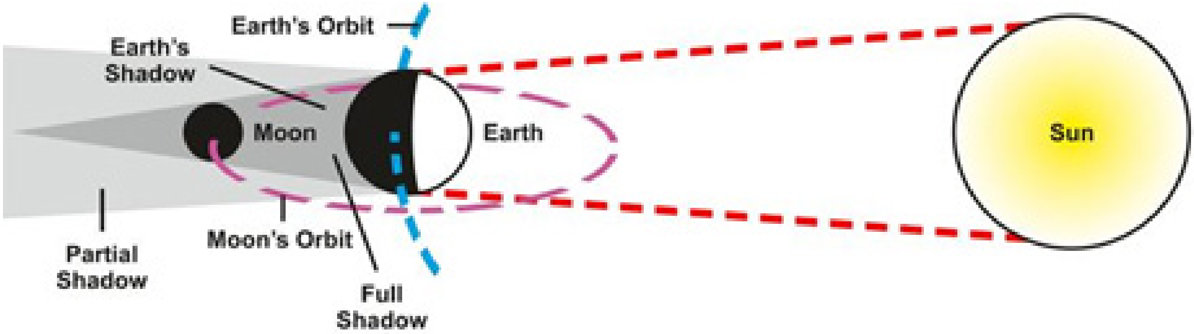


Fig. 3.5: Eclipse of the moon

Satellite images or Aerial Photographs: Moreover, aerial photographs taken by artificial satellites at great distances from the Earth all show that the Earth's surface is curved. Only spherical objects could give these curved shapes. Some of the photographs were taken by Apollo Spacecraft in 1968 (Apollo 8) and 1972 (Apollo 17).

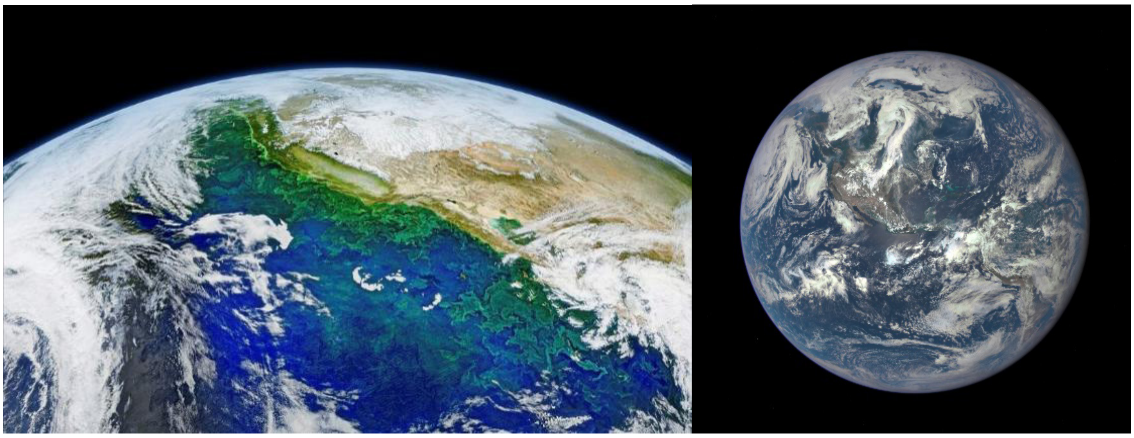
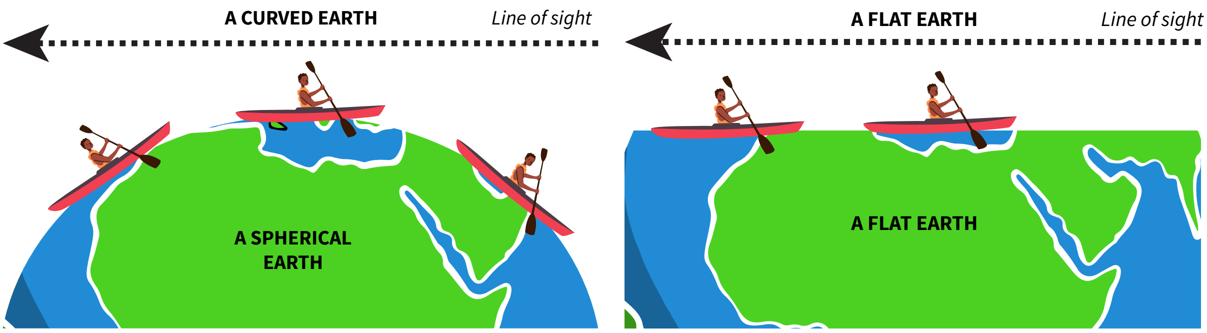


Fig. 3.6: Aerial or satellite photograph showing the round or spherical nature of the earth

Ship's visibility: When an observer stands at the coast to observe a ship approaching the shore, the mast of the ship will be seen first before the whole body of the ship appears. Two ships approaching the shore from the sea are both visible at the same time. The ship in front appears to be an observer before the one behind. If the Earth was not spherical but flat, both ships would appear at the same time. Furthermore, the observer at the shore watching the approaching ship would first see its mast, then the deck, and finally the entire hall. This is evidence to demonstrate the spherical shape of the earth. The observer would have seen the entire ship if the Earth was flat.



(a) The mast of a ship is seen before the hull on curved horizon. (b) A flat earth, the entire ship is seen at once on a flat surface

Fig. 3.7: Visibility of ships from a spherical Earth as against a flat Earth

Planetary bodies: All the other planets in space are round and the Earth being one of them must also be round.

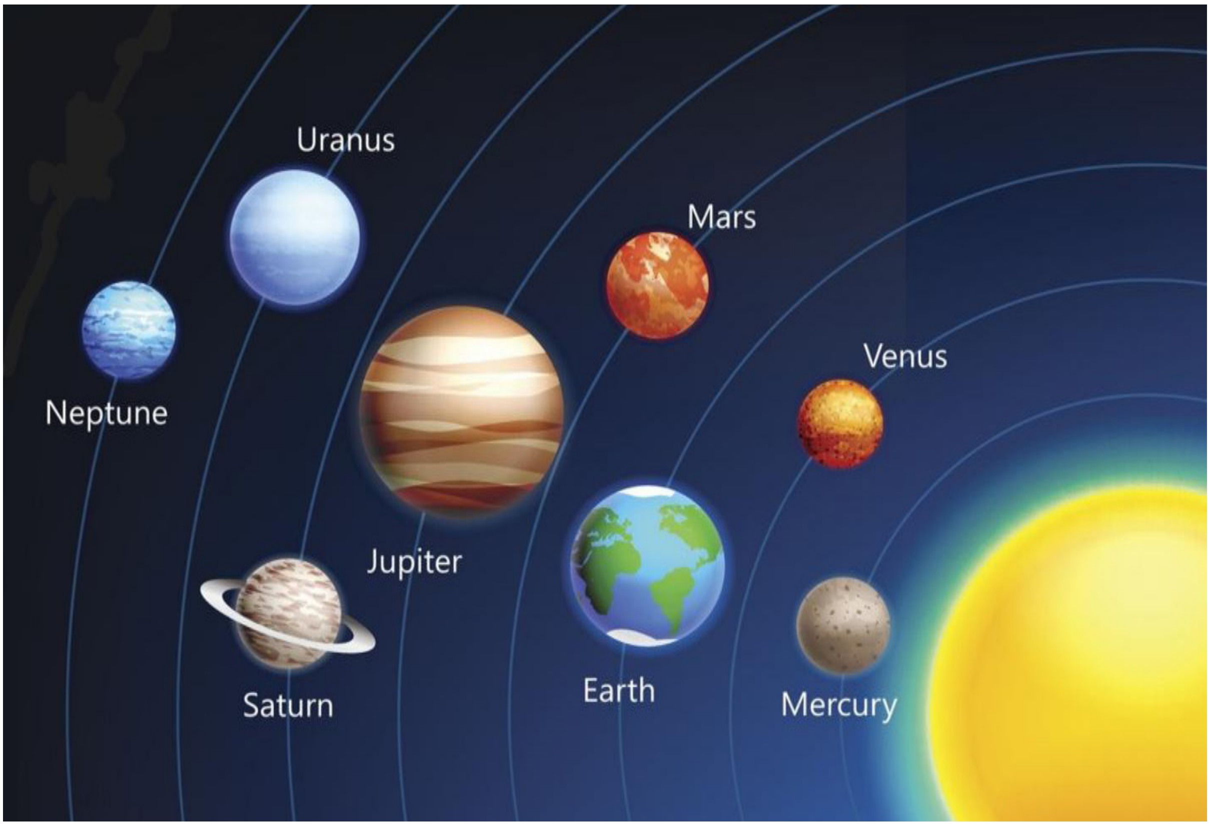
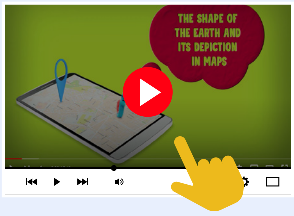
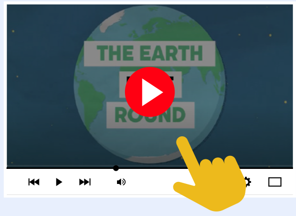


Fig. 3.8: Spherical nature of the Earth and other planets

Activity 3.3

1. Click on the links below and write a brief description of the evidence of the spherical Earth. Share your observations with a friend.





If you cannot access the video, check your school or local library or look for an internet café near your home.

2. Use a watermelon, two toothpicks and a torch (as the Sun). Stick the toothpicks into the upper side of the watermelon, one inch apart. Put the torchlight towards the toothpick and determine the length of the shadow. Write down your experiment and explain in your conclusion how the length of the shadow shows that the earth is curved.
3. Go to an open outdoor space, preferably a flat plane with no obstructed view, or a large body of water as it provides a better view without obstructions. Observe the surface of the Earth and the sky from a distance and describe the Earth's horizon as evidence to prove the shape of the Earth.
4. Explain, using diagrams, how the sunrise and sunset help prove the Earth is not flat.

   For this activity, draw two diagrams. One to show how the rotation of the Earth causes places to experience sunrise and sunset at different times and another to show the condition that would exist if the Earth were flat. Remember to explain why one side of our Earth is always dark yet rotation constantly changes which places experience darkness.
5. Explain, using diagrams, why early sailors knew the Earth was not flat.
   For this activity, only one of the proofs from the section above is needed with diagrams, either circumnavigation or visibility of ships approaching the shore.

EARTH'S ROTATION AND REVOLUTION

Movement of the Earth: The Earth undergoes two movements, namely, rotation (spin) and revolution (orbit).

Rotation of the Earth: This is the spinning or movement of the Earth around an axis. The spin is from west to east. Imagine looking down from space directly onto the North Pole, the Earth's spin is anticlockwise. The Earth's axis is an imaginary line passing through the North and South Poles. The Earth's axis is tilted at an angle of 23½° to the vertical plane. It takes 24 hours (one day) for the Earth to complete one rotation.

Visit this link for further reading or explanation on the rotation of the Earth.

If you cannot access the link, check your school or local library or look for an internet café near your home.

Effects of Earth's rotation

1. Day and night

The rotation of the Earth causes day and night. One side of the Earth always faces the Sun. This is our day. One side of the Earth always faces away from the Sun. This is our night. Due to the Earth's rotation from west to east, places on the Earth move in and out of the light and dark sides. This gives us the cycle of day and night. At the start of the day, the Sun always appears in the east. Sunrise occurs when the part of the Earth where you live rotates to face the Sun. At the end of the day, the Sun always sets in the west, marking the moment when your location turns away from the Sun. This regular rotational cycle results in the 24-hour day-night pattern that we observe.

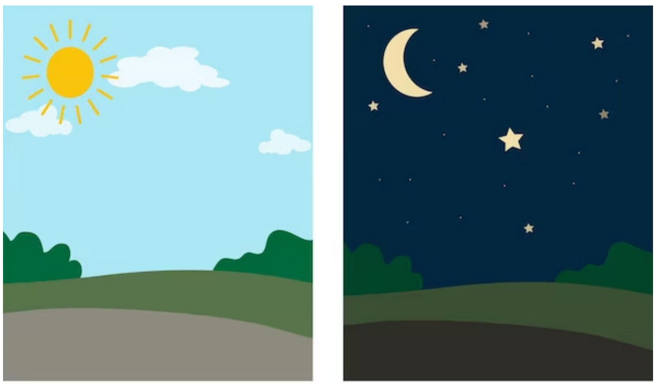


Fig. 3.9: Day and Night

Ghana is near the Equator. At the Equator, the length of night and day is nearly equal all year round – 12 hours a day, 12 hours a night. The variation in the length of day and night in other places on the Earth is caused by a combination of the tilt of the Earth's axis and orbit around the Sun.

2. Difference in time from place to place

The Earth is divided into 24 time zones, each covering 15 degrees of longitude. In each zone the times follow a 24-hour cycle, but they are calculated by subtracting hours before or behind the Prime Meridian (a line of longitude 0° which runs through Ghana). Time zones move together with the Earth's rotation. For example, if it is daytime in Ghana it is night in Japan due to the differences in their global position. Ghana is facing the Sun while Japan faces away from the Sun. Rotation means each place has a different solar time. For example, every place on the Ghanaian coast has a different solar time. This is not good when scheduling bus or train times or even the working day. We need time zones to rationalise solar time so business, trains, and buses can run in a coordinated way. Ghana has one time zone, making the time the same for the whole country whether you are on the coast in Accra, Cape Coast or Sekondi-Takoradi or further north in Tamale.

3. Deflection of winds and ocean currents

As the Earth rotates, its surface moves faster near the Equator than at the poles. This difference in rotational speed causes moving air masses and water currents to be deflected to the right in the Northern Hemisphere and the left in the Southern Hemisphere. That is why winds and sea waves do not move in a straight course but in an oblique or tilted manner.

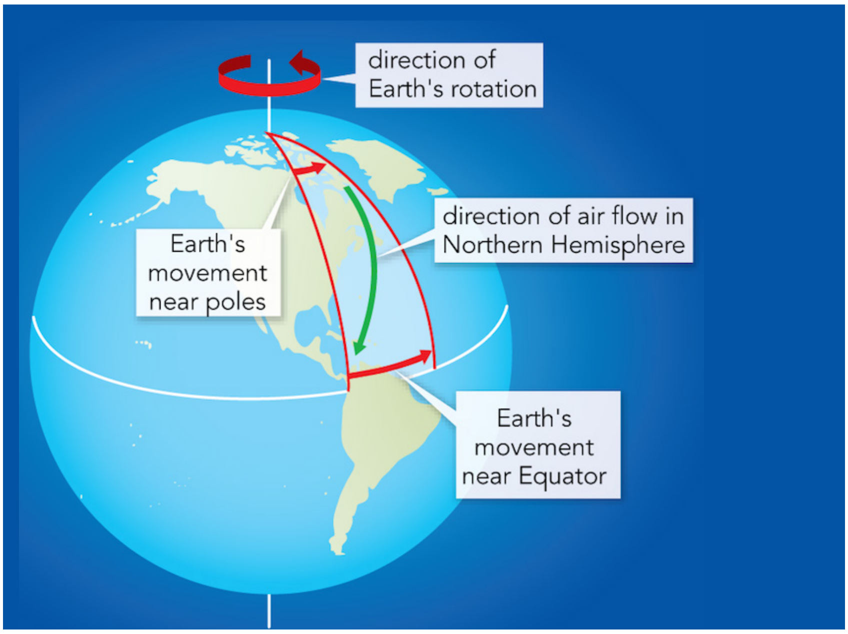


Fig. 3.10: Deflection of winds in the Northern Hemisphere

The wind changes direction as it moves from one location to the other due to the rotation of the Earth.

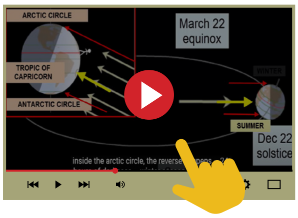
4. Daily rising and falling of tides

Coastal areas experience the daily rising and falling of tides due to the combined gravitational forces of the Moon and the Sun, as well as the Earth's rotation. A practical example is observing high and low tides at the beach. When it is high tide, the water level is at its highest point, covering more of the shore. As the Earth rotates, different coastal regions move into alignment with the gravitational forces, resulting in the cyclic rise and fall of tides throughout the day. This explains why there are high tides towards the evening and throughout the night when the moon is out.

5. Dawn and Twilight

One practical example of the effect of the Earth's rotation on dawn and twilight is stargazing. During the transition from night to day, or from day to night, the sky gradually brightens or darkens, respectively. This gradual illumination and dimming of the sky is known as dawn and twilight. By observing the sky during these periods, you can witness the changing colours and brightness as the sunlight scatters and bends in the Earth's atmosphere due to its rotation.

Visit the link below to watch a video on the rotation of the Earth.



If you cannot access the video, try using an orange with a straw through the middle to represent the axis. When rotating the orange make sure the axis is tilted and it goes round from west to east. That is anticlockwise when viewed from the top.

REVOLUTION OF THE EARTH

The revolution of the Earth is the movement of the Earth in its orbit around the sun. The Earth's axis is tilted at an angle of 66½° to the plane of orbit around the Sun. It takes the Earth 365¼ days to complete one revolution around the Sun and this marks a year. A calendar or normal year is 365 days while a leap year is 366 days. Do you understand how a leap year occurs? In every four years, one day is added to 365 days (¼ × 4) to make 366 days. As the Earth revolves around the sun every year, ¼ (6 hours) of a day is added to the 365 days to accumulate and make one day within four years. Thus, every fourth year of the revolution, there is a leap year which is 366 days.

Effects of the revolution on the Earth

1. It determines the length of a year

One complete revolution around the Sun takes approximately 365¼ days. This duration defines the time it takes for the Earth to complete its orbit and return to the same position relative to the Sun. The concept of a year is essential for calendars, agricultural cycles, and various cultural and religious celebrations.

2. It causes the four seasons

The revolution of the Earth, combined with its axial tilt, leads to the occurrence of the four seasons globally: spring, summer, autumn, and winter. In Ghana and West Africa, the four seasons are not experienced. This is because West Africa, and for that matter, Ghana lies in the tropics. In this area, including Ghana, due to the tropical or equatorial effect, the climate is tropical.

Tropical climates in general have two seasons, a wet season and a dry season, rather than the four seasons which is typical of temperate regions. Therefore, Ghana experiences the wet and dry seasons. As the Earth orbits the Sun, different parts of the Earth receive varying amounts of sunlight. During the wet season in Ghana, the weather becomes warm with much rainfall. This is because there is more direct sunlight, resulting in warmer temperatures. In contrast, during the dry season in Ghana, there is less direct sunlight, leading to cooler temperatures with dry conditions. The period with severe dry conditions is referred to as harmattan, mostly from December to January

3. It causes varying lengths of days and nights

As the Earth orbits the Sun, the tilt of its axis remains constant. However, different parts of the Earth receive varying amounts of sunlight at different times of the year. This mostly occurs in the temperate regions where the tilt is more pronounced. In tropical regions like West Africa, including Ghana, this is not well experienced since the Sun is almost always overhead. Thus, during the wet season, the hemisphere that is tilted towards the Sun experiences longer days and shorter nights. In contrast, during the dry season, the hemisphere that is tilted away from the Sun experiences shorter days and longer nights.

4. It determines changes in the position or altitude of the Sun

As the Earth orbits the Sun, the tilt of its axis causes the Sun's position in the sky to change throughout the year. For example, during the wet season in West Africa in a particular hemisphere, the midday sun appears higher in the sky, leading to longer daylight hours and more direct sunlight. In contrast, during the dry season, the midday sun appears lower in the sky, resulting in shorter daylight hours and less direct sunlight. These changes in the altitude of the midday sun impact solar radiation, temperature distribution, and plant growth patterns.

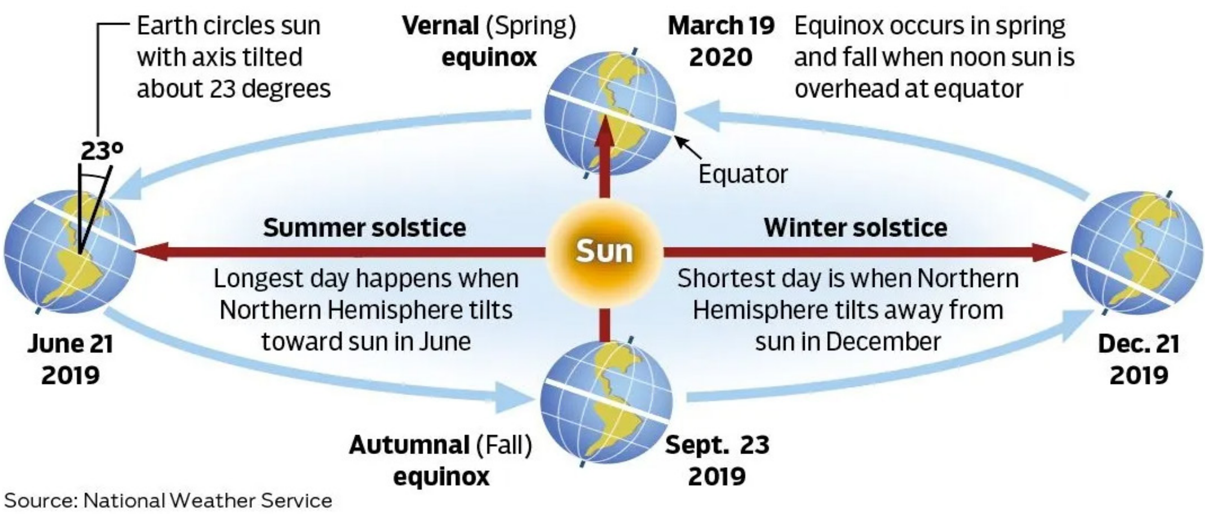


Fig. 3.11: Equinoxes and Solstices

The changes in the position of the midday sun at different times of the year causes differences in seasons such as wet and dry season in Ghana and West Africa. This is due to changes in the amount of sunshine.

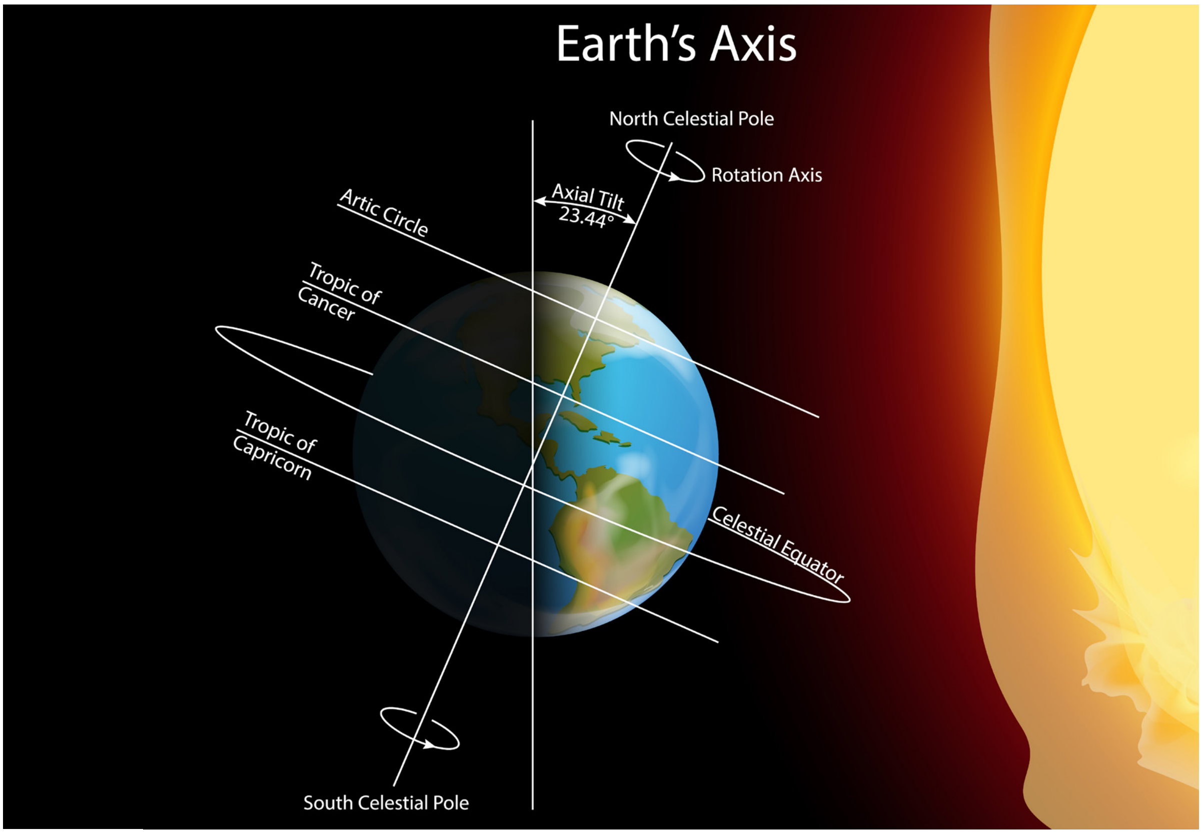


Fig. 3.12: The inclination of the Earth on its axis and orbit

Activity 3.4

1. Place a globe or spherical object representing the Earth on a table. Use a flashlight or a lamp to represent the Sun. Shine the light on the Earth from one side to demonstrate daylight and the opposite side to show night. Slowly rotate the globe on its axis while keeping the light source in the same position.

   Note: As the Earth rotates, different parts of the planet are exposed to sunlight, creating day in those regions while other parts experience night.
2. Observe and record the length and direction of shadows cast by any objects at various times of the day throughout the year. Then analyse the changes in shadow length and direction, to gain insights about the Earth's revolution and its effects on the position of the Sun in the sky.
3. Use a globe or any spherical object and a flashlight. Mark the centre or the middle of the spherical object as the equator and tilt it at an angle to represent the Earth's axial tilt. Then observe how the angle of the light changes as they revolve the globe around the flashlight to mimic the Earth's

revolution. Take notes on how the changing angle of sunlight helps you to explain the wet and dry seasons in Ghana and West Africa (the revolution of the Earth and seasonal changes).

ECLIPSE

- An eclipse is formed when three bodies, the Sun, the Earth and the Moon, are in a straight line during the movements (rotation and revolution) of the Earth.
- The Moon revolves around the Earth once every 27 days.
- The Earth and the Moon move together to complete one revolution around the Sun.
- During these movements, there comes a time when the Sun, the Earth and the Moon will be in a straight line, resulting in the formation of an eclipse.

Types of eclipse

1. Eclipse of the Sun (Solar Eclipse)

This occurs when the Moon comes between the Sun and the Earth, blocking of the Sun's ray from reaching the Earth's surface, thereby causing partial or total darkness on the Earth. It occurs during the day.

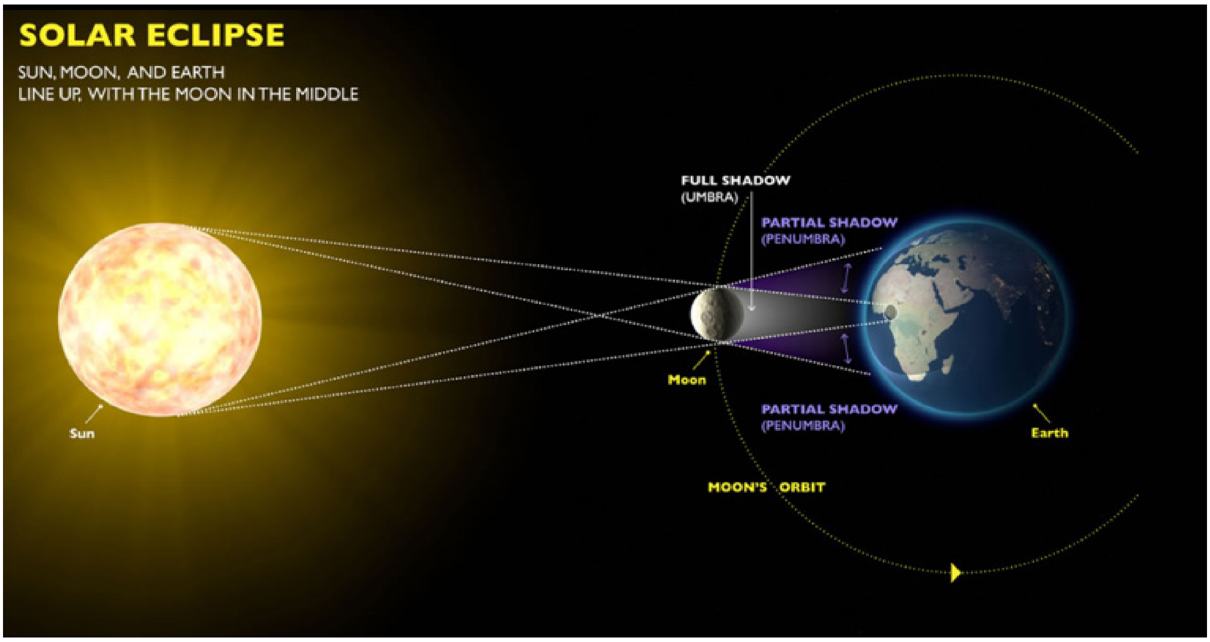


Fig. 3.13: Eclipse of the Sun

2. Eclipse of the Moon (Lunar Eclipse)

This occurs when the Earth comes between the Sun and the Moon which blocks the Sun's rays from reaching the Moon.

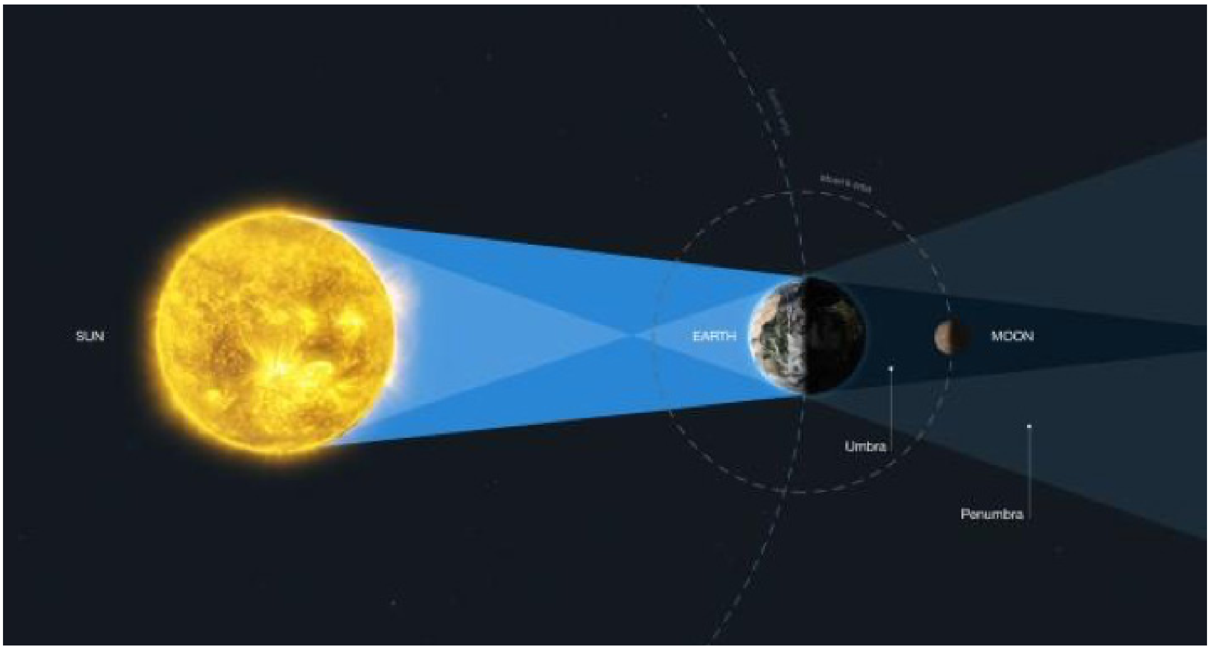
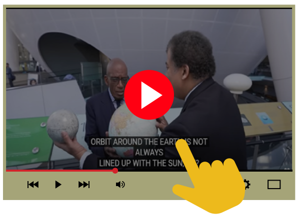


Fig. 3.14: Eclipse of the Moon

Visit this link for a video on solar and lunar eclipse



If you cannot access the video, check your school or local library or look for an internet café near your home.

Activity 3.5

1. Create physical models of the Earth, Moon, and Sun to illustrate the occurrence of eclipses and then simulate the alignment and shadowing effects using materials such as balls, lamps, and a light source.
2. Conduct a shadow play activity to help you understand the concept of an eclipse. With a flashlight representing the Sun, a small ball for the Moon, and a larger ball for the Earth, you can move the Moon around the Earth to observe the shadow effects on different parts of the Earth's surface to illustrate the eclipse of the Sun and Moon, respectively.

LATITUDES AND LONGITUDES

Latitudes are imaginary horizontal lines on the Earth's surface measured in degrees from the centre of the Earth's surface to the North and South Poles, starting from the line called the Equator which is the Earth's largest circumference, also called Latitude 0°. The North Pole is 90° from the Equator (90°N) and the South Pole is 90° from the Equator, (90°S). These imaginary lines on the surface of the Earth run parallel north and south of the Equator. Latitudes divide the Earth into two hemispheres, North and South. Because they are the same distance apart, they are also called Parallels. Some of the important lines of latitudes are the Equator, Tropic of Cancer and Tropics of Capricorn among others

Longitudes are imaginary vertical lines on the Earth's surface measured in degrees East and West of the Greenwich or Prime Meridian. Lines of longitude run from the North Pole to the South Pole. Longitudes West and East of the Greenwich Meridian increase in value to a maximum of 180°. This divides the Earth into two hemispheres, West and East. All longitudes have either E or W after their measured angle (20°W, 40°E for example) except at their meeting point at 180°, which is the International Date Line. Lines of longitude are also called Meridians. The Greenwich Meridian is called the Prime Meridian because it is the starting point of longitudes. Unlike latitudes, lines of longitude get closer together as they converge the Poles making the Earth look like the segments of an orange.

Lines of latitude and longitude are used to locate places on the Earth's surface. By using latitudes and longitudes as coordinates, we can determine the precise location of any point on the Earth's surface.

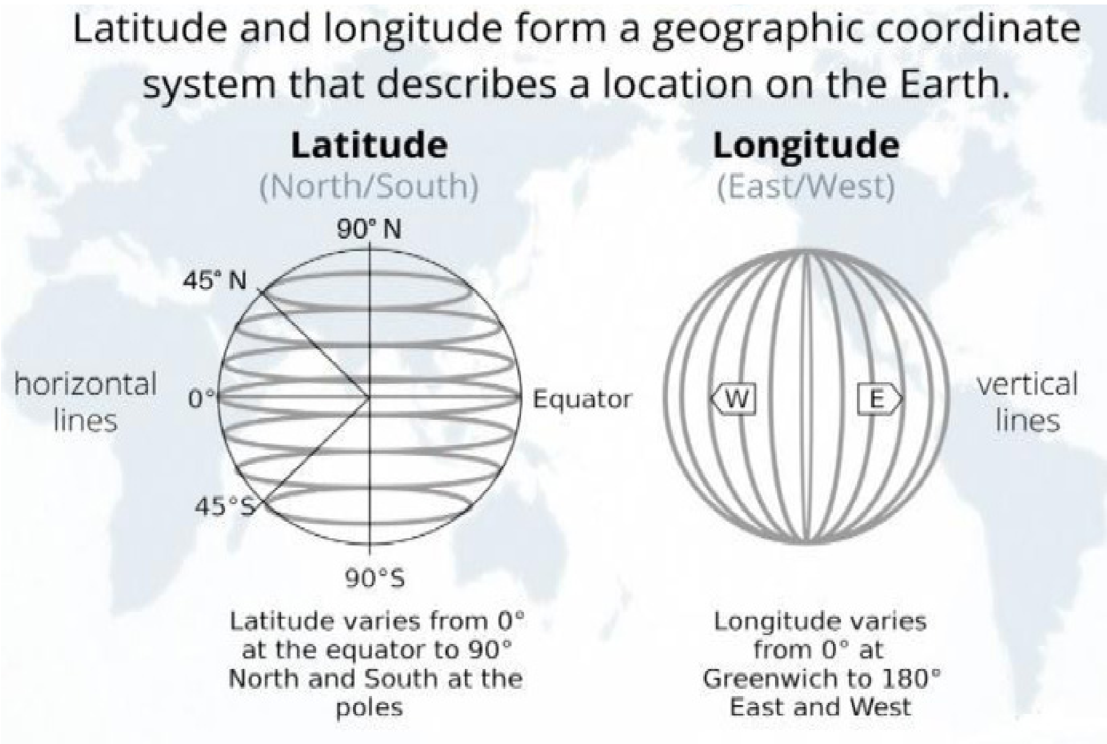


Fig. 3.15: Latitudes and Longitudes (Helmenstine, 2023)

Characteristics of Latitudes

1. They are measured in degrees, North and South of the Equator to a maximum of 90°.
2. They are also known as Parallels.
3. They are imaginary lines that run horizontally from West to East on maps or globes.
4. The circumference or the length of latitudes decreases from the equator towards the poles.
5. They are used in calculating linear distances on the Earth's surface.
6. The equator divides the earth into two equal hemispheres or halves, thus forming a great circle.

Important Lines of Latitude

1. North Pole (90°N)
2. Arctic Circle (66½°N
3. Tropic of Cancer (23½°N)
4. Equator (0°)
5. Tropic of Capricorn (23½°S)
6. Antarctic Circle (66½°S)
7. South Pole (90°S)

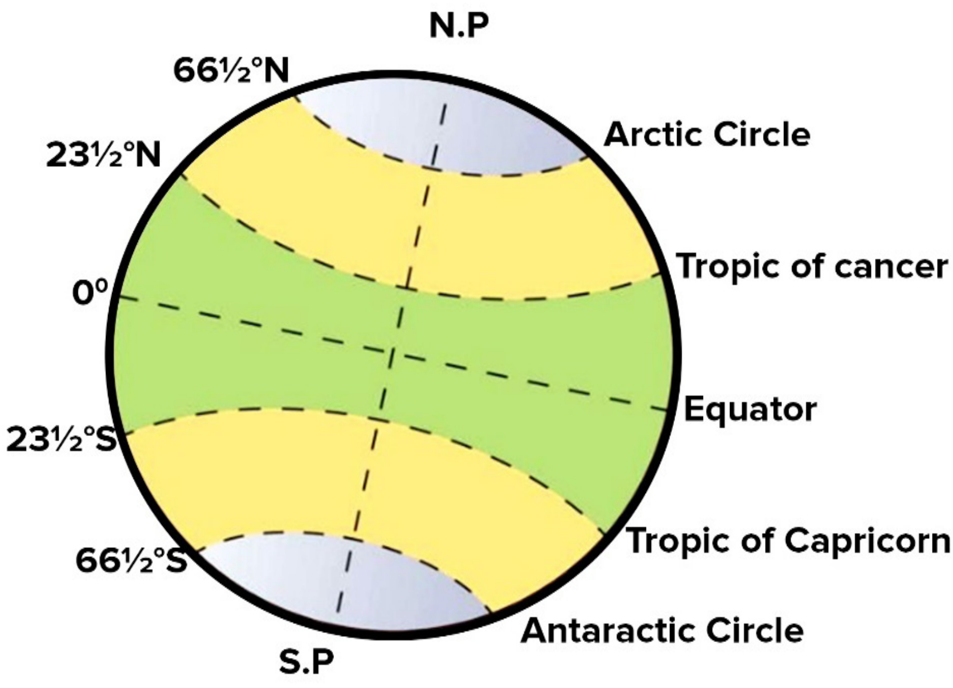


Fig. 3.16: Major lines of latitudes

Usefulness of latitudes

1. They are used in calculating linear distances on the Earth's surface.
2. They combine with longitudes to give the absolute location of a place.
3. They help when dividing the Earth into climatic zones.
4. Aircraft pilots use them when navigating their course.

Characteristics of Longitudes

1. They are measured in degrees, West or East of the Greenwich Meridian to a maximum of 180°.
2. They are also known as Meridians or mid-day lines.
3. They run from the North Pole to the South Pole.
4. They converge at the poles.
5. They are imaginary lines.
6. Two opposite longitudes divide the earth into two equal hemispheres, thus forming a great circle.
7. Each set of lines of longitude forms a semicircle.
8. They are farthest apart from each other at the equator but close or meet at the poles

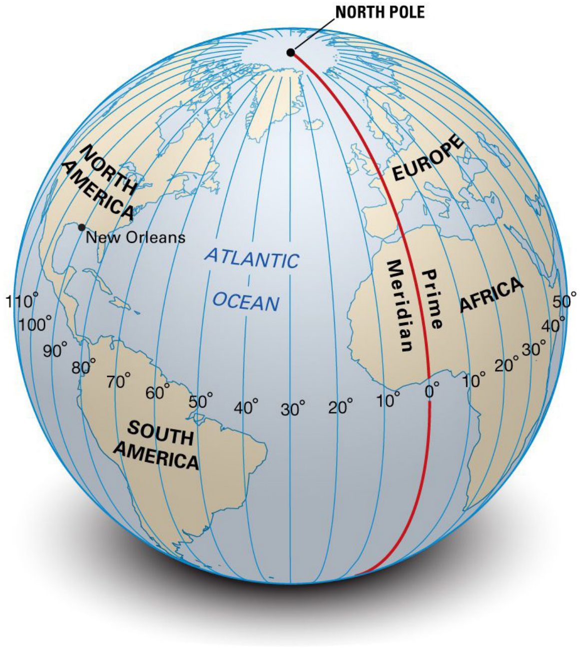


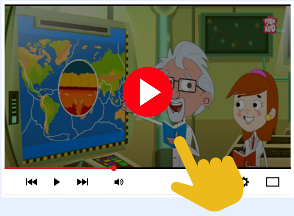
Fig. 3.17: Lines of longitude

The usefulness of lines of longitudes

1. They are used to find local time between two places.
2. They form great circle routes which are used in navigation by air and sea.
3. They combine with latitudes to give the absolute location of a place.

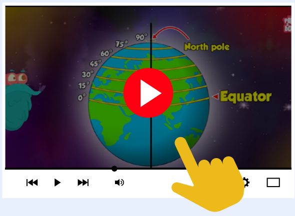
Activity 3.6

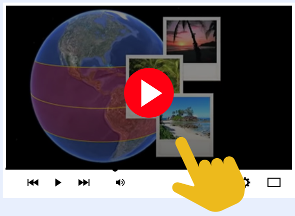
1. Visit the link below to watch a video on longitudes and latitudes



If you cannot access the video, check your school or local library or look for an internet café near your home.

2. Visit the link below to watch a video on the difference between longitudes and latitudes





If you cannot access the video, check your school or local library or look for an internet café near your home.

3. Use online maps like Google Earth or MapQuest to explore and interact with latitude and longitude coordinates.

   If you cannot access the online map, check your school or local library for an atlas or investigate an internet café near your home.

4. Sketch a large world map and label the lines of latitudes and longitudes.
5. (a) Use a world map or draw the globe. On it, locate and label the:
   - i. Equator or Latitude 0°
   - ii. Tropic of Cancer or Latitude 23.5°N
   - iii. Tropic of Capricorn or Latitude 23.5°S
   - iv. Arctic Circle or Latitude 66.5°N
   - v. Antarctic Circle or Latitude 66.5°S.

   (b) Colour or shade the regions between these lines to visualize the different zones.
6. (a) Draw a globe and indicate the following lines of latitude and longitude.

   (b) For this activity, try to partner with a friend or colleague.
   - i. 22°N and 45°E
   - ii. Greenwich Meridian
   - iii. 35°N and 139°E
   - iv. 51°S and 0°

CALCULATING DISTANCES USING LATITUDES AND TIME USING LONGITUDES

Distance: refers to the measure of how far apart two or more objects or locations are.

Distances along the same line of longitude can be calculated by working out the approximate distance in kilometres represented by one degree of latitude. Once this distance has been calculated and the difference in latitude is known then the distance can be determined.

Time: refers to the continuous progression of events and the measure of their duration.

Time differences between places can be calculated by working out the approximate time represented by one degree of longitude. Once the time represented by one degree is calculated and the difference in longitude is known then the time difference can be determined.

Calculation of Distances using Latitudes

Principle: Earth's POLAR circumference is approximately = 40,008km

if 360° = 40,008km

therefore 1° = 111.13 km (correct to 2dp)

The procedure used in calculating distances between two places at different latitudes on the same line of longitude

Locate the two places involved;

1. Find the difference in latitudes in degrees
   a. Where it is North-North, subtract (−)
   b. Where it is South-South, subtract (−)
   c. Where it is North-South or South-North, add (+)
   d. Where it is Equator (0°) to Northern Hemisphere/South Hemisphere, add (+)
2. Multiply the answer by 111.13 km to get the distance

Worked Examples within the same hemisphere

1. Calculate the distance between place 'X' on the equator and 'Y' on latitude 5°N.

Solution

Procedure 1: Locate places involved

Place 'Y' = 5°N

Procedure 2: Find the difference in latitudes

Difference in latitudes = 0° + 5°N

= 5°

Procedure 3: Multiply the answer by 111.13km to get the distance

Distance between Place X and Place Y

= 5 × 111.13km

= 555.65km (2dp)

2. Calculate the distance between two places on latitude "A" 23½°S' and "B"20°S.

Solution

Procedure 1: Locate places involved

Place 'A' = 23½°S

Place 'B' = 20°S

Procedure 2: Find the difference in latitudes

Difference in latitudes = 23½°S – 20°S

= 3½°

Procedure 3: Multiply the answer by 111.13km to get the distance

Distance between Place X and Place Y

= 3½ × 111.13km

= 388.96 km (2dp)

Worked Example within a different hemisphere

What will be the approximate distance between two countries that span latitudes 10°N and 8°S on the same longitude?

Solution

Procedure 1: Locate places involved

Country A = 10°N

Country B = 8°S

Procedure 2: Find the difference in latitudes

Difference in latitudes = 10°N + 8°S

= 18°

Procedure 3: Multiply the answer by 111km to get the distance

Distance between Place X and Place Y

= 18 × 111.13km

= 2000.34 km (2dp)

Note that this method cannot be used to calculate the distance between places on different lines of longitude.

Visit the link below to watch a video on calculating distances using Latitude

If you cannot access the video, check your school or local library for other worked examples or look for an internet café near your home.

Activity 3.8

1. How is distance calculation important to the following: navigation, flight planning, or long-distance athletes?
2. Draw a globe and indicate the Tropic of Cancer and the Tropic of Capricorn, indicating their latitudinal coordinates. Using their coordinates, calculate the distance between these two latitudes.
3. Practically demonstrate to a friend how 1° is equivalent to 111.13 km when calculating distances using Latitudes.
4. Using the Ghana map below, locate Accra on latitude 5°N and Wa on Latitude 10°N. Calculate difference in latitude. Use the difference in latitude to calculate the distance in kilometers. On a map the straight-line distance between Wa and Accra is 562 kilometres. Discuss the difference in your answer and the straight-line answer with your friends in class.

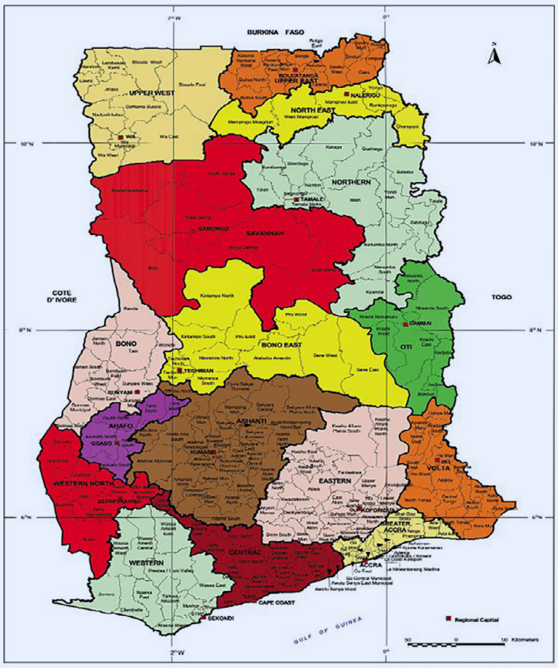


Fig. 3.18: Map of Ghana

Calculation of Time using Longitudes

Local Time/ Solar Time

Each Meridian has its local time. Since the Earth completes one rotation in approximately 24 hours, each hour corresponds to 15 degrees of longitude (There are 360 degrees in a full rotation (a circle) so 360 degrees / 24 hours = 15 degrees per hour or 15 degrees per 60 minutes). To work out the time difference for one line of longitude a simple calculation is done; 60 minutes / 15 degrees = 4 minutes per degree. Therefore, each degree of longitude represents a time difference of 4 minutes. The local time of places in the east is ahead of the local time of places in the west. This means that a country with a wider longitudinal extent may have different local times. To avoid confusion in the usage of time and date, Standard Time is applied.

Time Zones

The Earth is divided into 24 time zones, each representing 15° longitudinal extent with the Prime Meridian serving as the reference point. The time of places in the East is ahead of the time of places in the West.

Standard Time

This refers to the uniform time within a specific time zone that is commonly used as a reference for a region's clock and schedules. It is the time that is generally adopted by governments and organisations to create consistency and facilitate coordination within a particular geographic region. The chosen meridian is often called the standard meridian for that time zone and the time at this meridian is considered the standard time for the entire zone. Each standard time zone is defined by an offset from the Greenwich Mean Time (GMT) or Coordinated Universal Time (UTC). This offset represents the difference in hours between the Standard Time of the zone and GMT/ UTC. For instance, East African Time (EAT) in Kenya is UTC+03:00 which means it is three hours ahead of UTC. Countries such as Russia have 11 standard time zones ranging from UTC+2:00 to UTC+12:00.

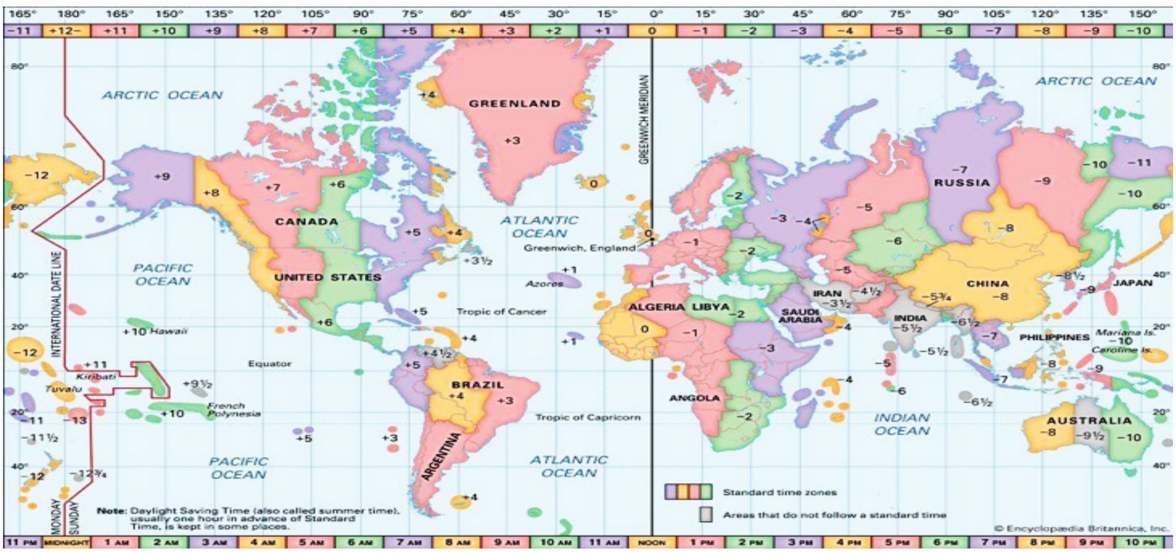


Fig. 3.19: GMT, UTC and Time Zones (Betts, 1998)

Greenwich Mean Time (GMT)

It is a time standard based on the mean solar time at the Prime Meridian, which passes through Greenwich, London. (The name Greenwich was named after the area called Greenwich in London hence Greenwich Meridian). The Greenwich Meridian also passes through Yendi and Tema in Ghana. The Prime Meridian (Longitude 0°) is the reference point and the time at this meridian is considered the baseline for GMT. It is important to know that GMT does not observe daylight saving time adjustments. In the UK, GMT is sometimes used to refer to standard time during the non-daylight-saving period while BST (British Summer Time) is used during daylight saving period.

The procedure used in calculating time differences between places

1. **Locate** the two places and their longitudes.
2. Find or calculate the **longitudinal differences** between the two places. Note that the rule is, if:
   a. the two given places are on the lines in the **same hemisphere** (i.e., both West or both East = Subtract **(–)**
   b. the two given places are the lines in **different/opposite hemispheres** (i.e. one east one west) = **Add (+)**
   c. one place is on **Greenwich Meridian (0°)** and the other is on a line in **Eastern Hemisphere or Western Hemisphere** = **Add (+) / Subtract (–)**
3. **Convert or change** the longitudinal differences to time.

   Note: 24 hours = 360°
   1 hour = 15°
   4 minutes = 1°

4. If the time at one place is known calculate the difference in latitude between the two places and convert this to hours and minutes. To calculate the different time, use the hours and minutes and add or subtract it from the known time. If the place is to the **EAST** of the known time add the hours **(Gain/Add/Ahead of time)** and if it is to the **WEST** subtract **(Loss/Subtract/Behind time)**

   For example, London on the Greenwich Meridian at 6pm GMT will always be behind the time of any places to the East and ahead of the time of any places to the West. So, if it is 6pm GMT in London and New York is 5 hours to the West then it will be GMT minus 5 hours, so it is 1pm. Berlin, to the East of London has a time difference of 1 hour so it will be GMT plus 1. The time in Berlin would be 7pm.

Worked Examples

1. The longitude of Station X is 0°and that of Station Y is 45°E.
   a. Is Station Y ahead or behind Station X and by how many hours?
   b. Calculate the time of Station Y if the time at Station X is 3 pm.

Solution:

Longitude of Station X = 0°
Longitude of Station Y = 45°E
Longitudinal Differences = 45° – 0°
= 45°
But 15° = 1 hour (60minutes)
Therefore 45° = $\frac{45°}{15°}$
Therefore, time difference = 3 hours
Time at Station X = 3 pm
Time at Station Y = 3 pm + 3 hours **(since Station X is on the Greenwich Meridian and Y is to the East of Station X, it is ahead of time, so the rule is to add the hours)= 6 pm**
Therefore, the time at Station Y is **6 pm**

Calculating Time Using Longitudes (Same Hemisphere):

2. Find the local time in Town X, on longitude 70°E, when the time in Town Y, longitude 15°E is 5 pm.

Solution:

Longitude of Town X = 70°E
Longitude of Town Y = 15°E
Longitudinal Differences = 70° – 15°
= 55°
But 15° = 1 hour
Therefore 55° = $\frac{55°}{15°}$
= 3 hours and 10°
But 1° = 4 minutes
Therefore 10° = 10 × 4 minutes
= 40 minutes
Therefore, time difference = 3 hours 40 minutes
Time at Town Y = 5 pm
Time at Town X = 5 pm + 3 hours 40 minutes **(since Town X is ahead of Town Y, the rule is adding the hours) = 8:40 pm**
The local time at Town X is **8:40 pm.**

Calculating Time Using Longitudes (Different Hemispheres):

3. If John in Thailand, 100°E telephones a friend in Liberia, 10°W on Monday, 11th August 2015 at 5 am, calculate the time and date that the friend will receive the call.

Solution:

Longitude of Liberia	= 10°W
Longitude of Thailand	= 100°E
Longitudinal Differences	= 10° + 100°
	= 110°
But 15°	= 1 hour
Therefore 110°	$= \frac{110°}{15°}$
	= 7 hours and 5°
But 1°	= 4 minutes
Therefore 5°	= 5° × 4 minutes
	= 20 minutes
Therefore, time difference	= 7 hours 20 minutes
Time at Thailand	= 5am
Date in Thailand	= Monday, 11th August 2015
Time at Liberia	= 5 am – 7 hours 20 minutes **(since Liberia is west of Thailand and behind it in time, SUBTRACT) = 9:40 pm**

(Be careful because things get tricky when you reach midnight. To reach midnight working backwards from 5am only takes up 5 hours of the 7hours 20minutes. Thailand has already passed midnight and that means they are in a new day, Monday. Taking the remaining 2 hours and 20 minutes from midnight shows that Liberia has not quite reached the new day, so John's friend is still having fun on Sunday)

So the date in Liberia = Sunday, 10th August 2015

John's friend will receive the call **9.40pm, Sunday 10th August 2015**

4. A football match is being played at 6:00 pm (18:00 GMT) in Town Y, which lies on Longitude 125°E. If this match is being telecast live across the world, at what time will people in Town T, which lies on Longitude 120°W watch the match?

Solution:

Longitude of Town Y	= 125°E
Longitude of Town T	= 120°W
Longitudinal Differences	= 125°+ 120°= 245°
But 15°	= 1 hour
Therefore 245°	$= \frac{245°}{15°}$
	= 16 hours and 5°.
But 1°	= 4 minutes

Therefore, 5° = 5° × 4 minutes
= 20 minutes
Therefore, time difference = 16 hours 20 minutes
Time at Town Y = 6 pm (18:00 GMT)
Time at Town T = 6 pm 18:00 GMT – 16 hours 20 minutes **(since Town T is west of Town Y, and behind in time subtract)** = **1:40 am**

Therefore, people in Town T which lies on longitude 120°W will watch the match at **1:40 am**.

Calculating Longitudes Using Local Time of Places:

Procedure:

1. Locate the two given places.
2. Find the time differences.
3. Multiply the time differences by 15° or 1° to get the longitude difference in degrees.
4. Calculate the longitude to the West or East. **Subtract the known longitude from the difference in degrees if the time is earlier (west)** or add if it is later (east). Make sure you take account of the moving across the Greenwich Meridian when stating your calculated longitude to be East or West.

Ask your teacher to explain the following examples if you do not understand them.

Worked Examples

1. Find the Longitude of Town A whose local time is 9:00 am when it is 4:00 pm the same day in Town B, 30°E.

Solution:

Note: 4:00pm is ahead of 9:00 am so that means Town B (30°E) is to the East of Town A.

Time at Town A = 9:00am
Time at Town B = 4:00pm
Time Differences = 94:00 am – 00 pm (09:00 GMT to–16:00 GMT)
= 7 hours
But 1 hour = 15°
Therefore 7 hours $= \frac{7 \text{ hours}}{1 \text{ hour}} \times 15°$
= 105°

So added together the longitudes A and B must be 105°.

This represents 7 hours' time difference.

A + B = 105°

Longitude of Town B = 30°E

A + 30° = 105°

So, A = 105° − 30°

Therefore, the Longitude of Town A = 105° − 30° (this applies the subtract rule since the time in town A is behind (earlier than) the time in town B on the same day) = 75°

Working from town B (30°E) westwards, you reach the Greenwich Meridian after 30 degrees and move into the western hemisphere. The longitude of town A must be in the western hemisphere. Therefore, the longitude of Town A is **75° W.**

2. If the local time in London, 0° is 12 noon and the time in Dhaka (Bangladesh) is 6pm, what is the longitude of Dhaka?

Solution:

Note: time in Dhaka (6:00pm) is ahead of London's time (12:00 noon), so Dhaka is at the East of London, 0°.

Time in London = 12:00 noon

Time in Dhaka = 6:00 pm (18:00 GMT)

Time Differences between countries

= 18:00 GMT – 12:00 noon

= 6 hours

But 1 hour = 15°

Therefore 6 hours $= \frac{6 \text{ hours}}{1 \text{ hour}} \times 15°$

= 90°

Longitude of London = 0°

Longitude of Dhaka = 0°+ 90° (Since Dhaka is to the East of London, apply the Add) = 90°E

The Longitude of Dhaka is **90° E**

International Date Line (IDL)

IDL is an imaginary line that approximately follows the 180° longitude. It passes through the Pacific Ocean. It serves as the demarcation line between two consecutive calendar days. IDL is not a straight line but deviates (it is zigzag) to accommodate political and territorial boundaries. This is to ensure that certain countries or island groups remain within the same day. A traveller crossing the dateline from east to west (right to left) loses a day while crossing the dateline from west to east (left to right) gains a day. For example, when it is midnight, Sunday on the Asiatic side, by crossing the line eastwards, he/she gains a day; it will be midnight Saturday on the American side.

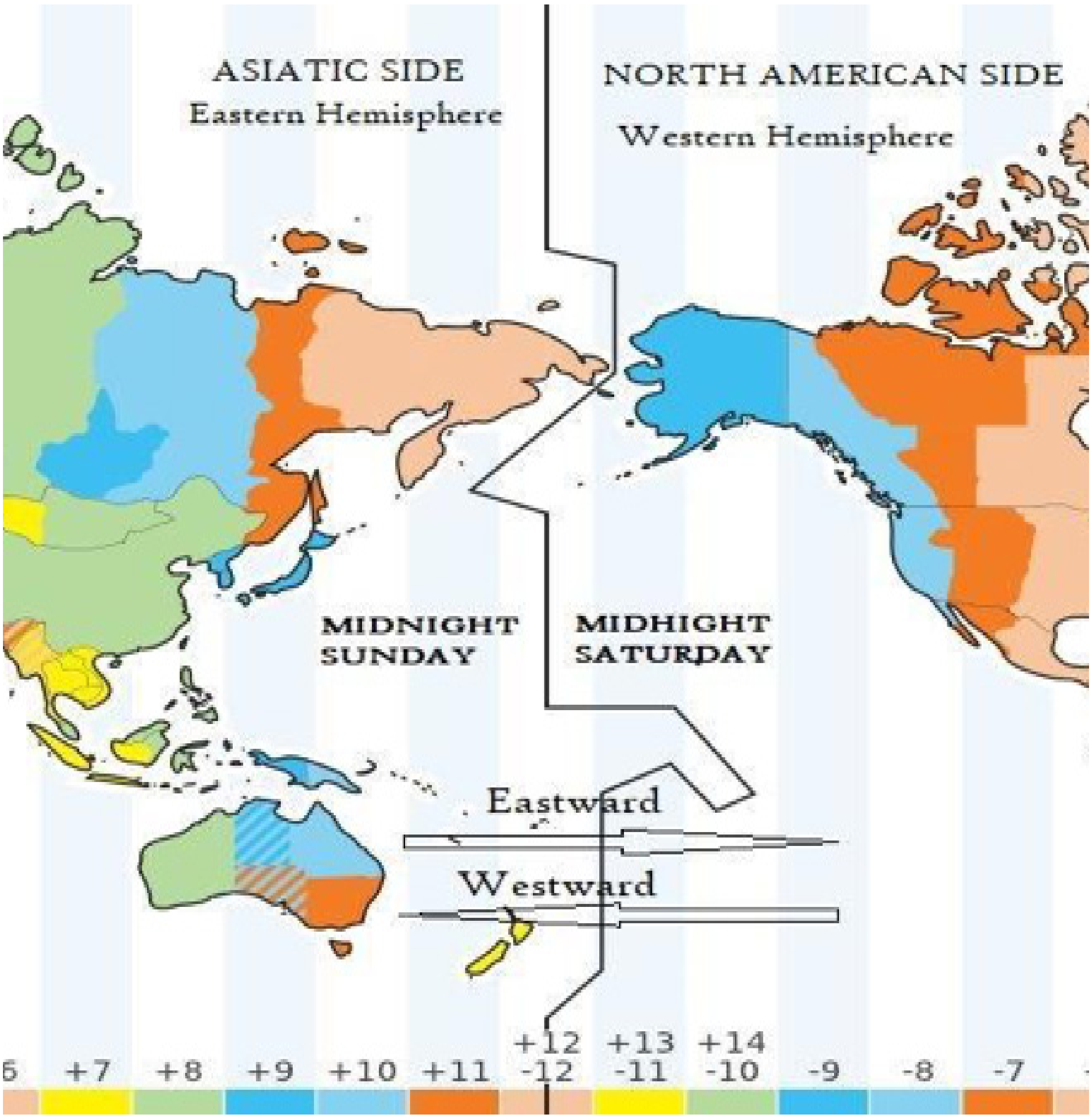


Fig. 3.20: International Date Line (Gonzales, 2015)

Note: *Losing or gaining a day when one crosses the IDL westward or eastward respectively, is paradoxical. For instance, when the traveller crosses the dateline eastward thus from Sunday to Saturday, he/she will have another Sunday to relive.*

Activity 3.9

1. How will you explain to a friend in your geography class, the process or procedure used in calculating time between two places at different longitudes? Write the procedure in an orderly manner in the exercise book and explain the rules to your friend.
2. An international football match between Nigeria and Sierra Leone is scheduled for 4:45 pm local time on Saturday in Port Harcourt, Nigeria (Longitude 7° E). Calculate the local time that the football fans in Freetown,

Sierra Leone (longitude 13°W) can tune in their radio sets for the match commentary.

3. If a place has 30°N and 90°W as its absolute location, how will you explain it to your friend?
4. The following are friends but lived in different cities
   a. Alice: She will be in New York City (longitude: -74° W).
   b. Bob: He will be in Tokyo (longitude: 139° E).
   c. Amina: She will be in Tema (longitude: -0°).
   d. Sulley: He will be in Sydney (longitude: 151° E).
   e. Dede: She will be in Cape Town (longitude: 18° E).

Now your tasks:

a. Calculate the time in each city when it is noon GMT.
b. The friends want to chat together on a video call. Which two friends might be too late to take part in the call?

Clue: If it is noon GMT, what time is it in New York City?

Given the longitude of New York City (74° W), you'll need to calculate the difference in longitude from GMT and add or subtract the time difference accordingly to find the local time. Remember 1 degree (1°) of longitude represents a time difference of 4 minutes and 15 degrees (15°) represents one hour.

What did I learn?

Review Questions

1. Describe, in your own words, how you can prove that the Earth is not a perfect sphere.
2. State five (5) characteristics of the Earth.
3. Choose your favourite proof that the Earth is not flat. Explain, in writing, to a non-geography student.
4. Explain, using a diagram, the Earth's 24-hour cycle of day and night.
5. With the aid of a globe, explain why the rotation of the Earth on its axis has resulted in the need for global time zones.
6. Explain why the concept of equal day and equal night is experienced almost every day in Ghana.
7. Write a summary of how solar and lunar eclipses occur.
8. Explain a lunar or solar eclipse with diagrams. Label the umbra and penumbra.
9. Imagine travelling from Axim on Latitude 5° through Kumasi to Bawku on Latitude 11°. Use an atlas or the Internet to identify any natural and human changes you are likely to encounter.
10. Explore practical uses of latitudes and longitudes in fields like aviation, shipping, road transport and weather forecasting. You could use books from the library, or the Internet or ask your teacher for useful information.
11. Imagine you are planning a hiking trip with your friends. You need to calculate the distance between the take-off (A) site and to destination site (B), given their latitude coordinates of A to be 40° N, and B to be 37° N. Using the difference in latitude, calculate the approximate distance between the two campsites in kilometres.
12. With practical examples, discuss why understanding latitude is crucial in your daily life situations.
13. As a school prefect, you are asked to plan an excursion trip with your tourism club. One observation site is located at 41° N, and another is at 61° N. Calculate the approximate distance between these two sites in kilometres.
14. A radio operator was speaking from GTV in Accra on longitude 0° at 6.00 pm and was told that the time the broadcast was listened to in neighbouring country A was midnight. What was the longitude of the listeners?
15. Find the time in town Z (75°E), when the time in Town B (20°E) is 6:00 pm.
16. Calculate the time difference between Ghana and Austria using longitudes. Ghana: 0° (Accra) Austria: 16°E (Vienna)

Answers to Review Questions

1. You will need to describe the experiment which takes two circumference measurements from a ball to show they are the same and compare this to the equatorial and polar circumferences of our Earth, which are not the same.
2. Any five (5) of the following characteristics: spherical in shape, equatorial diameter of the Earth is about 12,800 km, polar diameter is about 12,722 km, equatorial circumference is about 40,075 km, polar circumference is about 40,007 km, total surface area is about 510,000,000 km^2. Earth is slightly flattened at the poles and bulges at the equator, and it is a 'geoid'.
3. Describe one proof. You should include diagrams and a simple, but accurate, written description of the proof.
4. In your answer, you will need a diagram to show the Earth's position in relation to the Sun and label two areas of the Earth, day and night and show the direction of Earth's rotation using an arrow. In your written explanation, you need to be clear on why places on the Earth experience sunrise and day, sunset and night. Use the language of geography including words like 'cycle', 'east', 'west', 'sunrise', 'sunset', 'spin', and 'rotation'.
5. State the definition of a time zone. Explain what solar time is and link this to rotation. Explain why time zones and not solar time are used in the modern world.
6. The length of day and night is almost the same every day throughout the year because the sun is almost always overhead in the tropics.
7. Use the correct terms to do this. You must have two explanations. A solar eclipse happens when the Moon comes between the Earth and the Sun. You can see the circular edge shape of the Moon on the Sun as it passes between Earth and the Sun until the Sun disappears completely. Explain what umbra and penumbra mean. A lunar eclipse is when the Earth is between the Sun and the Moon. In this eclipse, you can see the circular edge shape of the Earth on the Moon as it passes between it and the Sun.
8. Accurate and labelled diagrams for either solar or lunar eclipse.
    a. Imagine travelling from Axim on Latitude 5° through Kumasi to Bawku on Latitude 11°. Use an atlas or the Internet to identify any natural and human changes you are likely to encounter.
    b. Explore practical uses of latitudes and longitudes in fields like aviation, shipping, road transport and weather forecasting. You could use books from the library, or the Internet or ask your teacher for useful information.
9. *Clue to review question one:* Look for maps that show natural vegetation, highland or lowland areas, climate, weather, drainage, farmlands, settlements, and economic activities in this area of Ghana.

10. The following are the usefulness of latitudes and longitudes in the fields of aviation, shipping, road transport and weather forecasting

- **a.** They are used in calculating linear distances on the Earth's surface.
- **b.** They combine with longitudes to give the absolute location of a place.
- **c.** They demarcate the Earth into climatic zones.
- **d.** They help determine the location of climate types and particular weather events.
- **e.** They are used to find local time between two places.
- **f.** They form great circle routes which are used in navigation by air and sea.
- **g.** They combine with latitudes to give the absolute location of a place.

11. Calculate the distance between place 'A' (40° N), and 'B' (37° N).

Solution

Step 1: Locate places involved

Place 'A' = 40°N

Place 'B' = 37°N

Step 2: Find the difference in latitudes

Difference in latitude = 40° − 37°

= 3°

Step 3: Multiply the answer by 111.13 km to get the distance

Distance between Place A and Place B

= 3 × 111.13

= 333.39 km (or 333 km to the nearest whole number)

12.

- **a.** It helps you to know your location at any point in time
- **b.** It gives an indication of the climate in a particular area
- **c.** Helps you in determining the type of crops to be grown in an area
- **d.** Understanding your latitude can help you access relevant information and resources, such as local emergency services, evacuation routes, and disaster response plans.
- **e.** It gives an individual direction to a place

13. Calculate the distance between places 'X'(41°N) and 'Y'(61°N)

Solution

Procedure 1: Find the difference in latitudes

Difference in latitudes = 61 − 41

= 20

Procedure 2: Multiply the answer by 111.13 km to get the distance

Distance between Place A and Place B

$= 20 \times 111.13$ km

$= 2222.6$ km (2223 km to the nearest whole number) `

14. *Solution*

Time of broadcast in Accra at GTV = 6.00 pm at 0°

Time in country A =12 midnight later than Accra so it must be to the East.

The difference in Time = (6 pm to 12 midnight – 6.00 pm) = 6 hours

Therefore, there is a difference of 6 hours between the broadcast GTV and country A,

Since 1 hour is 15°,

Hence $15 \times 6 = 90°$

Since the local time at GTV Accra is behind Country A, then GTV is West of Country A, then the longitude of the listener is GTV is 90°E.

15. *Solution :*

Longitude in Town Z = 75°E

Longitude in Town B = 20°E

Time in town B = 6:00 pm

Time in town Z= not known

difference: $75° - 20° = 55°$

Since 15° = 1 hour, you should be able to see that 55 divides by 15 three times with 10 left over = 3 hours. Since 1° = 4 min, then $10° = 10 \times 4 = 40$ minutes

Hence time difference = 3 hours, 40 minutes

Both towns are in the East, and Town Z is ahead of Town B so the time there is 9.40 pm

Now Time in Town Z is 6 + 3hrs, 40 minutes = 9:40 pm

16. *Solution*

Ghana: 0° (Accra)

Austria: 16° E (Vienna)

Longitude difference: 0° + 16° = 16°

Self-Assessment Questions

1. In what four ways are latitudes and longitudes different from each other?
2. State three characteristics that latitudes and longitudes share in common.
3. State TWO (2) ways in which the following people might find lines of latitude and longitude useful.
   a. A Pilot
   b. A Captain of a ship
   c. A long-distance driver
4. Discuss how longitude is related to time zones and how this affects travel and communication.
5. With the aid of a diagram (putting your information in the form of a diagram), calculate the distance between Town X on latitude 30° South and Town Y on latitude 40° north. Each town is on the same line of longitude.
6. What is the angular distance between two planes flying along the following lines of longitude
   i. 65°E and 20° E
   ii. 30°W and 70° E
7. The final of the Africa Cup of Nation Championship is to be played in Accra on Longitude 0° at 2.00 p.m. What will be the local time in
   i. Nigeria on Longitude 15° E
   ii. Senegal on longitude 15° W.
8. An important announcement from London (longitude 0°) at 15.40 G.M.T. was picked up by the navigator of a ship anchored off the coast of West Africa at Longitude 10° W. What is the local time for the ship?
9. An Airplane took off from Lagos at 6:00 am and landed in Accra at 6:00 am the same day. Explain the coincidence in time concerning longitudes and time.

Extended Reading

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Glossary:

WORDS	MEANING
International Date Line:	This is an imaginary line of longitude at which a day is lost or gained and occurs or is found approximately 180°.
Great Circle:	Any circle that divides the Earth into equal half and passes through the center of the Earth.
Solar time:	is the measurement of time based on the position of the sun in the sky. It is the time indicated by a Sundial (Sunshine recorder).

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