12

"We are children of the Earth, blessed by the Sun, and guided by the Moon." – **Kalpana Chawla**

Earth, Moon, and the Sun

The Big Question

Have you ever stood outside on a sunny day and watched your shadow? In the morning, it's a long, stretched-out version of you. By noon, it shrinks, becoming a small blob at your feet. Then, as evening approaches, it stretches out again in the opposite direction. Why does this happen? Is the Sun playing a game of cosmic tag with the Earth, moving across our sky? Or is something else, something much bigger, going on? This daily dance of light and shadow is a clue to the grand movements of our planet in space.

Meet EeeBee.AI

Hello, young scientists! I'm EeeBee, your curious companion on this journey through the cosmos. Get ready to explore the fascinating movements of our home planet, its natural satellite, and the star that gives us life. I'll be here to guide you, ask questions, and share amazing facts. **Let's unravel the mysteries of the sky together!**

Learning Outcomes

By the end of this chapter, you will be able to:

- **Recall:** The concepts of rotation and revolution from Grade 6.
- **Describe:** The Earth's revolution around the Sun and its orbit.
- **Identify:** Safe practices for observing solar eclipses.
- **Analyse:** How the tilt of Earth's axis and its revolution lead to the change in seasons.

From Last Year's Notebook

- Stars and Constellations
- Satellites
- The Solar System

Science Around You

From ancient civilisations tracking seasons for agriculture to modern-day space missions, understanding the movements of Earth, the Moon, and the Sun has always been fundamental to human life. These celestial dances dictate our days, nights, seasons, and even spectacular events like eclipses, influencing everything from our sleep cycles to global climate patterns.

NCF Curricular Goals and Competencies

CG 12.1 – Understand the rotation and revolution of Earth and their effects.

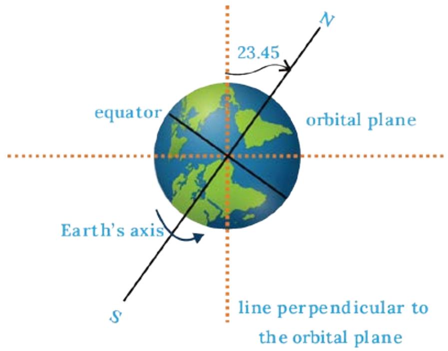
CG 12.2 – Learn how solar and lunar eclipses occur due to alignment of celestial bodies.

Mind Map

Earth, Moon, and the Sun

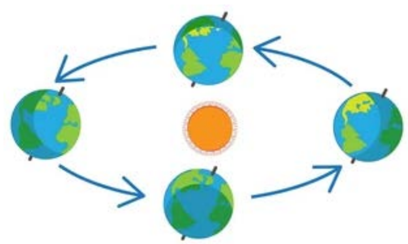
Rotation of the Earth

- Earth spins on its axis (~24 hrs).
  - ✓ Causes day & night.
  - ✓ Sun, Moon, stars appear to move.
  - ✓ **Direction:** West → East.



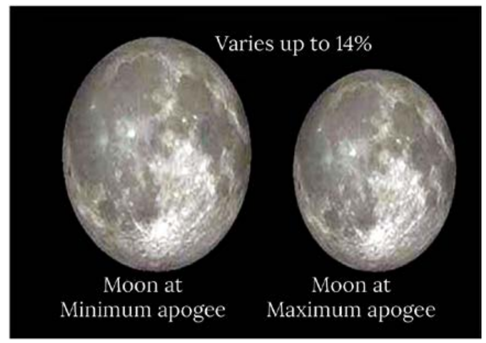
Revolution of Earth

- Earth moves around Sun (elliptical orbit).
- Time: ~365 days 6 hrs → Leap Year every 4 yrs.
- **Effects:**
- Different **constellations.**
  - ✓ Seasons (due to axial tilt):
  - ✓ **Solstices** → longest/shortest days.
  - ✓ **Equinoxes** → equal day & night.



Eclipses

- When one celestial body blocks light.
- **Solar Eclipse (New Moon):** Moon between Sun & Earth.
- **Total:** Sun fully covered, corona visible.
- **Safety:** Use glasses/pinhole.
- **Lunar Eclipse (Full Moon):** Earth between Sun & Moon.
- **Total:** Moon turns reddish (blood moon).
- **Safe to watch.**



In Focus

- Rotation of the Earth
- Revolution of the Earth
- Eclipses

Introduction

Imagine a spinning top. It whirls around a central point, an imaginary line running through its middle. Our planet Earth does the exact same thing, just on a much grander scale. This spinning motion is called rotation. The Earth spins on an imaginary line called its axis of rotation, which passes through the North and South Poles. This single, constant motion is responsible for the most fundamental rhythm of our lives: the cycle of day and night. In this section, we will explore how this rotation creates day and night, why the Sun and stars appear to move across the sky, and how we can prove the Earth is indeed spinning.

From History's Pages

For centuries, humans believed the Earth was stationary and everything in the sky revolved around it. However, thinkers and astronomers challenged this view. Around the 5th century CE, the Indian astronomer Aryabhata correctly proposed that the Earth spins on its axis, causing the apparent movement of the stars. In the 16th century, Nicolaus Copernicus developed a model with the Sun at the center of the solar system. Later, Galileo Galilei's telescope observations supported this model. In the 19th century, Léon Foucault used a special pendulum to provide the first direct, simple proof of the Earth's rotation.

Rotation of the Earth

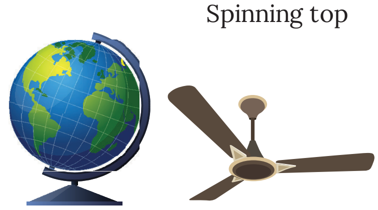
What is Rotation?

Rotation is the spinning of an object around an internal, imaginary line called its axis of rotation. Just as a spinning top twirls rapidly on its tip, or a dancer turns around gracefully, rotation involves circular motion around a central point. In the case of planets and celestial bodies like Earth, this rotation is smooth and continuous. Every point on a rotating object traces a circular path around its axis.

Spinning top

Real-Life Examples:

- A spinning top turns swiftly on its central tip.
- A ceiling fan rotates around a fixed motor at the center.
- A globe mimics Earth's rotation on a tilted axis.



Globe Ceiling fan

Fig. 12.1 Rotating Objects

Earth's Axis of Rotation

Earth spins around an imaginary line connecting its North Pole and South Pole — this line is called its axis of rotation. Importantly, this axis is not perfectly vertical; it is tilted by approximately 23.5° from the vertical relative to its orbit around the Sun. This tilt is crucial for understanding the phenomenon of seasons, which we will explore in upcoming sections.

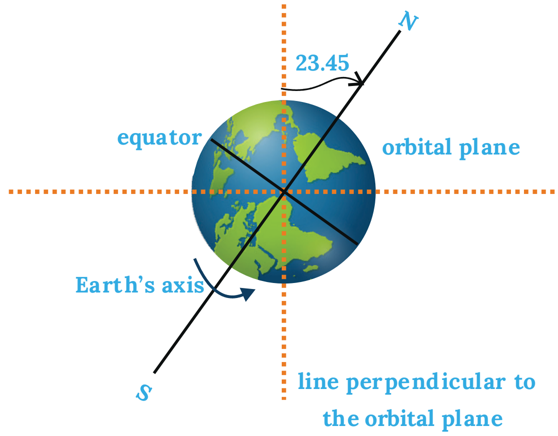


Fig. 12.2 Earth's Axis of Rotation

Direction and Duration of Earth's Rotation

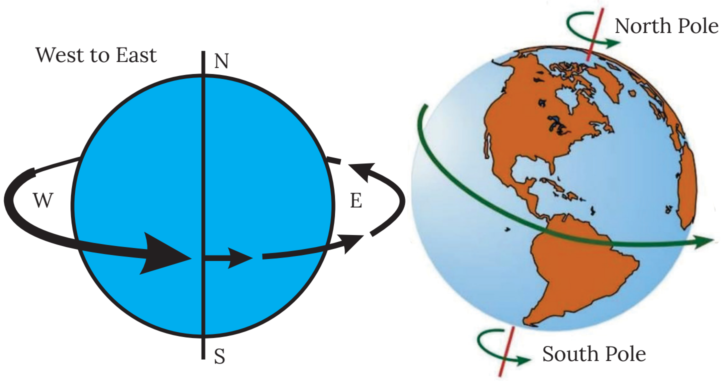


Fig. 12.3 Earth's Rotation

Earth rotates from West to East. If you look at Earth from above the North Pole, it appears to spin in a counter-clockwise direction. This movement causes the Sun and other celestial bodies to appear to rise in the East and set in the West. One full rotation takes nearly 24 hours, which forms the basis of our daily time cycle.

- **Sidereal Day:** ~23 hrs 56 mins (relative to stars)
- Solar Day: 24 hrs (relative to the Sun — used in our clocks)

The Day and Night Cycle

Why Day Turns to Night and Vice Versa

The continuous rotation of Earth results in alternating day and night. The half of the Earth facing the Sun receives light (day), while the opposite half is in shadow (night). As Earth spins, different locations rotate into and out of sunlight, creating sunrise and sunset.

Fig. 12.4 The Day and Night Cycle

Apparent Motion of Celestial Bodies

When we look up at the sky from Earth, it appears as though the Sun rises in the east, travels across the sky during the day, and sets in the west. Similarly, we observe the Moon and stars changing their positions throughout the night. At first glance, it might seem as if these celestial objects are actually moving around the Earth. However, this perception is not entirely accurate. In reality, it is the Earth itself that is rotating on its axis, and this rotation gives rise to what is known as the apparent motion of celestial bodies.

This concept can be compared to the experience of sitting in a moving vehicle. When you look out the window of a car that is driving forward, the trees, buildings, and landscape seem to be moving backward. Of course, these things are not actually moving — it is your own motion that creates the illusion. Similarly, the Sun, Moon, and stars seem to move across the sky because we are standing on a rotating Earth. This daily spinning motion creates the illusion that these celestial objects are shifting positions, even though most of them are relatively stationary in the sky. Understanding this illusion helps us better grasp how our position on a rotating planet influences what we observe in the universe.

Keywords

Sidereal Day: A sidereal day is the time taken by Earth to complete one full rotation relative to distant stars, not the Sun. It lasts approximately 23 hours, 56 minutes, and 4 seconds.

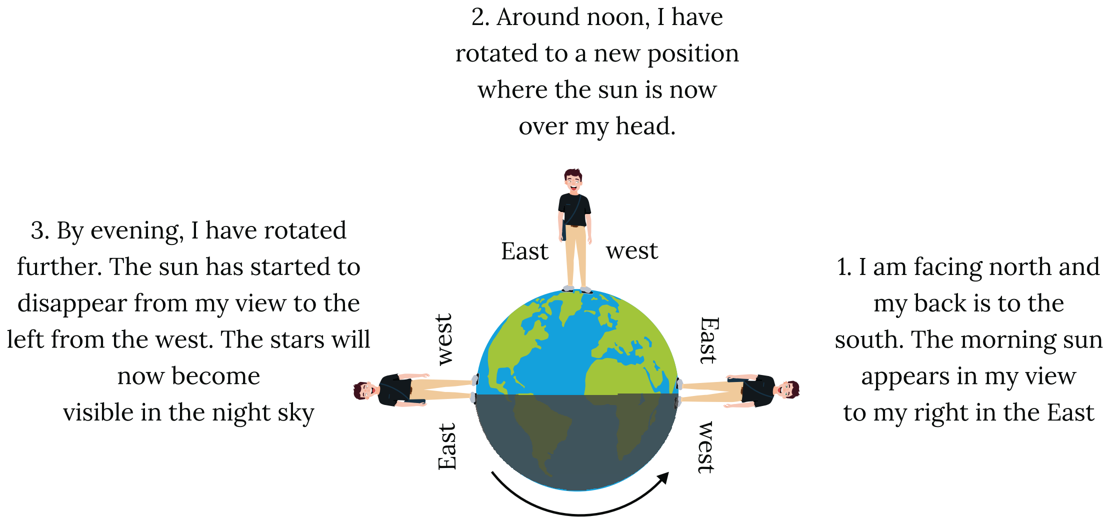


Fig. 12.5 Apparent Motion of Celestial Bodies

- Pole Star (Dhruva Tara): Appears fixed because Earth's axis points toward it.
- **Star Trails:** Long-exposure photography reveals stars as arcs around the Pole Star.

How Earth's Rotation Shapes Our World

Earth's rotation is a powerful, invisible force shaping life on our planet. The axis tilt (23.5°), the rotational direction (West to East), and the 24-hour cycle all influence timekeeping, climate, weather, and our perception of the sky.

Despite rotating at nearly 1670 km/h at the Equator, we don't feel it — because we, along with everything around us, are moving at the same speed. The Pole Star remains almost stationary in our sky due to its alignment with Earth's axis, aiding in ancient and modern navigation.

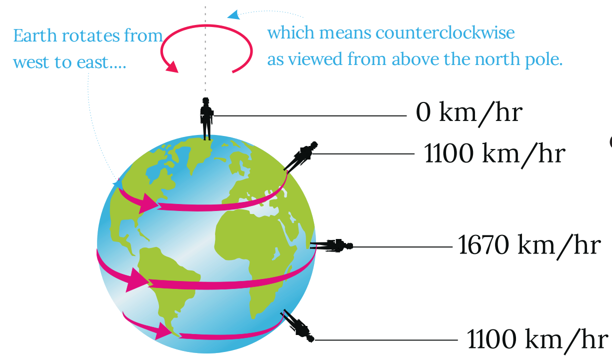


Fig. 12.6 Rotational Direction

This invisible motion helps organize our time, structures our day and night, and defines fundamental truths of astronomy and Earth sciences.

Scientific Applications of Earth's Rotation

Application	Explanation	Scientific Reasoning
Day and Night Cycle	Parts of Earth rotate into and out of sunlight.	Earth's spherical shape allows only half to be lit at a time; rotation causes all regions to face the Sun.
Time Zones	Different parts of Earth experience noon at different times.	Earth rotates 15° each hour, leading to 24 time zones for accurate solar time.
Apparent Star Movement	Stars seem to move across the sky each night.	As Earth rotates, we change our viewpoint, making stars seem to move from East to West.
Foucault Pendulum	Pendulum's swing appears to shift over time.	Earth rotates under the pendulum, but the swing remains fixed in space.
Coriolis Effect	Winds and currents curve right (Northern Hemisphere) or left (Southern Hemisphere).	Moving air and water are deflected due to Earth's rotating reference frame.

Fact Flash

Even though we don't feel it, you are moving at a speed of about 1670 km/h (more than 1,000 mph) if you're standing at the equator!

That's faster than most airplanes fly! But because everything around you (air, trees, buildings) is rotating at the same speed, it feels like you're standing still.

Common Misconceptions

- × **Misconception:** The Sun moves across the sky from East to West during the day.
- ✓ **Correction:** The Sun only appears to move because Earth rotates from West to East. This rotation creates the illusion that the Sun is moving across the sky, but in reality, it's Earth that is spinning beneath you.
- × **Misconception:** Night occurs because the Sun goes behind the Earth or turns off.
- ✓ **Correction:** The Sun doesn't go anywhere or "turn off." Night happens because Earth rotates, turning parts of the planet away from the Sun. Those areas then experience darkness while the other half enjoys daylight.

Science Around You

Have you ever noticed how the Sun rises in the East every morning and sets in the West each evening? This daily pattern happens because Earth is constantly spinning on its axis.

Street lights turning off in the morning, shadows changing direction throughout the day, or your clock ticking from one hour to the next—all these are signs of Earth's silent spin. It's the reason we have mornings, afternoons, evenings, and nights—right outside your window!

Activity

Model the Day and Night Cycle

Objective: To help students understand how Earth's rotation causes day and night.

Materials: A globe or ball (representing Earth), A torch or flashlight (representing the Sun), A dark room

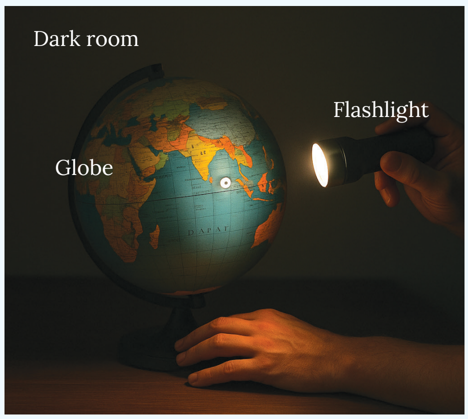


Fig. 12.7 Materials Required

- **Procedure:**
    1. Place the ball on a table in the dark room.
    2. Shine the flashlight on one side of the ball to represent sunlight.
    3. Slowly rotate the ball from West to East
    4. Observe how parts of the globe move from day to night and back.
    5. Mark a point (e.g., India) and trace its journey from night to day and back.
- **Think About:**
    - What happens to the marked point as you rotate the ball?
    - When would it be sunrise or sunset for that point?

Knowledge Checkpoint

Gap Analyzer™ Homework | Watch Remedial

Remembering

Multiple Choice Questions:

1. Which of the following phenomena is primarily caused by the Earth's rotation?
   a) Change of seasons ☐ b) Lunar eclipses ☐
   c) Day and night cycle ☐ d) Phases of the Moon ☐

Understanding

2. If you observe the Sun rising in the East and setting in the West, what does this tell you about Earth's rotation?
   a) Earth rotates from East to West. ☐ b) Earth rotates from West to East. ☐
   c) Earth does not rotate; the Sun orbits Earth. ☐
   d) Earth's axis is tilted ☐
3. Which celestial body appears almost stationary in the Northern Hemisphere sky due to Earth's axis of rotation pointing towards it?
   a) The Sun ☐ b) The Moon ☐
   c) The Pole Star (Polaris) ☐ d) Venus ☐

Short Answer Question:

Applying

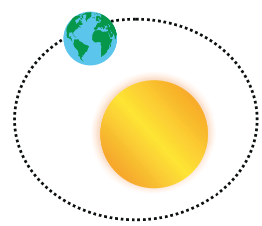
4. Explain why we experience day and night.
5. A student claims that the Sun moves around the Earth every day. How would you correct this misconception using the concept of Earth's rotation?

Long Answer Question:

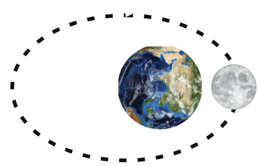
Analyzing

6. Describe the Earth's axis of rotation, its direction of rotation, and the period it takes for one complete rotation. How do these factors lead to the apparent movement of the Sun and stars across the sky?

Revolution of the Earth



Beyond its daily spin on its axis, Earth undertakes a far more majestic and significant movement — it journeys around the Sun. This continuous movement is known as the revolution of the Earth. Unlike rotation, which gives rise to day and night by spinning the Earth once every 24 hours, revolution takes the Earth through its orbital path around the Sun once every year, causing phenomena like changing seasons, variations in daylight hours, and shifts in the constellations visible in the night sky. Earth's revolution is intricately linked with its axial tilt of 23.5°, making it a key reason why our planet experiences different climates and seasons.



Understanding Earth's revolution is not just a lesson in astronomy — it's a story that connects with every aspect of life on Earth. From the planning of harvests and festivals to the migration of animals and our perception of time, the revolution of Earth affects all living beings in profound ways.

What is Revolution?

Revolution refers to the movement of an object in a fixed path around another object. In astronomy, it commonly describes how planets orbit the Sun or how moons orbit planets. For example, the Moon revolves around Earth, and Earth revolves around the Sun.

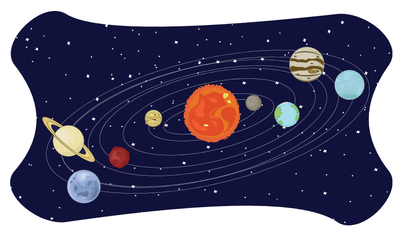


Fig. 12.8 Revolution

Earth's revolution is not a straight-line motion, but an elliptical orbit (oval-shaped), which means Earth's distance from the Sun varies slightly throughout the year. This revolution, combined with the tilt of Earth's axis, determines how sunlight falls on different parts of the globe over the year, resulting in seasonal changes.

Examples:

- Satellites revolving around Earth.
- The Moon revolving around Earth.
- All eight planets revolving around the Sun in elliptical orbits.

Earth's Orbit and Its Shape

Earth does not move in a perfect circle around the Sun. Its orbit is elliptical, meaning slightly elongated, with the Sun at one of the focal points, not the center. Due to this elliptical orbit, Earth is sometimes closer to the Sun and sometimes farther away.

- When Earth is closest to the Sun (around January 3rd), the point is called Perihelion.
- When Earth is farthest from the Sun (around July 4th), the point is called Aphelion.

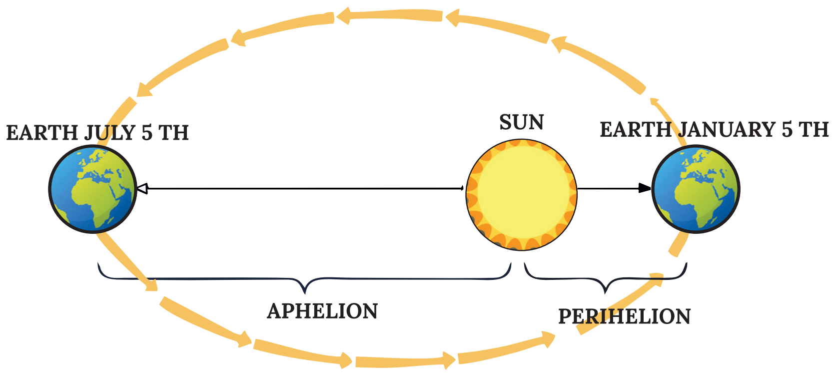


Fig. 12.9 Earth's Orbit

Interestingly, the variation in distance does not cause the seasons — that is a common misconception. Instead, the axial tilt plays a far more important role in determining seasons.

Earth's Period of Revolution

Earth takes about 365 days and 6 hours to complete one full revolution around the Sun. This period is known as a solar year. However, our standard calendar only has 365 days, so the extra 6 hours are accumulated over four years to make 24 hours (1 full day). That extra day is added to February every fourth year, creating a leap year.

This system helps our calendars stay aligned with Earth's position in space and the resulting seasons. Without leap years, our calendar would slowly shift, and over centuries, the seasons would no longer align with the months we associate them with.

Fig. 12.10 Earth's Period of Revolution

Why the Night Sky Changes Throughout the Year

As Earth continues its journey around the Sun, our vantage point in space changes. This results in a shift in the view of stars and constellations in the night sky. Certain constellations are only visible during particular times of the year.

For instance:

- Orion is visible in the Northern Hemisphere during winter.
- Scorpius appears during the summer months.

This change in the night sky throughout the year has been known since ancient times. Civilizations used these star patterns to predict seasons, navigate oceans, and guide agricultural activities.

Why Do Seasons Occur?

The tilt of Earth's axis (about 23.5°) is the primary cause of seasons — not the varying distance from the Sun. As Earth revolves around the Sun, this tilt remains fixed relative to the stars, meaning Earth's North Pole always points towards the same direction in space (near Polaris, the North Star).

Here's how the tilt affects seasons:

- When the Northern Hemisphere is tilted towards the Sun, it experiences summer: days are longer, and the Sun's rays strike more directly.
- At the same time, the Southern Hemisphere is tilted away from the Sun, experiencing winter: shorter days and less intense sunlight.

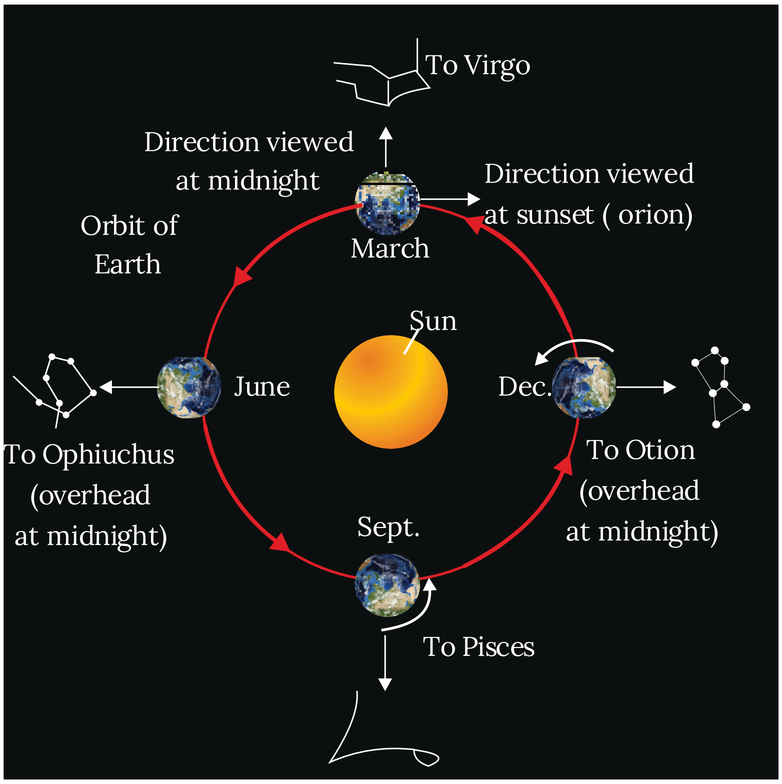


Fig. 12.11 The changing view of the night sky

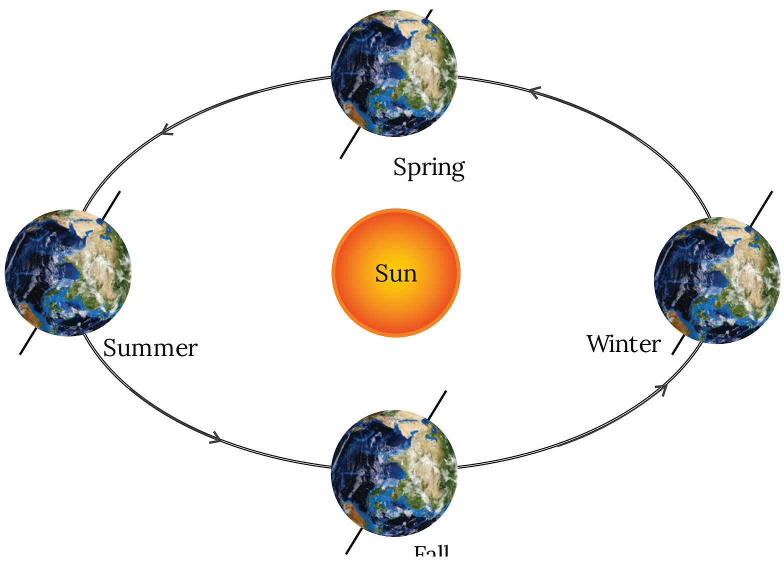


Fig. 12.12 Northern Hemisphere

- Six months later, the situation reverses. The Southern Hemisphere gets direct sunlight (summer), and the Northern Hemisphere gets less (winter).
- Spring and Autumn occur when neither hemisphere is tilted significantly toward or away from the Sun — during equinoxes, when day and night are approximately equal.

Solstices and Equinoxes

Throughout Earth's orbit, there are four key positions that mark important seasonal transitions:

Solstices:

- Summer Solstice (June 21): Longest day of the year in the Northern Hemisphere.
- Winter Solstice (December 22): Shortest day of the year in the Northern Hemisphere.

Equinoxes:

- Vernal (Spring) Equinox (March 20): Equal day and night; start of spring in the Northern Hemisphere.

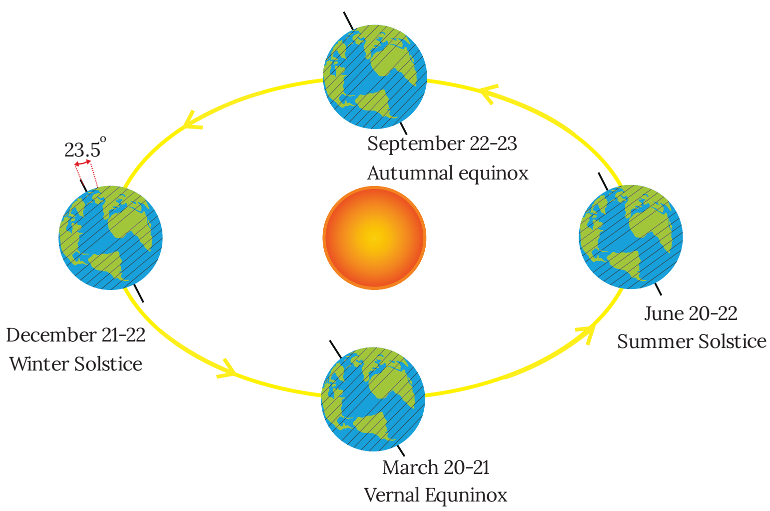


Fig. 12.13 Solstices and Equinoxes

- Autumnal **Equinox** (September 23): Equal day and night; start of autumn in the Northern Hemisphere. During **solstices**, one hemisphere receives maximum sunlight while the other receives the least. During equinoxes, the Sun's rays fall directly on the equator, giving roughly equal day and night to the entire planet.

Examples from the Real World

Calendars and Leap Years

The concept of a 365-day year with a leap year every four years is directly based on Earth's revolution. Without adjusting for the extra 6 hours, our calendar would shift out of sync with the solar year, and over time, seasons wouldn't match the months.

Agricultural Cycles

For farmers across the world, understanding the cycle of seasons is crucial. Planting and harvesting times are decided based on seasonal changes brought by Earth's revolution. Monsoon, spring crops, winter dormancy — all are connected to Earth's orbital position.

Animal Migration

Many animals migrate due to seasonal shifts in temperature and food availability. For example, birds like Arctic Terns migrate thousands of kilometers from one pole to another following Earth's seasons.

Weather and Climate Patterns

Global climate zones (tropical, temperate, and polar) and seasonal weather variations such as monsoons, snowfall, and dry spells are all influenced by the combination of revolution and axial tilt.

Earth's Revolution at a Glance

Topic	Details
Type of Movement	Revolution – Earth orbiting around the Sun
Duration of One Revolution	365 days and 6 hours
Shape of Orbit	Elliptical
Closest Point to the Sun	Perihelion (~January 3rd)
Farthest Point from the Sun	Aphelion (~July 4th)
Axial Tilt	23.5°, constant direction toward North Star
Seasons Caused By	Combination of revolution and axial tilt
Leap Year Reason	Extra 6 hours each year, adding up to one full day every 4 years
Night Sky Changes	Due to Earth's shifting position in orbit
Solstices	Longest and shortest days (June 21, December 22)
Equinoxes	Equal day and night (March 20, September 23)

Keywords

Solstices occur twice a year when the Sun reaches its highest or lowest point in the sky at noon. They mark the longest day (summer solstice) and the shortest day (winter solstice) of the year.
Equinoxes occur twice a year when day and night are approximately equal in length. This happens when the Sun is directly above the equator, marking the start of spring and autumn.

Fact Flash

If Earth's orbit were perfectly circular and its axis had no tilt, we wouldn't have seasons at all! The entire planet would experience the same weather patterns year-round—no snowy winters or sunny summers!

Common Misconceptions

- × **Misconception:** Seasons occur because Earth is closer to the Sun in summer and farther in winter.
- ✓ **Correction:** Seasons are caused by Earth's axial tilt, not distance from the Sun. In fact, Earth is closest to the Sun during the Northern Hemisphere's winter!
- × **Misconception:** All places on Earth experience four seasons equally.
- ✓ **Correction:** Near the equator, seasons are less pronounced, while polar regions can have extreme daylight variations, such as six months of daylight or darkness.

Science Around You

Ever noticed how days are longer in summer and shorter in winter? Or how you see Orion in the winter sky but not in summer? These everyday experiences are due to Earth's revolution and axial tilt, which change the Sun's angle and the stars visible from Earth throughout the year.

Activity

Why Do We Have Seasons?

Objective: To demonstrate how Earth's axial tilt and revolution around the Sun cause the seasons.

Fig. 12.14 Materials Required

- **Materials:**

  A shoebox (or a large box), A small globe or a ball (representing Earth), A torch or flashlight (representing the Sun), A stick/ skewer (to tilt the "Earth"), Markers and stickers

- **Procedure:**

  1. Place the torch in the center of the shoebox (this is your Sun).
  2. Fix the ball (Earth) on a stick and tilt it at around 23.5°.
  3. Move the ball in a circle around the torch, keeping the tilt in the same direction.
  4. Observe how the light from the torch hits different parts of the "Earth" more directly or indirectly as it revolves.
  5. Mark different seasons on the orbit path based on sunlight intensity and tilt.

  Expected Learning: Students visually understand how the tilt and revolution of the Earth result in different seasons.

Knowledge Checkpoint

Gap Analyzer™ Homework

Watch Remedial

Multiple Choice Questions:

Understanding

1. What is the primary cause of Earth's seasons?
   a) Earth's varying distance from the Sun. ☐ b) Earth's rotation on its axis. ☐
   c) The tilt of Earth's axis combined with its revolution around the Sun. ☐
   d) The Moon's gravitational pull. ☐

Remembering

2. Approximately how long does it take for Earth to complete one revolution around the Sun?
   a) 24 hours ☐ b) 28 days ☐ c) 365 days and 6 hours ☐ d) 12 months ☐
3. During which event are day and night hours approximately equal across the entire globe?
   a) Summer Solstice ☐ b) Winter Solstice ☐ c) Equinox ☐ d) Aphelion ☐

Short Answer Question:

Applying

4. Explain the difference between Earth's rotation and revolution.
5. If the Earth's axis were not tilted, how would seasons be affected?

Long Answer Question:

Analyzing

6. Describe how the tilt of Earth's axis and its revolution around the Sun combine to create the four seasons. Use examples of how sunlight intensity and daylight hours change in different hemispheres.

Eclipses

Imagine the Sun, our life-giving star, suddenly disappearing from the sky in the middle of the day, or the bright full Moon turning a ghostly red. These spectacular celestial events are called eclipses. Eclipses occur when one celestial body blocks the light from another, casting a shadow. They are a direct consequence of the precise alignment of the Sun, Earth, and Moon. While awe-inspiring, understanding the science behind them reveals that they are natural, predictable phenomena. In this section, we will explore the two main types of eclipses: solar and lunar, and learn about their causes and characteristics.

What is an Eclipse?

An eclipse is an astronomical event that occurs when an astronomical object is temporarily obscured, either by passing into the shadow of another body or by having another body pass between it and the viewer. Essentially, it's a cosmic alignment where one celestial body blocks the light from another, creating a shadow. The term "eclipse" comes from the Greek word "ekleipsis," meaning "abandonment" or "forsaking," reflecting the ancient fear associated with the temporary disappearance of the Sun or Moon.

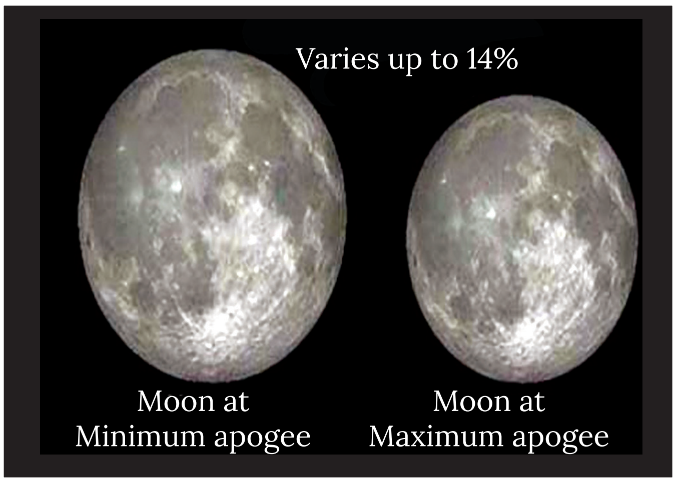


Fig. 12.15 Eclipse

Apparent Size of Sun and Moon

For an eclipse to occur, the obscuring body must appear large enough in the sky to block the light source. While the Sun is vastly larger than the Moon in actual physical size (about 400 times wider), it is also vastly farther away from Earth (about 400 times farther than the Moon). This remarkable cosmic coincidence means that the Sun and the Moon have almost the same apparent size when viewed from Earth. This similarity in apparent size is what allows the Moon to completely cover the Sun during a total solar eclipse.

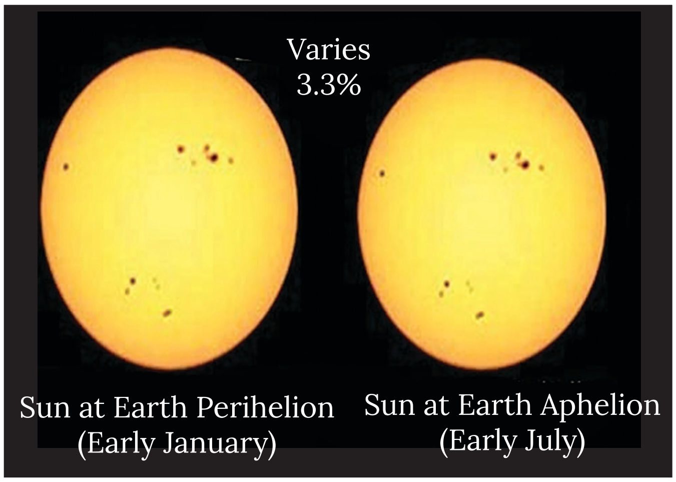


Fig. 12.16 Apparent Size of Sun and Moon, Kolkata, India

Solar Eclipse

A **solar eclipse** occurs when the Moon passes directly between the Sun and Earth, casting a shadow on Earth's surface and blocking the Sun's light. This can only happen during a new moon phase, when the Moon is between the Earth and the Sun. However, not every new moon results in a solar eclipse because the Moon's orbit is slightly tilted relative to Earth's orbit around the Sun.

Types of Solar Eclipses:

- **Total Solar Eclipse:** Occurs when the Moon completely covers the Sun's disk. This happens in the darkest part of the Moon's shadow (the umbra). Observers in the umbra experience complete darkness during the day, and the Sun's faint outer atmosphere (**corona**) becomes visible.
- **Partial Solar Eclipse:** Occurs when the Moon only partially covers the Sun's disk. This happens in the lighter part of the Moon's shadow (the penumbra). Observers see only a portion of the Sun obscured.

Annular Solar Eclipse: Occurs when the Moon is at its farthest point from Earth in its elliptical orbit (apogee) during a solar eclipse. At this distance, the Moon's apparent size is slightly smaller than the Sun's, so it doesn't completely cover the Sun. A bright ring of sunlight (an "annulus") is visible around the Moon's silhouette.

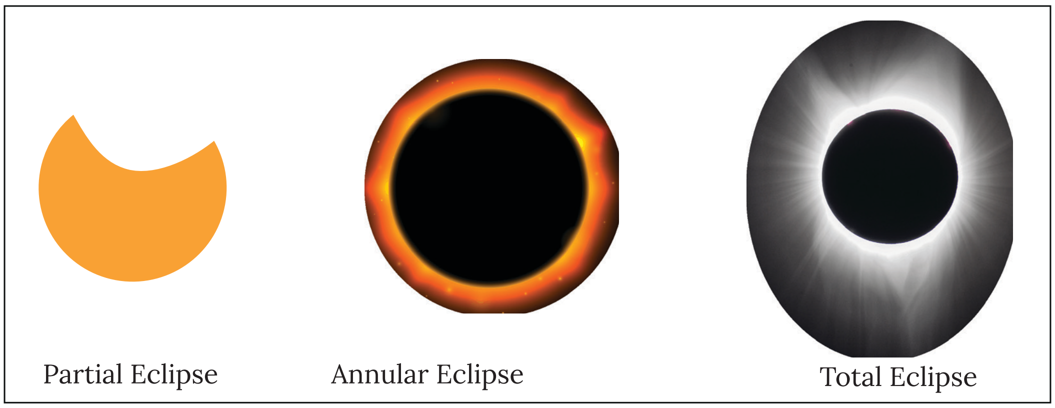


Fig. 12.17 Types of Solar Eclipses

Geometry of Solar Eclipse:

The alignment is **Sun - Moon - Earth**. The Moon's shadow consists of two main parts: the dark, inner **umbra** (where total eclipse occurs) and the lighter, outer **penumbra** (where partial eclipse occurs). The umbra is narrow, so a total solar eclipse is visible only from a very small path on Earth's surface.

Keywords

Corona: is the outermost layer of the Sun's atmosphere, visible as a glowing halo during a total solar eclipse. It consists of extremely hot plasma and extends millions of kilometers into space.

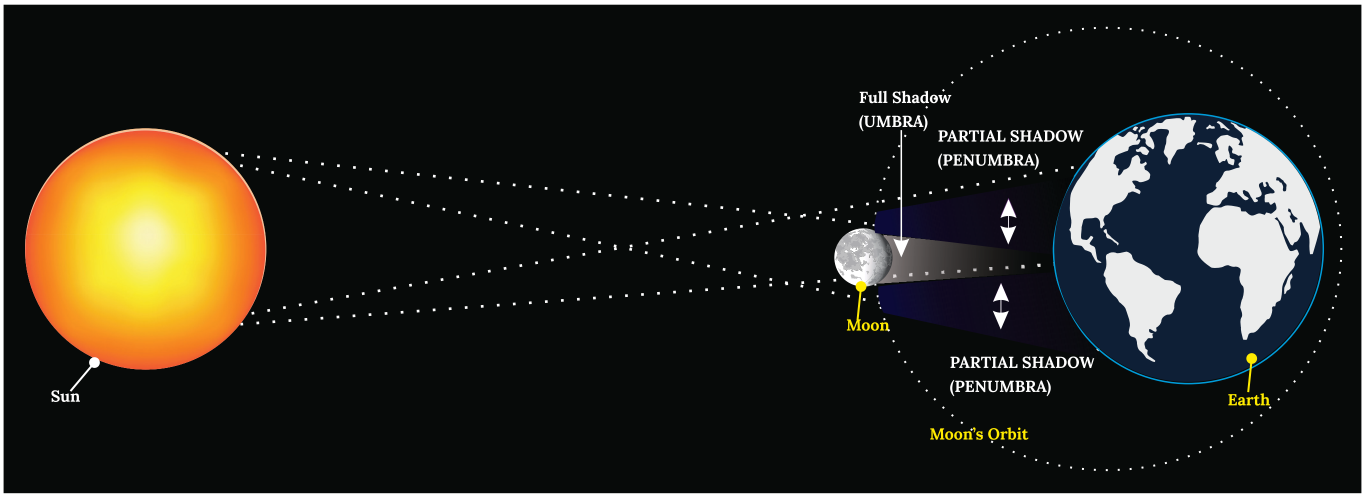


Fig. 12.18 Solar Eclipses

Types of Solar Eclipses:

Type of Eclipse	Description	Shadow Region Involved	Visibility
Total	Moon completely covers the Sun. The Sun's corona is visible.	Umbra	Very narrow path on Earth
Partial	Only part of the Sun is covered by the Moon.	Penumbra	Wider area
Annular	The Moon is too far to cover the Sun entirely, forming a "ring of fire".	Central shadow with un-covered rim	Moderate path width

Safety during Solar Eclipse:

NEVER look directly at the Sun, even during a partial solar eclipse or the partial phases of a total solar eclipse, without proper eye protection. The Sun's intense light can cause permanent eye damage or blindness. Regular sunglasses are NOT safe. Special solar filters, eclipse glasses, or pinhole projectors are required for safe viewing.

Fig. 12.19 Safety During Solar Eclipse

Lunar Eclipse

A **lunar eclipse** occurs when the Earth passes directly between the Sun and the Moon, casting Earth's shadow on the Moon. This can only happen during a full moon phase, when the Moon is on the opposite side of Earth from the Sun. Unlike solar eclipses, lunar eclipses are visible from any location on Earth where the Moon is above the horizon.

Types of Lunar Eclipses:

- **Total Lunar Eclipse:** Occurs when the entire Moon passes through Earth's darkest shadow (the **umbra**). During totality, the Moon often appears reddish or coppery, sometimes called a "blood moon." This is because some sunlight is refracted (bent) by Earth's atmosphere and scattered, with red light being scattered less and reaching the Moon.
- **Partial Lunar Eclipse:** Occurs when only a portion of the Moon passes through Earth's umbra.

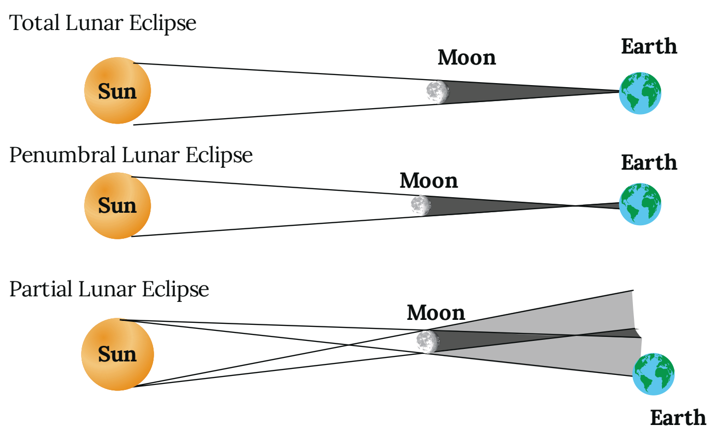


Fig. 12.20 Types of Lunar Eclipses

- **Penumbral Lunar Eclipse:** Occurs when the Moon passes only through Earth's lighter, outer shadow (the **penumbra)**. This type of eclipse is often subtle and difficult to notice, as the Moon only dims slightly.

Geometry of Lunar Eclipse:

The alignment is **Sun - Earth - Moon**. Earth's shadow, like the Moon's, has an umbra and a penumbra. Because Earth is much larger than the Moon, its shadow is much wider, meaning lunar eclipses can last for several hours and are visible to a much larger portion of Earth's population.

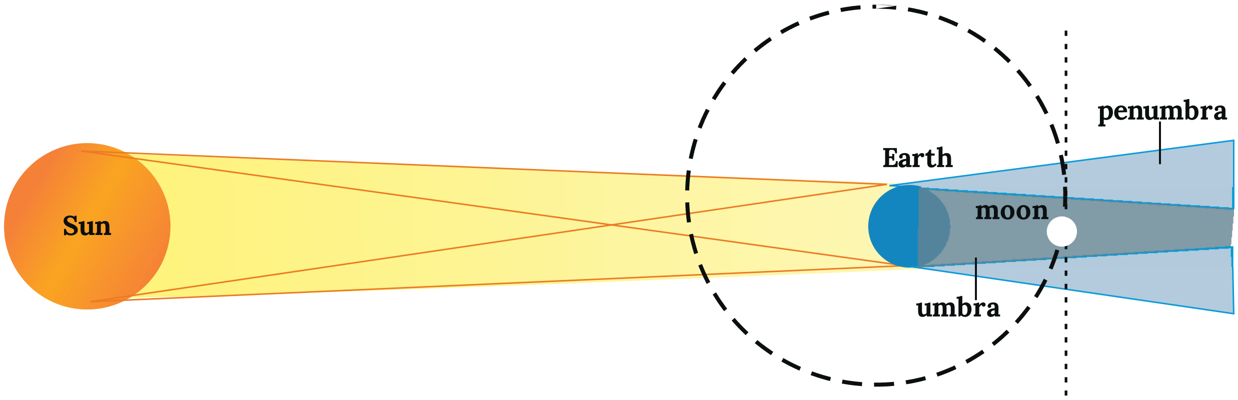


Fig. 12.21 Geometry of Lunar Eclipse

Types of Lunar Eclipses:

Type of Eclipse	Description	Shadow Region Involved	Visibility
Total	Entire Moon enters Earth's umbra, turning red.	Umbra	Visible to all where Moon is up
Partial	Only a part of the Moon enters the umbra.	Umbra	Visible to a large area
Penumbral	Moon enters only Earth's penumbra, slightly dimming.	Penumbra	Often unnoticed

Safety during Lunar Eclipse:

It is **completely safe** to view a lunar eclipse with the naked eye, binoculars, or a telescope. The Moon's light is reflected sunlight, and even when eclipsed, it is not harmful to the eyes.

Eclipses are **spectacular celestial events** that occur due to the precise alignment of the Sun, Earth, and Moon. While the Sun is approximately 400 times larger in diameter than the Moon, it is also about 400 times farther away from Earth. This remarkable cosmic coincidence results in both the Sun and the Moon having nearly the same apparent size in our sky. This similarity in apparent size is a critical factor that allows for total solar eclipses.

Fact Flash

The "blood moon" effect during a total lunar eclipse is caused by the same phenomenon that makes sunsets and sunrises appear red. Earth's atmosphere scatters blue light more effectively than red light. So, when sunlight passes through Earth's atmosphere on its way to the Moon during a lunar eclipse, most of the blue light is scattered away, leaving primarily red light to be refracted onto the Moon's surface.

Keywords

Spectacular celestial events are striking sky phenomena like eclipses, meteor showers, and auroras caused by movements of celestial bodies. They are admired for their rare, bright, and dramatic appearances in the sky.

Common Misconceptions

× **Misconception:** Solar eclipses are dangerous because the Sun emits special harmful rays during an eclipse.

✓ **Correction:** The Sun does not emit any special harmful rays during an eclipse. The danger comes from the fact that even a small sliver of the Sun's disk is intensely bright and can cause permanent retinal damage if viewed directly. During a partial eclipse, or the partial phases of a total eclipse, people are tempted to look because the light seems dimmer, but it's still powerful enough to cause harm.

× **Misconception:** The Moon completely disappears during a total lunar eclipse.

✓ **Correction:** The Moon does not disappear during a total lunar eclipse. Instead, it often takes on a reddish, coppery, or orange hue. This is because some sunlight is refracted (bent) by Earth's atmosphere and scattered, with the red wavelengths of light being less scattered and reaching the Moon's surface.

Science Around You

Though we have a new moon every month, solar eclipses are rare. This is because the Moon's orbit is tilted about 5° to Earth's orbit (called the ecliptic plane). Eclipses only happen when the Sun, Moon, and Earth align near the points where their orbits intersect, known as the nodes.

Activity

Shadow Play – Understanding Eclipses

Objective: To understand how solar and lunar eclipses occur using basic hand-shadow modeling.

Fig. 12.22 Materials Required

- **Materials:** A torch/flashlight, A ball (Moon), A wall or white paper (to project shadows), A friend or classmate (optional for pairs)
- **Procedure:**
  1. Face the wall and hold the ball (Moon) in front of you.
  2. Shine the torch (Sun) from behind the ball toward the wall.
  3. Move the ball slowly and observe its shadow on the wall — this shows a solar eclipse.
- **This models a solar eclipse** – The Moon blocking sunlight from reaching Earth.

  For Lunar Eclipse:
  1. Keep the torch shining at the ball (Moon).
  2. Now place your hand (Earth) between the torch and the ball.
  3. Watch the Earth's shadow fall on the ball.
- **This models a lunar eclipse** – The Earth blocking sunlight from reaching the Moon.
- **Quick Discussion:**
  - What do you notice about the shadows?
  - Why are eclipses not seen every month?
  - Which eclipse is safer to view with the naked eye?

Knowledge Checkpoint

Gap Analyzer™ Homework

Watch Remedial

Multiple Choice Questions:

Remembering

1. What is the correct alignment of celestial bodies during a solar eclipse?
   - a) Sun - Earth - Moon ☐
   - b) Sun - Moon - Earth ☐
   - c) Moon - Sun - Earth ☐
   - d) Earth - Moon - Sun ☐
2. Why does the Moon appear reddish during a total lunar eclipse?
   - a) The Moon emits red light during an eclipse. ☐
   - b) Earth's atmosphere scatters blue light, allowing red light to reach the Moon. ☐
   - c) The Sun emits red light during an eclipse. ☐
   - d) Dust in space reflects red light onto the Moon. ☐

Understanding

3. Which type of eclipse is always safe to view directly with the naked eye?
   - a) Total Solar Eclipse ☐
   - b) Partial Solar Eclipse ☐
   - c) Annular Solar Eclipse ☐
   - d) Total Lunar Eclipse ☐

Short Answer Question:

Applying

4. Why don't we experience a solar eclipse every new moon and a lunar eclipse every full moon?
5. A friend wants to watch a solar eclipse with regular sunglasses. What advice would you give them and why?

Long Answer Question:

Analyzing

6. Compare and contrast solar and lunar eclipses, discussing their geometry, the phase of the Moon during which they occur, their visibility from Earth, and safety precautions for viewing.

SUMMARY

Earth, Moon, and the Sun

1. Rotation of the Earth

The Earth is constantly spinning on an imaginary line passing through its North and South Poles, called its axis. This spinning motion is known as rotation. Earth completes one full rotation in approximately 24 hours, which defines one day.

- **Effects of Rotation:**
  - **Day and Night:** As Earth rotates, different parts of its surface face the Sun, experiencing daylight, while the side facing away experiences darkness (night).
  - **Apparent Movement of Celestial Bodies:** The rotation of Earth makes it appear as if the Sun, Moon, and stars are moving across the sky. The Sun appears to rise in the east and set in the west because Earth rotates from west to east.
  - **Direction of Earth's Rotation:** Earth rotates from west to east.

2. Revolution of the Earth

Beyond its daily spin, Earth also travels in an orbit around the Sun. This journey is called revolution.

- **Earth's Orbit:** The path Earth takes around the Sun is called its orbit, which is not a perfect circle but an ellipse (an elongated oval). The Sun is slightly off-center in this ellipse.
  - ✦ **Perihelion:** Earth's closest point to the Sun in its orbit.
  - ✦ **Aphelion:** Earth's farthest point from the Sun in its orbit.
- **Period of Revolution (The Year):** Earth takes approximately 365 days and 6 hours to complete one revolution, defining one year. The extra 6 hours accumulate, leading to a leap year (366 days) every four years.
- Effects of Revolution (combined with Axial Tilt):
  - ✦ **Changing View of the Night Sky:** As Earth revolves, its position relative to distant stars changes, causing different constellations to be visible at different times of the year.
  - ✦ **Solstices and Equinoxes:** Specific points in the orbit marking seasonal transitions. Solstices are when one hemisphere is maximally tilted towards/away from the Sun (longest/shortest days). Equinoxes are when the axis is neither tilted towards nor away, resulting in equal day and night globally.

3. Eclipses

Eclipses are spectacular celestial events that occur when one celestial body blocks the light from another, casting a shadow.

- **Apparent Size of Sun and Moon:** Despite their vast difference in actual size, the Sun and Moon appear almost the same size from Earth due to their relative distances. This cosmic coincidence allows for total solar eclipses.
- **Solar Eclipse:** Occurs when the Moon passes directly between the Sun and Earth (SUN→MOON→EARTH), blocking the Sun's light and casting a shadow on Earth.
  - ✦ **Occurs during:** New Moon phase.
  - ✦ **Types:**
  - ➢ **Total Solar Eclipse:** Moon completely covers the Sun (occurs in the Moon's darkest shadow, the umbra). Sun's corona becomes visible.
  - ✦ **Safety:** NEVER look directly at the Sun during a solar eclipse without specialized eye protection (eclipse glasses, pinhole projector).
- **Lunar Eclipse:** Occurs when the Earth passes directly between the Sun and the Moon (SUN→EARTH→MOON), casting Earth's shadow on the Moon.
  - ✦ **Types:**
  - ➢ **Total Lunar Eclipse:** Entire Moon passes through Earth's darkest shadow (umbra). Moon often appears reddish ("blood moon") due to refracted sunlight.
  - ✦ **Safety:** Completely safe to view with the naked eye, binoculars, or telescopes.

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Example Based Questions

Multiple Choice Questions

1. The rotation of Earth on its axis causes:

(a) Seasons (b) Day and night
(c) Eclipses (d) High and low tides

Answer: (b) Day and night

Explanation: Earth rotates once every 24 hours. The side facing the Sun experiences day, while the opposite side has night. Seasons are caused by revolution and tilt, not rotation.

2. How much time does Earth take to complete one revolution around the Sun?

(a) 24 hours (b) 365 days and 6 hours
(c) 30 days (d) 12 months exactly

Answer: (b) 365 days and 6 hours

Explanation: Earth takes about one year (365¼ days) to complete one revolution. That extra 6 hours adds up, leading to an extra day (leap year) every 4 years.

3. A lunar eclipse occurs when:

(a) Earth comes between Sun and Moon
(b) Moon comes between Earth and Sun
(c) Sun comes between Earth and Moon
(d) Moon hides behind clouds

Answer: (a) Earth comes between Sun and Moon

Explanation: In a lunar eclipse, Earth blocks sunlight from reaching the Moon, casting its shadow on the Moon. In contrast, a solar eclipse occurs when the Moon blocks sunlight from reaching Earth.

Short Answer Questions

4. How does the rotation of Earth affect our daily life?

Answer: The rotation of Earth causes day and night. It regulates human activities, sleep cycles, plant photosynthesis, and animal behaviour. Without rotation, one side of Earth would always have day while the other would remain in darkness, making life impossible.

5. What is the main difference between rotation and revolution?

Answer:

- Rotation: Earth spins on its own axis (24 hours), causing day and night.
- Revolution: Earth moves around the Sun (365¼ days), causing seasons.

Thus, rotation controls the daily cycle, while revolution controls the yearly cycle.

6. Why don't eclipses happen every month when the Moon revolves around Earth?

Answer: Eclipses don't occur monthly because the Moon's orbit is tilted about 5° compared to Earth's orbit around the Sun. Most of the time, the Moon passes slightly above or below Earth's shadow. Only when Sun, Earth, and Moon are in a straight line do eclipses occur.

Long Answer Questions

7. Explain how Earth's revolution and tilt cause seasons.

Answer:

- Earth revolves around the Sun once in 365¼ days.
- Its axis is tilted at 23.5°.
- During revolution, different parts of Earth tilt toward or away from the Sun at different times of the year.
- When the Northern Hemisphere tilts towards the Sun, it gets longer days and summer, while the Southern Hemisphere has shorter days and winter. Six months later, the reverse happens.

8. Describe solar and lunar eclipses with differences.

Answer:

1. Solar Eclipse:

- Occurs when the Moon comes between Earth and Sun.
- Moon's shadow falls on Earth, blocking sunlight.
- Can be partial or total.
- Example: Observed during daytime.

2. Lunar Eclipse:

- Occurs when Earth comes between Sun and Moon.
- Earth's shadow falls on the Moon, making it dark.
- Seen by people on the night side of Earth.

Conclusion: Eclipses are fascinating celestial events that help us understand the alignment and motion of Earth, Moon, and Sun.

Gap Analyzer™
Complete Chapter Test

EXERCISE

A. Choose the correct answer.

1. The Earth's spinning motion on its own axis is called:
   (a) Revolution ☐ (b) Rotation ☐
   (c) Orbit ☐ (d) Eclipse ☐
2. Which phenomenon is directly caused by Earth's rotation?
   (a) Seasons ☐ (b) Leap years ☐
   (c) Day and night ☐ (d) Lunar eclipses ☐
3. The Earth's path around the Sun is known as its:
   (a) Axis ☐ (b) Equator ☐
   (c) Orbit ☐ (d) Meridian ☐
4. A total solar eclipse occurs when the alignment of celestial bodies is:
   (a) Sun - Earth - Moon ☐ (b) Sun - Moon - Earth ☐
   (c) Moon - Sun - Earth ☐ (d) Earth - Sun - Moon ☐
5. During which phase of the Moon can a lunar eclipse occur?
   (a) New Moon ☐ (b) First Quarter ☐
   (c) Full Moon ☐ (d) Last Quarter ☐

B. Fill in the blanks.

1. Earth completes one _________ in approximately 24 hours, causing day and night.
2. The longest day of the year in the Northern Hemisphere is marked by the _________ Solstice.
3. The path of Earth around the Sun is an _________ shape.
4. During a total solar eclipse, the darkest part of the Moon's shadow is called the _________.
5. It is _________ to view a lunar eclipse with the naked eye.

C. Write True or False.

1. Earth's rotation is responsible for the changing view of constellations in the night sky. _________
2. Perihelion is the point in Earth's orbit where it is farthest from the Sun. _________
3. The "blood moon" effect during a total lunar eclipse is due to sunlight being refracted by Earth's atmosphere. _________
4. A leap year has 365 days. _________
5. The Sun and Moon have the same actual physical size, which allows for eclipses. _________

D. Define the following terms.

1. Rotation (of Earth)
2. Revolution (of Earth)
3. Axial Tilt
4. Umbra
5. Solar Eclipse

E. Match the columns.

	Column A		Column B
1.	Day and Night	(a)	Earth's farthest point from Sun
2.	Seasons	(b)	Sun-Moon-Earth alignment
3.	Aphelion	(c)	Caused by Earth's rotation
4.	Total Lunar Eclipse	(d)	Sun-Earth-Moon alignment, Moon turns red
5.	Solar Eclipse	(e)	Caused by axial tilt + revolution

F. Assertion and Reason

Directions: In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is NOT the correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

(e) Both A and R are false.

1. **Assertion (A):** The Sun appears to rise in the east and set in the west.

   Reason (R): Earth rotates from west to east.

2. **Assertion (A):** A lunar eclipse occurs during every full moon.

   Reason (R): The Moon's orbit is tilted with respect to Earth's orbit around the Sun.

3. **Assertion (A):** Seasons on Earth are caused by Earth's changing distance from the Sun.

   Reason (R): Earth's axis is tilted as it revolves around the Sun.

G. Give reasons for the following statements.

1. We experience day and night because the Earth rotates on its axis.
2. The Sun appears to move across the sky due to the rotation of the Earth.
3. Seasons change due to Earth’s tilt and revolution.
4. Looking at a solar eclipse can harm the eyes.

H. Answer in brief.

1. Explain how Earth's rotation creates the cycle of day and night.
2. What are the two main types of eclipses and their Sun, Earth, Moon alignments?
3. How does the Earth's axial tilt lead to different seasons?
4. Why don't eclipses occur every month, despite the Moon's monthly cycle?

I. Answer in detail.

1. Analyze the combined effects of Earth's rotation and revolution. Explain how rotation leads to day and night and the apparent movement of celestial bodies.
2. Describe the specific alignment required for a solar eclipse. Explain the difference between the umbra and penumbra and how they relate to total, partial, and annular solar eclipses.
3. Discuss the various ways the Earth's revolution and axial tilt influence our lives. Explain how these astronomical phenomena directly impact our calendar system, agricultural practices, and the biological behaviors of animals.

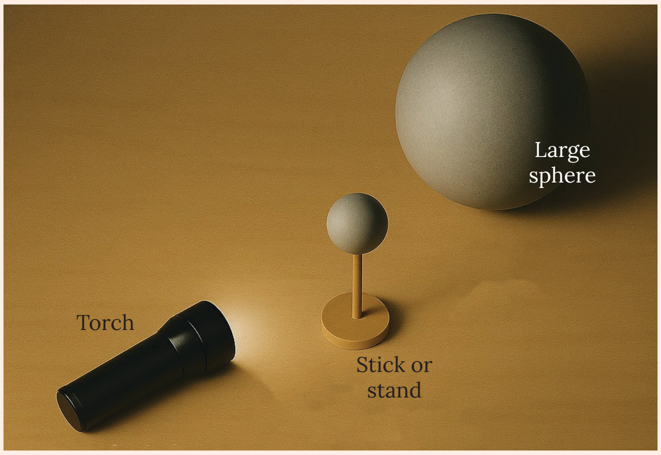
SKILL-BASED PRACTICE

Activity Time

STEM

Modelling an Eclipse

Materials Needed: A bright light source, A larger sphere, A smaller sphere, A darkened room, A stick or stand to hold the "Moon" sphere



Materials Required

Activity Steps:

1. Place the lamp (Sun) at one end of the room.
2. One student holds the basketball (Earth) away from the Sun.
3. Another student holds the smaller ball (Moon) on a stick.
4. **Solar Eclipse:** Keep the Moon between the Sun and Earth so its shadow falls on Earth.
5. **Lunar Eclipse:** Keep the Earth between the Sun and Moon so its shadow falls on the Moon.

Questions:

1. What did you observe on the "Earth" during the solar eclipse model?
2. What did you observe on the "Moon" during the lunar eclipse model?
3. Why is the "Moon's" shadow smaller on the "Earth" than the "Earth's" shadow on the "Moon"?
4. What is the importance of having a dark room for this model?

Skills Covered: Model Building, Observation, Understanding Eclipse Geometry, Spatial Reasoning

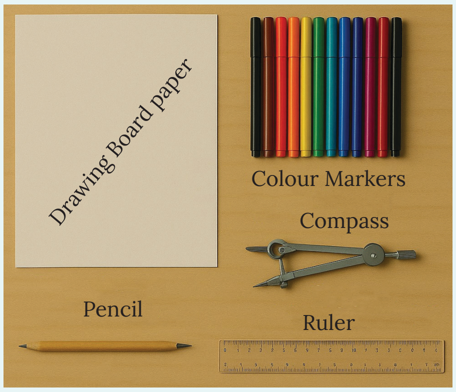
Creativity

Art

"Celestial Motion" Diagram

Task: Design a large, artistic poster or diagram that visually represents the rotation of Earth, the revolution of Earth around the Sun, and the revolution of the Moon around Earth. Use arrows to show motion, and include small illustrations for key concepts (e.g., day/night, seasons, phases of Moon, an eclipse alignment).

Materials: Drawing board paper, Coloured markers, pencils, or paints, Compass or string to draw orbits, Ruler



Materials Required

Questions:

1. How did you distinguish between rotation and revolution in your diagram?
2. What visual elements did you use to show the cause of seasons?
3. How did you represent the alignment for a solar and/or lunar eclipse?

Skills Covered: Creativity, Visual Representation, Communication of Scientific Concepts

Time and Seasons Inquiry

Group Activity

Investigating Day Length and Temperature

Activity Instructions: Work in a group to research and analyze data.

1. **Data Collection (Simulated/Real):**
   - ✦ Find a reliable online source (e.g., weather website, astronomical almanac) to find the approximate daylight hours and average monthly temperatures for a city in the Northern Hemisphere (e.g., London, New York) and a city in the Southern Hemisphere (e.g., Sydney, Buenos Aires) for at least four months: January, April, July, and October.
2. **Comparison:** Create a simple table to compare the daylight hours and temperatures for both cities across these months.
3. **Analysis:** Discuss your findings within your group.

Questions:

1. In which months did the Northern Hemisphere city have longer daylight hours and higher temperatures? What season would this represent?
2. In which months did the Southern Hemisphere city have longer daylight hours and higher temperatures? What season would this represent?
3 Explain how Earth's revolution and axial tilt cause the variations in daylight hours and temperature you observed.

Skills Covered: Research & Data Collection, Data Analysis, Understanding Seasons, Critical Thinking

A Year on Planet Zorp

Case Study

Imagine a fictional planet called Zorp. This unusual planet has some very different features compared to Earth. Zorp spins on its axis once every 10 Zorp-hours, which means its days are much shorter than Earth's. The people (or creatures) living there would experience sunrise and sunset many times in what we call one Earth-day. Interestingly, Zorp's axis has no tilt at all; it stands perfectly upright as it moves around its star. Because of this, the planet does not experience any seasons—there would be no summer, winter, spring, or autumn. Instead, the amount of sunlight stays the same all year round, and every place on Zorp would receive equal day and night cycles without big changes. Zorp also takes 400 Zorp-days to complete one full revolution around its star. This means its year is made up of exactly 400 short days. Compared to Earth's 365 days, Zorp's year is a little longer, but since each day is much shorter, the creatures on Zorp would count many more sunrises and sunsets in a year. Life on such a planet would be very different from Earth.

Questions:

1. How long is one Zorp-day?
2. Would Zorp experience distinct seasons (like summer, winter, spring, autumn)? Why or why not?
3. How long is one Zorp-year in Earth-day equivalents?
4. If Zorp has a moon, and its moon passes between Zorp and its star, what kind of event would Zorp experience?
5. Would Zorp's Moon ever appear "red" during an eclipse if Zorp has an atmosphere? Explain.

Skills Covered: Classification, Analysis, Teamwork, Communication, Scientific Investigation

Earth, Moon, and Sun

Source Based Question

Source Passage (NASA Science, Earth Observatory, June 2021):

Image Credit: NASA

"According to NASA's Earth Observatory, the Earth, Moon, and Sun are locked in a constant motion that shapes life on our planet. The Earth spins on its axis once every 24 hours, which creates day and night. It also moves around the Sun once every year, causing the cycle of seasons. Meanwhile, the Moon completes one orbit around the Earth every 27.3 days and shows different phases depending on its position relative to the Sun and Earth.

These motions also lead to rare but spectacular events.
A solar eclipse occurs when the Moon passes between the Earth and the Sun, briefly blocking sunlight. A lunar eclipse happens when Earth's shadow falls on the Moon. NASA scientists explain that the gravitational pull of the Moon, together with the Sun, creates tides that rise and fall in Earth's oceans. By studying these motions, scientists can improve calendars, understand climate patterns, and even plan future space missions. The Earth-Moon-Sun system is not only a subject of science but also a guide for human culture, agriculture, and exploration for thousands of years."

Questions:

1. **Understanding the System**
   - How does the Earth's rotation affect our daily life?
   - Why do we see different phases of the Moon each month?
2. **Cause and Effect**
   - What causes solar and lunar eclipses?
   - How do the Moon and Sun together affect ocean tides?
3. **Thinking Deeper**
   - Why do you think ancient people used the Earth, Moon, and Sun to make calendars?
   - How might studying this system help future space exploration?

Skills Covered: Observation, Curiosity, Critical thinking, Connecting real-life observations