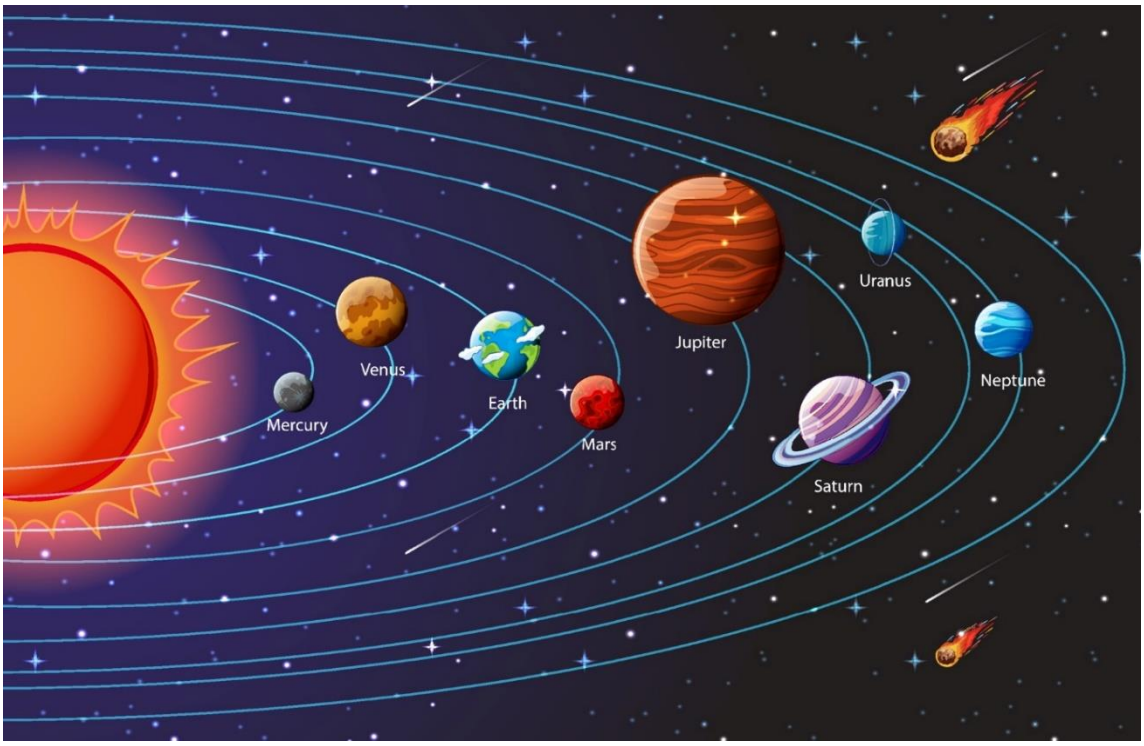
Theme: Earth and Space Physics

TOPIC: THE SOLAR SYSTEM

Competency: *The learner should understand the relative movement of the earth and moon in relation to the sun and explain the consequences for the Earth.*

LEARNING OUTCOMES The learner should be able to:	SUGGESTED LEARNING ACTIVITIES
a. know the relative sizes, positions, and motions of the earth, sun and moon (k, u) b. understand how day and night occur and demonstrate the phases of the moon (u, s) c. understand the roles of the sun, earth and moon in explaining time, seasons, eclipses, and ocean tides (k, u, gs) d. know the components of the solar system and their positions (k) e. know the main characteristics of the inner and outer planets in the solar system(k) f. understand the various views about the origin and structure of the universe (k, v/a	• In pairs, learners research and explain ona poster; • how the Earth orbits around the sun and the moon around the Earth and the time taken for these orbits • the cause of day and night • why the shape of the moon appears to change over a period of time when viewed from the Earth • how the tilt of the Earth gives rise to seasons in some parts of the world • the implications of the above for activities on Earth • In pairs, learners use a model to explain how the earth and moon move relative to the sun and use it to explain eclipses. • In groups, learners research, discuss and report on the connection between the moon and ocean tides. • In pairs, learners research and report on: • the components of the solar system, and make a scale model of the planets and place them in order showing their relative distance from the Sun • the main characteristics of the inner four and outer four planets • why the Earth is the only planet which supports life • In groups, learners research, discuss and explain, using an appropriate medium: • the asteroid belt and where it is found in the Solar System • the origin and structure of the universe

THE SOLAR SYSTEM



The components of the solar system and their positions

The solar system consists of **eight planets** (Mercury, Mars, Venus, Earth, Neptune, Uranus, Saturn, and Jupiter), **dwarf planets**, **asteroids**, **comets**, and other objects. The positions of the planets vary as they orbit the Sun. Here's a brief overview of the components and their relative positions:

1. The **Sun**: The centre of the solar system, a star that provides light and heat.
2. The **Inner Planets**:
   - Mercury: Closest to the Sun, smallest planet.
   - Venus: Second planet from the Sun, hottest planet.
   - Earth: Third planet from the Sun, home to diverse life forms.
   - Mars: Fourth planet from the Sun, also known as the Red Planet.
3. The **Outer Planets**:
   - Jupiter: Largest planet, fifth from the Sun, gas giant.
   - Saturn: Sixth planet from the Sun, known for its rings, gas giant.
   - Uranus: Seventh planet from the Sun, icy planet, tilted axis.
   - Neptune: Eighth and farthest planet from the Sun, icy planet.
4. **Dwarf Planets**:
   - Pluto: In the Kuiper Belt, a region of icy bodies.
   - Eris: In the scattered disc, a distant region.
   - Ceres: In the asteroid belt between Mars and Jupiter.
5. **Asteroids**: Small rocky objects, mostly in the asteroid belt.
6. **Comets**: Icy bodies that release gas and dust when near the Sun.
7. **Kuiper Belt**: A region of icy bodies and small celestial objects.
8. **Oort Cloud**: A distant, spherical shell of icy bodies surrounding the solar system.

The asteroid belt and where it is found in the solar system

The asteroid belt is a region of space between the orbits of Mars and Jupiter where most of the asteroids in our Solar System are found orbiting the Sun.
The asteroid belt probably contains millions of asteroids. Here are some key points about the asteroid belt:

- **Origin**: The asteroid belt is thought to be made up of material that was never able to form into a planet or the remains of a planet that broke apart a very long time ago.
- **Location**: The asteroid belt is located between the orbits of Mars and Jupiter, roughly spanning the space between them.
- **Shape**: The asteroid belt is torus-shaped, meaning it is shaped like a doughnut.
- **Size**: The asteroid belt is estimated to contain between 1.1 and 1.9 million asteroids larger than 1 kilometre in diameter, and millions of smaller ones.
- **Composition**: Asteroids are rocky, airless remnants left over from the early formation of our solar system.
- **Types**: There are three broad composition classes of asteroids: C-type (chondrite), S-type ("stony"), and M-type (metallic).
- **Orbits**: Asteroids in the asteroid belt have elliptical orbits around the Sun, and they also rotate, sometimes quite erratically, tumbling as they go.
- **Moons**: More than 150 asteroids are known to have a small companion moon, and some have two moons.

The main characteristics of the inner and outer planets in the solar system

Below are the main characteristics of the inner and outer planets in the solar system:

a) **Inner Planets**: Mercury, Venus, Earth, and Mars
Characteristics:
- Terrestrial planets (rock and metal)
- Closer to the Sun (warmer)
- Smaller and denser
- Fewer moons
- Thin atmospheres
- Geologically active

b) **Outer Planets**: Jupiter, Saturn, Uranus, and Neptune
Characteristics:
- Gas giants (hydrogen and helium)
- Larger and less dense
- Farther from the Sun (colder)
- Thick atmospheres
- Many moons
- Ring systems

Why Earth is the only known planet that supports life

1. Unique Distance from the Sun: Earth is positioned at an optimal distance from the Sun, allowing for liquid water to exist and supporting life.
2. Atmosphere: Earth's atmosphere is composed of 78% nitrogen, 21% oxygen, and trace amounts of other gases, providing a perfect balance for life to thrive.
3. Water: Earth is the only planet with liquid water, essential for life as we know it.
4. Magnetic Field: Earth's magnetic field protects life from harmful solar and cosmic radiation.
5. Plate Tectonics: Earth's dynamic plate tectonics create diverse environments and ecosystems, supporting a wide range of life forms.
6. Moon's Influence: The Moon's gravitational pull stabilizes Earth's axis, allowing for a relatively constant climate.
7. Organic Compounds: Earth's surface and atmosphere contain organic compounds, building blocks of life.
8. Temperature Range: Earth's temperature range allows for liquid water and supports life processes.
9. Solar Energy: Earth receives the perfect amount of solar energy to support life.
These factors combined create a habitable environment, making Earth the only known planet supporting life. The search for life beyond Earth continues, with scientists exploring possibilities on Mars, exoplanets, and beyond!

Relative sizes, positions, and motions of the earth, sun, and moon

Relative Sizes:

- Earth: diameter of approximately 12,742 kilometres (7,918 miles)
- Sun: diameter of approximately 1,392,684 kilometres (865,374 miles) - about 109 times larger than Earth
- Moon: diameter of approximately 3,475 kilometres (2,160 miles) - about 1/4 the size of Earth

Relative Positions:

- Earth orbits the Sun at an average distance of approximately 149.6 million kilometres (92.96 million miles)
- Moon orbits Earth at an average distance of approximately 384,400 kilometres (238,900 miles)

Motions:

- Earth rotates on its axis from west to east, completing one rotation in approximately 24 hours
- Earth orbits the Sun in an elliptical orbit, completing one orbit in approximately 365.25 days (1 year)
- Moon orbits Earth in an elliptical orbit, completing one orbit in approximately 27.3 days (lunar month)

- Moon also rotates on its axis, but is tidally locked to Earth, meaning it always shows the same face to our planet
- The Sun is the centre of our solar system, and the Earth and other planets orbit around it due to its massive gravity.
- The Moon's orbit is gradually increasing in distance from Earth at a rate of about 3.8 centimetres (1.5 inches) per year.
- The Earth's rotation is gradually slowing down due to the Moon's gravitational pull, which is why we have leap seconds to account for the difference.

Origin of day and night

Day and night occur due to the **Earth's rotation on its axis** and its **orbit around the Sun**. Here's a simplified explanation:

1. **Earth's Rotation**: The Earth rotates from west to east, which means it spins around its axis from the Pacific Ocean towards the Atlantic Ocean. This rotation causes different parts of the planet to face towards or away from the Sun, resulting in day and night.
2. **Day**: When a region on Earth faces the Sun, it receives direct sunlight, experiencing daytime. The Sun's rays illuminate the atmosphere, scattering shorter wavelengths of light (like blue and violet) more than longer wavelengths (like red and orange), giving the sky its blue colour.
3. **Night**: As the Earth continues its rotation, the region moves away from the Sun's direct light, entering the Earth's shadow. This area no longer receives direct sunlight, resulting in nighttime. The sky can take on hues of orange, pink, and purple during sunset and twilight due to the scattering of light by atmospheric particles.
4. **Earth's Orbit**: The Earth's orbit around the Sun affects the duration and intensity of day and night. As the Earth moves closer to the Sun (perihelion), the days are slightly longer, and as it moves farther away (aphelion), the days are slightly shorter.
5. **Seasonal Variations**: The tilt of the Earth's axis (about 23.5 degrees) and its orbit around the Sun also cause seasonal changes in day length and intensity. During summer in the Northern Hemisphere, the North Pole is tilted towards the Sun, resulting in longer days and more direct sunlight. Conversely, during winter, the North Pole is tilted away from the Sun, leading to shorter days and less direct sunlight.

In summary, day and night occur due to the Earth's rotation, which causes different regions to face towards or away from the Sun, combined with its orbit around the Sun, which affects the duration and intensity of daylight throughout the year.

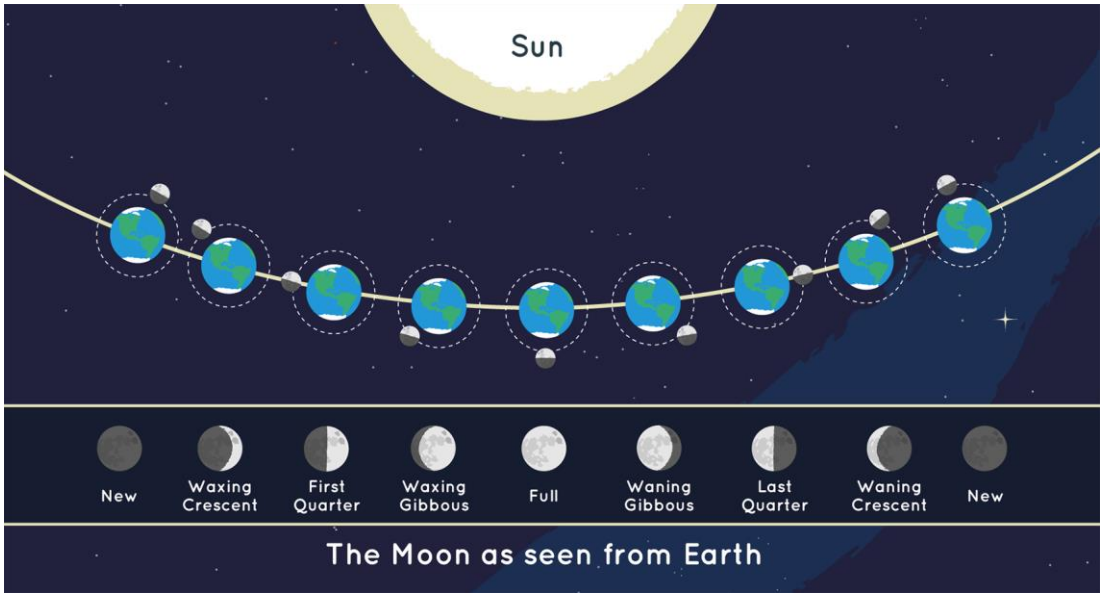
The phases of the moon

The phases of the moon are the different ways the moon appears as it orbits around the Earth. Here's a demonstration of the phases of the moon:

- **New Moon**: This is the first phase of the moon, where the side of the moon facing the Earth is not illuminated by the sun.

- **Waxing Crescent**: As the moon moves away from the new moon phase, we start to see a small sliver of light on the right side of the moon. This phase is called the waxing crescent moon.
- **First Quarter**: As the moon continues to move, we see half of the moon's illuminated surface. This phase is called the first quarter moon.
- **Waxing Gibbous**: The moon continues to appear larger and fuller as it approaches full moon. This phase is called the waxing gibbous moon.
- **Full Moon**: When the entire face of the moon is illuminated by the sun, we see a full moon.
- **Waning Gibbous**: After full moon, the moon starts to appear smaller and thinner as it moves away from full moon. This phase is called the waning gibbous moon.
- **Last Quarter**: As the moon continues to move, we see half of the moon's illuminated surface again. This phase is called the last quarter moon.
- **Waning Crescent**: Finally, we see a small sliver of light on the left side of the moon as it approaches the new moon phase again. This phase is called the waning crescent moon.

Remember, the phases of the moon repeat every **29.5 days**, which is the time it takes the moon to complete one orbit around the Earth.



The roles of the sun, earth and moon in explaining time, seasons, eclipses and ocean tides

The sun, Earth, and moon play crucial roles in explaining various phenomena related to time, seasons, eclipses, and ocean tides:

1. Time:

- The sun's consistent daily movement across the sky helps us measure time (days, hours, minutes).
- The Earth's rotation and orbit around the sun determine our 24-hour day and 365.25-day year.

2. Seasons:

A season is a period of a year which is distinguished by special climate conditions.

- The Earth's tilt (23.5°) and orbit around the sun cause seasons:
- Northern Hemisphere: winter (away from sun), summer (toward sun)
- Southern Hemisphere: vice versa

Uganda and the **East African region** experience a **tropical climate** with two main seasons: the wet season and the dry season.

a) Wet Season (March to May and September to November)

- Characterized by heavy rainfall and high humidity
- Temperatures range from 20-25°C (68-77°F)
- This season is ideal for agriculture, and it's the main planting season
- The wet season is also a great time for outdoor activities like hiking and wildlife viewing

b) Dry Season (December to February and June to August)

- Characterized by dry and sunny conditions with minimal rainfall
- Temperatures range from 15-20°C (59-68°F)
- This season is ideal for tourism, as the weather is conducive for outdoor activities like wildlife viewing, hiking, and cultural tours
- The dry season is also a great time for farming, as the dry conditions make it easier to harvest crops

Regional Variations

- In Uganda, the mountainous regions like the Rwenzori Mountains and Mount Elgon experience a cooler climate with more rainfall than the lower-lying areas.
- In Kenya, the coastal regions experience a more humid climate than the inland regions.
- In Tanzania, the northern regions like the Serengeti and Ngorongoro experience a more temperate climate than the southern regions.

Impact on Agriculture and Daily Life

- The wet season is ideal for planting crops like maize, beans, and rice, while the dry season is ideal for harvesting.
- The dry season can be challenging for farmers, as it requires irrigation to sustain crops.
- The seasons also impact daily life, as the wet season can make roads impassable, while the dry season can lead to water scarcity.

The Four Seasons

In most countries, including all western countries, the year is basically divided into **four** seasons; that is spring, summer, autumn (fall) and winter seasons. The seasons occur because of two factors;

- Motion of the earth around the sun
- Rotation of the earth about its axis

The time of year a region experiences a season depends on whether it is in the Northern or Southern Hemisphere. Seasons in the Southern Hemisphere are opposite to those in the Northern Hemisphere. For example, when the Southern Hemisphere experiences winter its northern neighbours encounter summer.

Spring:

- Typically begins around March 20/21 (vernal equinox)
- Lasts for about 3 months
- Characterized by:
  - Warmer temperatures
  - Increased daylight hours
  - Blooming flowers and greenery
  - Rainfall and thunderstorms

Summer:

- Typically begins around June 20/21 (summer solstice)
- Lasts for about 3 months
- Characterized by:
  - Warmest temperatures of the year
  - Longest daylight hours
  - School vacations and summer breaks
  - Outdoor activities like swimming, camping, and sports

Autumn (or Fall):

- Typically begins around September 22/23 (autumnal equinox)
- Lasts for about 3 months
- Characterized by:
  - Cooler temperatures
  - Decreasing daylight hours
  - Leaves changing colours and falling
  - Harvest season for crops

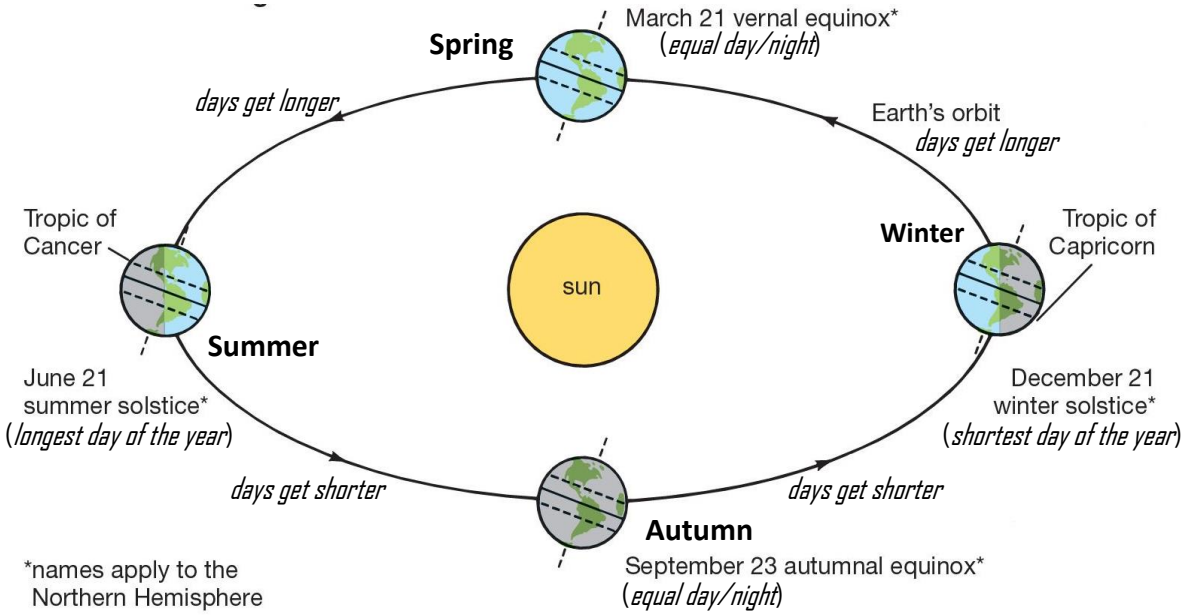
Winter:

- Typically begins around December 21/22 (winter solstice)
- Lasts for about 3 months
- Characterized by:
  - Coldest temperatures of the year
  - Shortest daylight hours
  - Snowfall and frost
  - Holiday seasons like Christmas and New Year's

Important Dates:

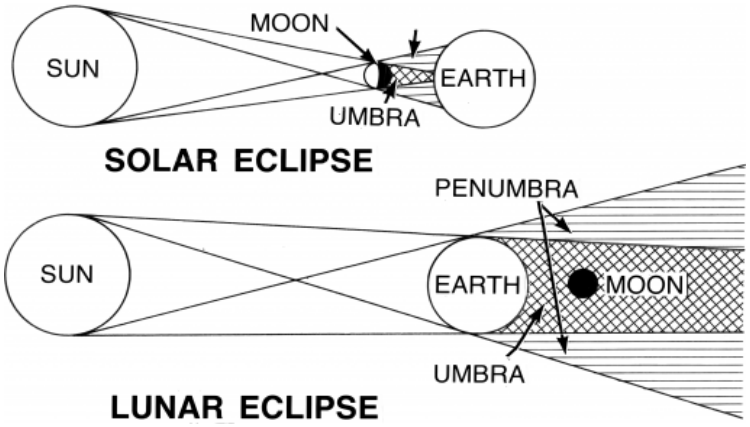
- Vernal equinox (spring): March 20/21
- Summer solstice (summer): June 20/21
- Autumnal equinox (autumn): September 22/23
- Winter solstice (winter): December 21/22

Note: The exact dates of the seasons can vary slightly from year to year due to Earth's elliptical orbit around the sun and the tilt of its axis.



3. Eclipses:

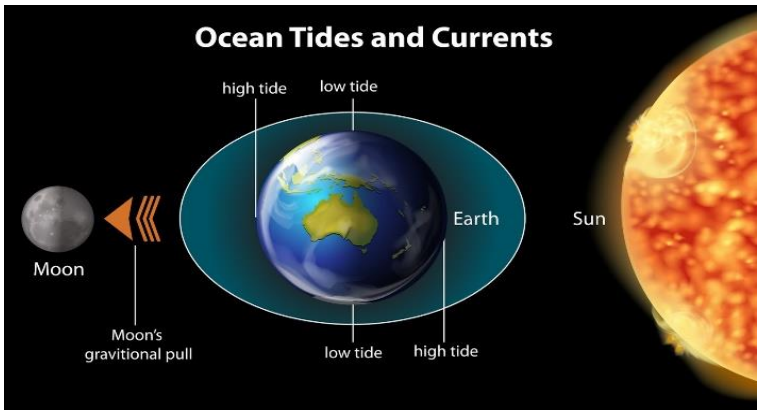
- Solar eclipses: moon passes between Earth and sun, blocking sunlight
- Lunar eclipses: Earth passes between sun and moon, casting a shadow on the moon



4. Ocean Tides:

Gravitational pull of the moon (and sun) on Earth's oceans causes tides:

- High tide: moon's pull causes ocean bulge
- Low tide: moon's pull causes ocean recede



The various views about the origin and structure of the universe

The most widely accepted explanation for the origin and structure of the universe is the Big Bang Theory, which posits that the universe began as an incredibly hot and dense point around 13.7 billion years ago.

The Big Bang expanded the universe, and matter condensed into clouds that eventually became galaxies. In these galaxies, gas and dust formed distinct clouds, and some of these clouds collapsed into stars. Around some of these stars, more gas and dust formed planets.

The solar system is believed to have been formed with the planets being created from the disc of matter left over from gravitational attraction that pulled together clouds of hydrogen gas and dust that formed the sun. When the material rotated around the sun, the gravitational attraction between small pieces caused them to join together and grow in size. The rotating disc is believed to have been formed from which the planets emerged.

The whole solar system was formed from the rotating disc supported by the fact that the orbits of the planets are more or less in the same plane making all the planets to revolve around the sun in the same direction.

Structure of the Universe

- Galaxies and Stars: The universe has an infinite number of galaxies and solar systems, and each galaxy is moving away from each other.
- Dark Matter and Dark Energy: The universe is made up of ordinary matter (4.9%), dark matter (26.8%), and dark energy (68.3%).
- Expansion: The universe is expanding, and the rate of expansion is increasing.

TOPIC: STARS AND GALAXIES

Competency: *The learner should be able to understand the life-cycle of stars and the source of their energy*

LEARNING OUTCOMES The learner should be able to:	SUGGESTED LEARNING ACTIVITIES
a. know the source of energy in stars and appreciate the importance of the energy produced by the sun to the people on Earth (k, u) b. appreciate that stars vary in colour and brightness(u) c. know that stars have life cycles and that the fate of stars (white dwarfs, neutron stars and black holes) depends on their initial size (k, u)	• In pairs, learners research and explain in a diagram: • how the sun produces the energy needed for life to survive • that the sun is a relatively small star which will eventually become a red giant, and then a white dwarf • the approximate amount of energy produced by the sun per second, the proportion of the sun's energy reaching the Earth's surface and the proportion of that which is captured for photosynthesis • In pairs, learners research, explain, and report on: • the variation in colour and brightness of stars in the Milky Way in terms of their size and distance from Earth • the different stages in the life cycle of a star • how the nuclear reactions that provide the energy in stars change as they grow older, and that they get hotter • what neutron stars and black holes are and how they were formed • what a supernova is and how it arises

Stars

A star is a massive, luminous ball of gas that is held together by its own gravity. Stars are primarily composed of hydrogen and helium, and they generate energy through nuclear reactions that occur in their cores.

Stars range in size from the size of Earth to 1,000 times the diameter of the Sun. Stars can have more mass and be smaller than our Sun, or they can have less mass and be larger than our Sun.

A star moving towards the Earth will be shifted towards the blue end of the spectrum, while stars moving away from Earth will show a shift towards red.

Here are some key characteristics of stars:

1. **Mass**: Stars come in a range of masses, from about 0.1 to 100 times the mass of the Sun.
2. **Surface Temperature**: Stars have surface temperatures that range from about 3,000 to 50,000 Kelvin (K).
3. **Luminosity**: Stars emit a tremendous amount of energy, with luminosities that range from about 0.01 to 100,000 times the luminosity of the Sun.
4. **Life Cycle**: Stars are born from giant molecular clouds and go through a life cycle that includes:
    a. Protostar
    b. Main Sequence
    c. Red Giant
    d. White Dwarf
    e. Neutron Star or Black Hole
5. **Types**: There are many types of stars, including:
    a. Main Sequence Stars (like the Sun)
    b. Red Giants
    c. White Dwarfs
    d. Neutron Stars
    e. Black Holes
    f. Brown Dwarfs
    g. Variable Stars
6. **Distances**: Stars are at various distances from us, ranging from a few light-years to millions of light-years away.
7. **Motion**: Stars move through space, with some having high velocities and others moving slowly.
8. **Age**: Stars have ages that range from a few million to billions of years.
9. **Composition**: Stars are made up of various elements, including hydrogen, helium, and heavier elements forged in their cores.
10. **Death**: Stars eventually die, with some ending in a supernova explosion and others fading away as white dwarfs.

Stars are incredibly diverse and play a crucial role in the universe, serving as the source of light and heat for planets and the foundation for life itself.

Source of energy in stars and the importance of the energy produced by the sun to the people on earth

The source of energy in stars is nuclear fusion, where hydrogen atoms fuse together to form helium, releasing energy in the process.
The energy produced by the sun is crucial for life on Earth, as it provides light, heat, and power for photosynthesis, which supports the food chain. Additionally, solar energy is harnessed by humans for electricity, cooking, and water purification, making it a vital component of our daily lives.

The sun's energy production and how much of it is utilized by Earth:

- Energy produced by the sun per second: The sun fuses about 620 million metric tons of hydrogen every second.
- Proportion of the sun's energy reaching the Earth's surface: About 30 percent of the solar energy that reaches Earth is reflected back into space. The rest is absorbed into Earth’s atmosphere.
- Proportion of the sun's energy captured for photosynthesis: Almost all life on Earth relies on solar energy for food, either directly or indirectly. Producers rely directly on solar energy. They absorb sunlight and convert it into nutrients through a process called photosynthesis.

Variation in colour and brightness of stars

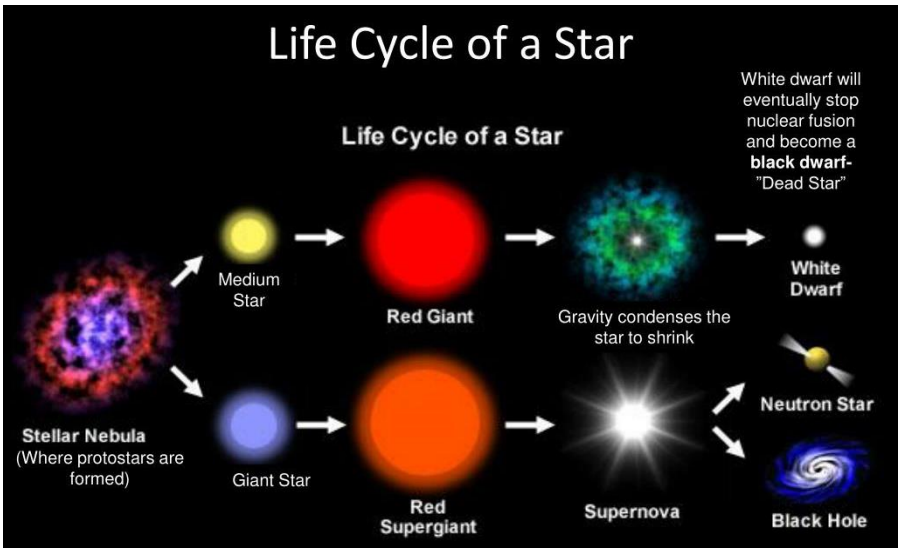
- The colour and brightness of stars vary based on their surface temperature, with hotter stars appearing blue and cooler stars appearing red.
- The brightness of a star is also related to its distance from Earth, with stars that are closer appearing brighter.
- Additionally, the size of a star can be determined by its colour, with blue stars typically being larger than red stars.

Life cycles of stars

The life cycle of a star is the process by which a star is born, lives, and dies. The stages of a star's life cycle are as follows:

1. **Formation**: Stars are born in nebulae, which are huge clouds of gas and dust.
2. **Main Sequence**: The stage at which a star fuses hydrogen into helium in its core and releases energy in the form of light.
3. **Red Giant**: When a star runs out of hydrogen fuel, it expands and cools, becoming a red giant.
4. **Helium Flash**: The star undergoes a brief helium flash, where helium fusion occurs in the core.

5. **White Dwarf**: The star contracts and cools, eventually becoming a white dwarf.
6. **Neutron Star** or **Black Hole**: If the star is massive enough, it will end its life in a supernova explosion, leaving behind either a neutron star or a black hole.
7. **Final Stage**: The final stage of a star's life cycle depends on its mass. Smaller stars will eventually become **black dwarfs**, while more massive stars will end as neutron stars or **black holes**.



Galaxies

Galaxies are massive, gravitationally bound systems consisting of stars, stellar remnants, interstellar gas, dust, and dark matter. The term is derived from the Greek word galaxias, meaning "milky," a reference to the Milky Way galaxy that contains our solar system.

Here are some key characteristics of galaxies:

Types of Galaxies

- **Spiral**: Spiral galaxies are defined by the presence of spiral arms and resemble giant rotating pinwheels with a pancake-like disk of stars and a central bulge or tight concentration of stars.
- **Elliptical**: Elliptical galaxies have shapes that range from completely round to oval. They are less common than spiral galaxies and usually contain little gas and dust and show very little organization or structure.
- **Lenticular**: Lenticular galaxies are a kind of cross between spirals and ellipticals. They have the central bulge and disk common to spiral galaxies but no arms.
- **Irregular**: Irregular galaxies have unusual shapes, like toothpicks, rings, or even little groupings of stars.
- **Active**: Around 10% of known galaxies are active, which means their centres appear more than 100 times brighter than the combined light of their stars.

Galaxy Facts

- The universe is made up of many different galaxies.
- The largest galaxies contain trillions of stars and can be more than a million light-years across.
- The smallest galaxies can contain a few thousand stars and span just a few hundred light-years.
- The Sun is one of the billions of stars in a galaxy called the Milky Way.
- Most large galaxies have supermassive black holes at their centres, some with billions of times the Sun's mass.
- Most galaxies are between 10 billion and 13.6 billion years old.
- Some are almost as old as the universe itself, which formed around 13.8 billion years ago.

TOPIC: SATELLITES AND COMMUNICATION

Competency: *The learner should be able to explain what artificial satellites are and how they are applied in space exploration and other fields*

LEARNING OUTCOMES The learner should be able to:	SUGGESTED LEARNING ACTIVITIES
a. understand what artificial satellites are and how we make use of them in research and in everyday life (u, s) b. appreciate the importance of space exploration (u, v/a)	In pairs, learners research and report on types of artificial satellite, particularly geostationary satellites and explain: • how they are used in GPS navigation systems • the value of photographs such as those taken by the Hubble Space Telescope. • the purpose of the International Space Station and its role in space exploration

Understanding what artificial satellites are and how they are made use of in research and in everyday life

Introduction

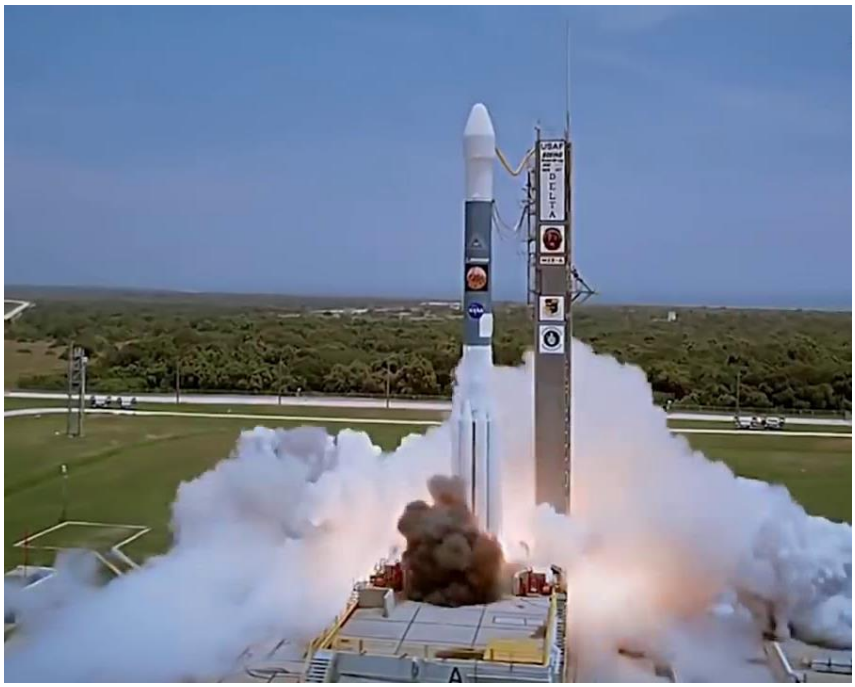
In everyday life we use telephones, listen to radios and watch television. These devices receive and transfer information through various equipment that are around the globe at different points.

There are objects (natural and artificial) that orbit planets such as our own Earth called satellites. The man-made satellites are used to relay analogue and digital information during communication and also for exploration of the space around the earth and the other planets.

Satellites

A satellite is an object that orbits around a larger object in space. The Earth and Moon are natural satellites that moves around the Sun and the Earth respectively.

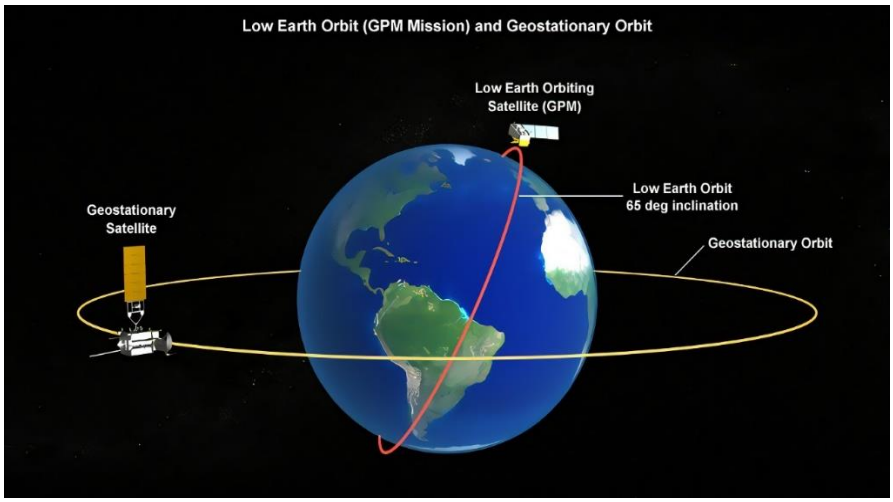
Artificial satellites are launched into space using rockets. The rocket gives the satellite a very high acceleration and velocity to overcome the pull of gravity.



The design, size and altitude of an artificial satellite depends on its purpose.

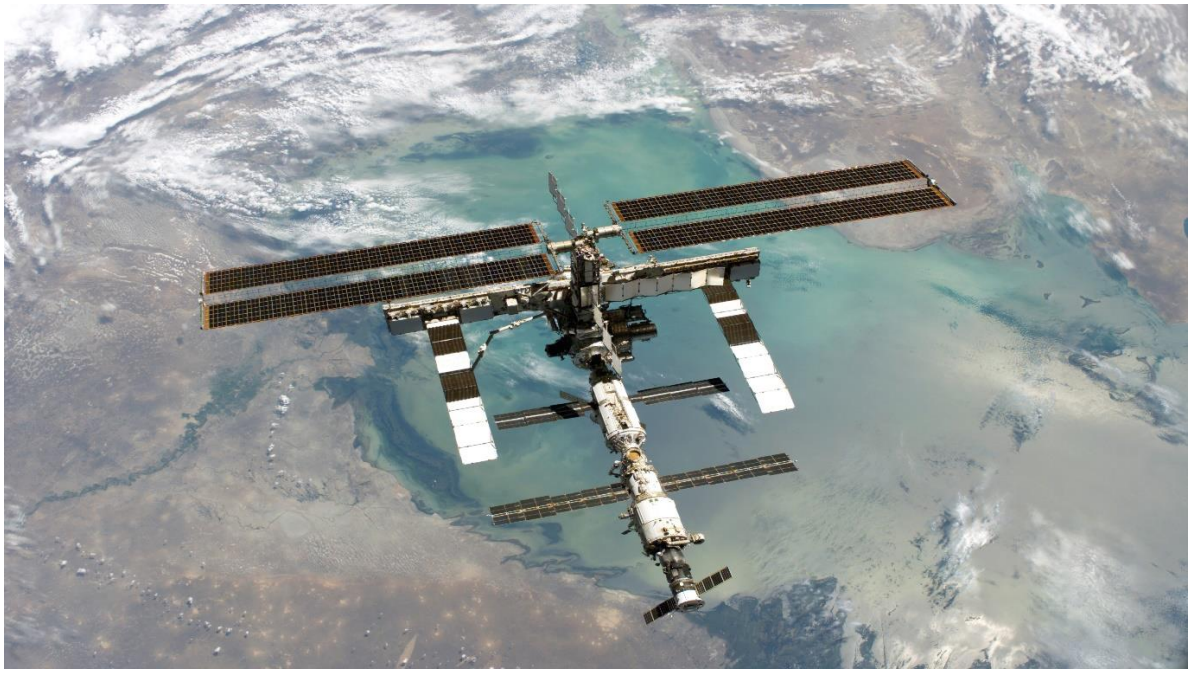
The path followed by a satellite when moving around a planet is called an orbit. Satellites move at different speeds in their orbits depending on the velocity with which they were launched.

The time spent by a satellite to complete one revolution is called its period.



Types of Artificial satellites:

There are thousands of artificial satellites that have been launched into orbits around the Earth and other planets. They have varying sizes with some as short as 10 cm and others about 7 m long and having solar panels measuring up to about 50m in length. The largest artificial satellite is the **International Space Station** (ISS).



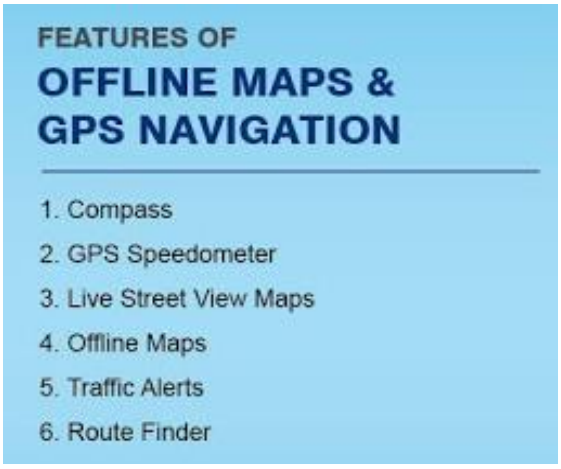
The **International Space Station** (**ISS**) shown in the picture above is the largest space station ever assembled and maintained in low Earth orbit by a collaboration of five space agencies and their contractors:

1. **NASA** (United States),
2. **Roscosmos** (Russia),
3. **JAXA** (Japan),
4. **ESA** (Europe), and
5. **CSA** (Canada).

The primary purpose of the International Space Station is to have an **international orbital laboratory** where microgravity and space environment experiments can be performed. The objective of the ISS is therefore to help in medical research, microgravity research, astrophysics, geology, weather prediction, and technology development amongst others.

Different satellites serve various purposes in space. They are used for:

1. **Navigation**: Global Positioning System (GPS) Satellites orbit at an altitude of 20,000 km above the surface of the Earth, and are used to calculate the exact location of a GPS receiver on Earth.

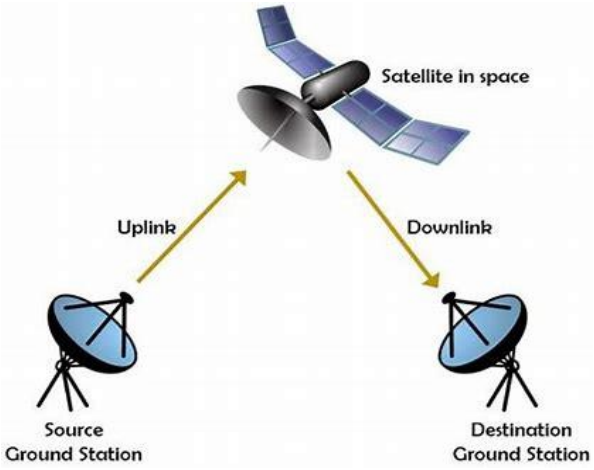


2. **Communication**: Communication satellites are used for television, phone or internet transmissions.

How do Satellites Enable Communication?

Satellites act as relay stations in the sky, receiving and transmitting signals between different locations on Earth. Here's how it works:

- **Uplink:** A signal is sent from a ground station or a user's device to the satellite.
- **Transponder:** The satellite receives the signal and amplifies it using a transponder.
- **Downlink:** The amplified signal is then transmitted back to Earth, where it's received by a ground station or user's device.



3. **Weather**: Weather satellites are used to image clouds and measure temperature and rainfall. Weather patterns is monitored to enable accurate forecasting and storm tracking.
4. **Earth observation**: Earth observation satellites are used to photograph and image the Earth. Valuable data is obtained for environmental monitoring, agriculture, and disaster response.
5. **Astronomy**: Astronomical satellites are used to monitor and image space.

Importance of space exploration

Space exploration is crucial for:

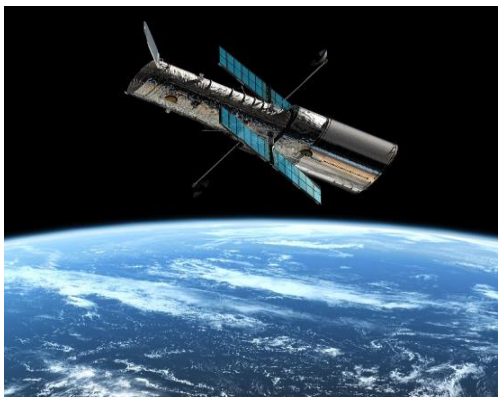
1. **Advancing Scientific Knowledge**: Understanding the universe, its origins, and the laws of physics.
2. **Improving Daily Life**: Spin-off technologies like GPS, weather forecasting, and telecommunications.
3. **Inspiring Future Generations**: Encouraging interest in STEM fields (science, technology, engineering, and mathematics).
4. **Potential Resources**: Access to minerals, water, and energy sources in space.
5. **Long-term Survival**: Ensuring humanity's survival by colonizing other planets.
6. **Understanding Earth**: Studying other planets and their environments to better understand our own planet.
7. **Medical Breakthroughs**: Space research leading to medical advancements, like remote health monitoring.
8. **International Cooperation**: Fostering global collaboration and diplomacy through joint space missions.
9. **Expanding Economic Opportunities**: Creating new industries, jobs, and markets through space exploration.
10. **Human Curiosity**: Satisfying our innate desire to explore and discover the unknown.

Space exploration benefits humanity in numerous ways, from scientific discoveries to practical applications and inspiring future generations.

The Hubble Space Telescope

The Hubble Space Telescope is a space telescope that was launched into low Earth orbit in 1990 and remains in operation. It was not the first space telescope, but it is one of the largest and most versatile, renowned as a vital research tool and as a public relations boon for astronomy.
The Hubble telescope is named after astronomer Edwin Hubble and is one of NASA's Great Observatories. The Space Telescope Science Institute selects Hubble's targets and processes the resulting data, while the *Goddard Space Flight Centre* controls the spacecraft.

The *Goddard Space Flight Centre* is located in Greenbelt, Maryland, Northeast of Washington, DC – USA.



Images taken by Hubble have **helped scientists estimate the age and size of the universe**. Scientists believe the universe is almost 14 billion years old. Hubble has helped scientists understand how planets and galaxies form. An image called the "Hubble Ultra Deep Field" shows the farthest galaxies ever seen.

SAMPLE QUESTIONS

Item 1

In a certain country, a Television (TV) reporter was reporting live near the ocean about the high tides during night time. Viewers in another country were watching the live broadcast of the news bulletin during day time. The viewers wondered how it could be day and night at the same time, and how the event in one country could be watched live on TV in another country.

Task

Use your knowledge of physics to help the viewers to understand;

(a) the possibility of it being day in one place and night in another place.

(b) the occurrence of high ocean tides.

(c) how an event in one place can be broadcast live in another country.

SCORING GUIDE

(a) The possibility of day in one place and night in another. This is caused by the rotation of the earth about its axis (spinning). A point directly taking the sun will experience day while the one on the other side of the earth will be experiencing darkness (night). As the earth rotates, the point ceases to be directly under the sun hence becoming dark. At this time, the other side of the earth will be experiencing day time.

(b) Occurrence of the high ocean tides. High tides are caused by the moon's gravitational pull. The tidal forces cause the earth and its water to bulge out on the side closest to the moon and the side furthest from the moon. These bulges are the high tides.

(c)
- *Images are picked by cameras and changed to a frequency (signals) suitable for satellite transmission.*
- *The signals are transmitted from a ground based satellite dish (station transmitter) to a satellite in a geo-stationary orbit.*
- *The signals are then amplified/modulated another frequency to satellite dishes on the earth's surface at TV stations.*
- *The received signals are decoded by a decoder and then sent to the television for display.*