THEME: EARTH AND SPACE PHYSICS

Under this theme, we shall study about the earth, everything above the earth, the sun, the solar system and beyond.

TOPIC 1: THE SOLAR SYSTEM

The solar system is the gravitation bound system bound of the sun and the objects that orbit it.

Components of the solar system

1. The sun
2. Planets
3. Asteroids
4. Comets
5. Moons

1. *Comets*

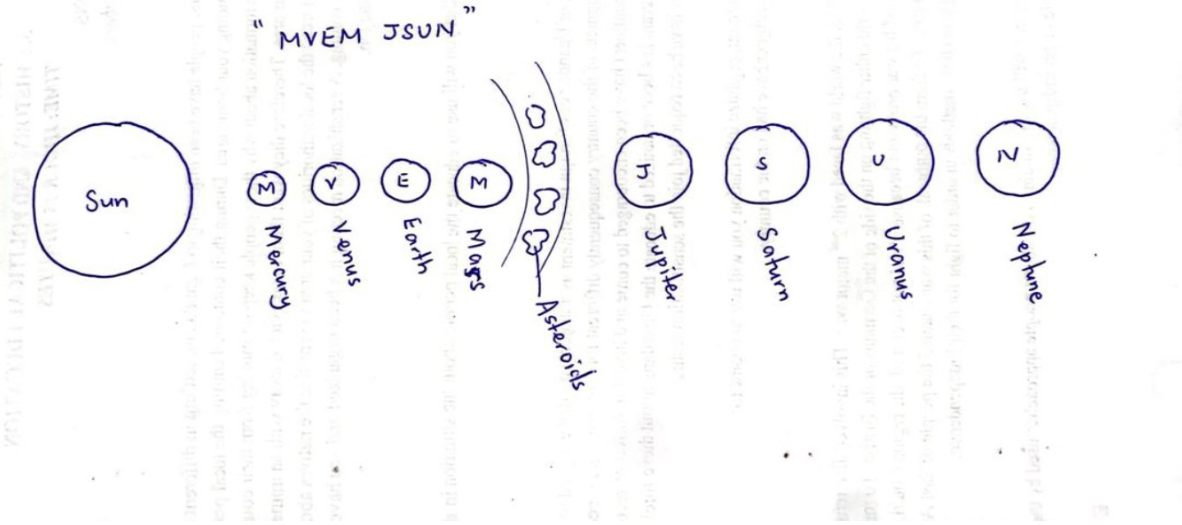
Comets are objects that move around the sun usually at a great distance from it.

Comets are cosmic snow balls of frozen gases, rocks, and dust that orbit the sun. eg Halley's comet

1. Asteroids

Asteroids are small rocky objects that orbit the sun between Mars and Jupiter.

3. Planets



Planets are both **terrestrial** (inner planets) and **Jovian planets** (outer planets)

3.1 ***Terrestrial planets (inner planets)***

Terrestrial planets are the four innermost planets in the solar system.

Examples of terrestrial planets

- Mercury (closest to the sun)
- Venus
- Earth
- Mars

3.2 Jovian planets (outer planets)

These are also known as the gas giants, are planets which are furthest from the sun

Examples of Jovian planets

- Jupiter
- Saturn
- Uranus
- Neptune

Differences between the inner planets and outer planets

The inner planets	**The outer planets**
They have small size	They have huge (big) size
They have solid surfaces and thin	They have balls of gas with no surface
They have greater density	They have smaller density
They have varied atmospheres	They have similar atmosphere
They spin slowly	They spin quickly
They orbit the sun quickly	They orbit the sun slowly
Few moons	Lots of moons

Despite of those planets lying in the two categories that is inner and outer planets, each of them has different features as shown below;

a) Mercury

- ✓ It is the smallest planet in the solar system
- ✓ It is the closest planet to the sun
- ✓ It is so close to the sun that the day time temperature is approximately 450^0C and that at night is -178^0C

b) Venus

- ✓ It is the second planet from the sun
- ✓ It is the brightest planet in our solar system
- ✓ It is called Earth's sister planet because they quite similar in size and gravity

c) Earth

- ✓ Its average temperature is 57^0C
- ✓ It is the third planet from the sun
- ✓ It has a satellite called **moon**
- ✓ It is the only planet in the entire solar system that has life because it has an atmosphere that contains 21% oxygen and liquid water on its surface.

d) Mars

- ✓ It has only two moons
- ✓ It is often called the red planet, is a rocky planet in the solar system
- ✓ It is the second smallest planet in the solar system

Features of the outer planets

e) Jupiter

- ✓ It is the fifth planet from the sun
- ✓ This is the largest planet in the solar system
- ✓ It has faint rings
- ✓ It has at least 79 known moons

f) Saturn

- ✓ It is the sixth planet from the sun
- ✓ It is the second largest planet in solar system
- ✓ It has very bright icy rings
- ✓ It has 82 unknown moons

g) Uranus

- ✓ It is the seventh planet from the sun
- ✓ It spins backwards in an opposite direction to the rest of the planets
- ✓ It spins very fast, takes only 17 hours for a complete rotation

h) Neptune

- ✓ It is the farthest planet from the sun
- ✓ It has 14 known moons
- ✓ Its surface is extremely cold

Note:

1. Jupiter size is more than two and half times all the other planets in the solar system. It has the same composition as the sun, the only difference is that its gases do not burn.
2. You cannot stand on the surface of any of the outer planets because they don't have a solid surface, they are gaseous.
3. **Asteroid belt** is a cloud of solid rock and metallic bodies orbiting the sun. It is found between the orbits of Jupiter and Mars. It acts as a boundary between the inner rocky planets and outer gas giant planets.
4. An orbit is a regular repeating path that one object in space takes around another one.

Qn. Why do outer planets have more moons and rings

Moons:The outer planets are big hence they have high gravity and the are distant from the sun. This means that a larger gravitational pull is able to control more moons revolving around the planet.

Rings: Because the rings are made of frozen icy dust, and the sun is too hot and close to to inner planets for the rings to form.

THE EARTH

The earth's surface is divided into continents, oceans, and crustal planets. The planet's interior is composed of a solid iron core and a molten outer core.

The atmosphere protects life on earth by absorbing harmful radiation and maintaining a stable climate.

Earth is home to vast oceans, lakes, rivers and ground water covers approximately 71% of the planet's surface

The force that keeps the earth's orbit around the sun is called **gravitational force** between the planets and the sun**.**

THE SUN

The sun is the star at the center of the solar system. It is the only star in the solar system.

It is a massive, hot ball of plasma which is heated by energy produced by **nuclear fusion** reactions at its center.

MOTION OF PLANETS AROUND THE SUN.

The motion of planets is both **rotational** and **revolutional**.

Rotation involves the planets spinning about a fixed axis and **revolution** involves a planet travelling around the sun.

One complete rotation is equal to the one day plus night and one complete revolution is equal to a year.

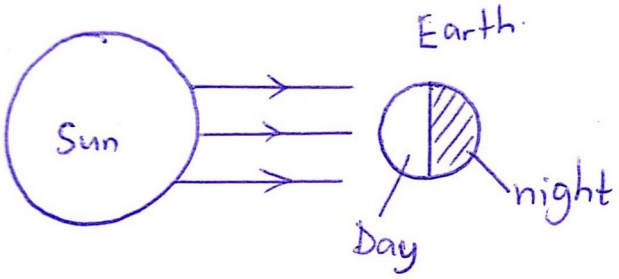
DAYS AND NIGHT

Day and night is caused by:

1. The earth is **spherical** in shape and

2. The **rotation** of the earth about its axis (spinning).

As the earth rotates about its axis, the part facing the sun receives sunlight and it is day. The part facing away from the sun will receive no sunlight, it is darkness hence it will experience night.

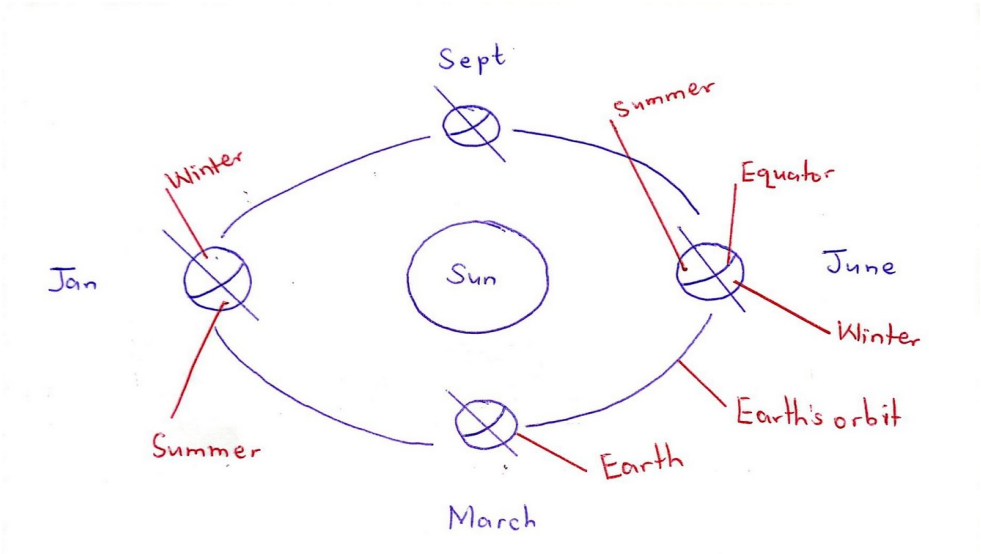


Note:

1. The earth rotates from west to east that is why the sun appears to be moving across the earth from east to west.

2. The only reason why you cannot feel the movement of the earth is because the earth is very big and its movement is very regular since there is no resistance to its motion.

THE SEASONS ON EARTH



Seasons are caused by:

1. **Revolution** of the earth around the sun.

2. The earth's axis is **tilted** at 23.5°

Hence different areas on earth receive more solar energy than others. This results into changes in weather and climatic conditions of various regions on earth.

When the northern hemisphere is tilted towards the sun, it experiences **Summer** and when it is tilted away from the sun, it experiences **Winter**.

Uganda is in the equatorial region and it experiences **dry** and **wet** seasons.

It experiences wet season when the sun is **overhead** in March and September. The land receives maximum solar energy, warm air rises, moist air rises, cools, and condenses to form heavy rainfall hence wet Season.

It experiences dry season when the sun is **not overhead**. When the Sun Is Not Overhead, the land receives less solar heating, air becomes cooler and more stable, it does not rise causing less cloud formation and rainfall hence dry Season.

In **Spring**, the hemisphere tilts toward the Sun after winter and it warms up. In **Autumn,** the hemisphere away from the sun after summer and it cools down.

QN: What causes floods in one area and sunny in another area?

The earth's curvature and different time zones causes two areas to experience different weather conditions.

Weather patterns are influenced by local conditions like wind patterns and temperature gradients.

QN: What causes total darkness during day time?

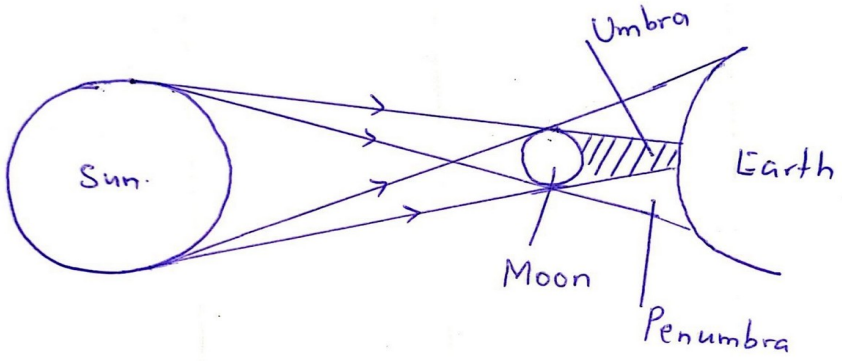
Total darkness during day time is caused by total solar eclipse of the sun.

Solar eclipse occurs when the moon passes between the sun and the earth and all the three are in a straight line.

During solar eclipse, the moon blocks light from the sun and the moon casts its shadow on the earth's surface forming both the umbra and penumbra.

The area covered by the umbra has total eclipse and the sun cannot be seen.

The area covered by the penumbra has partial eclipse and only part of the sun is seen. The area on the earth where there is no shadow has no eclipse and the full sun is seen.



THE MOON

- The moon is about a quarter of the size of the earth in width
- The moon is at a distance of about 384,400 km from the earth
- The moon is the largest natural satellite on the earth.

The difference shapes of the moon in the night sky originate from the fact that there exists **relative motions** between the moon and the earth orbiting the sun.

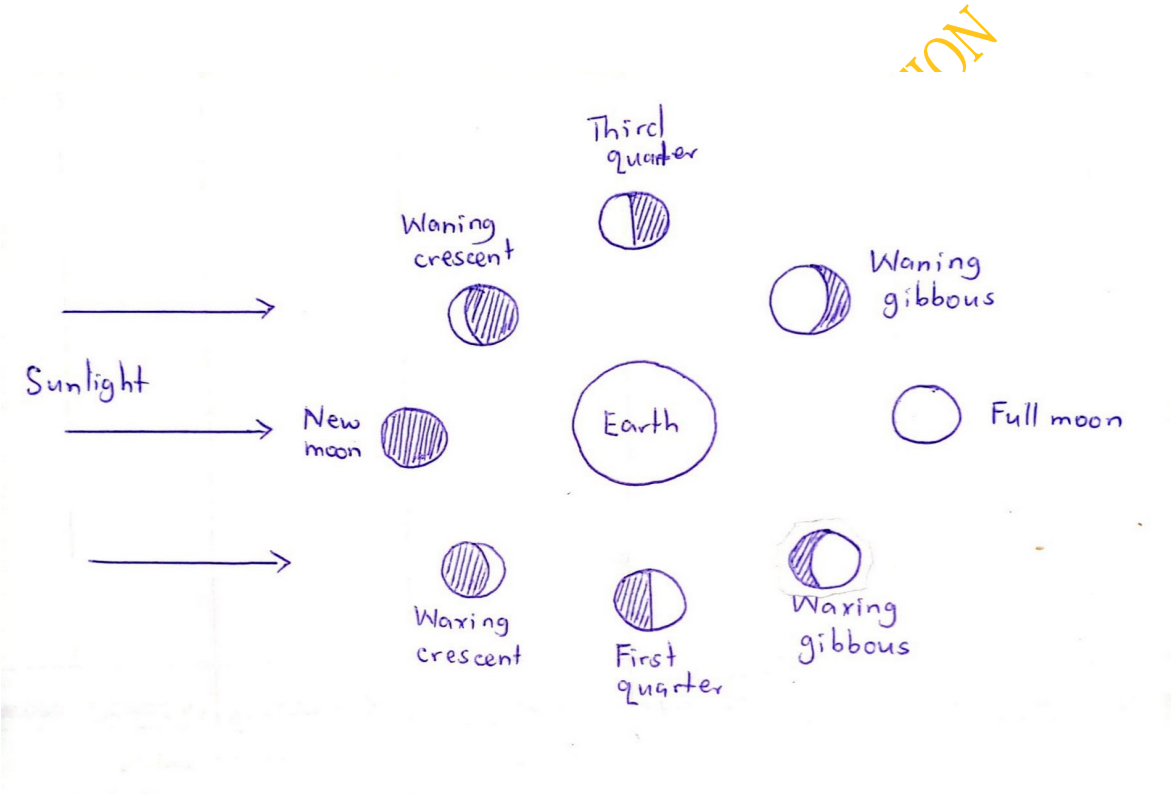
The moon revolves about the earth in an elliptical orbit for a period of 29.5 days. The gravitational force always keep the moon in its path

The motion the moon around the earth is similar to that of planets around the sun.

PHASES OF THE MOON

The phases of the Moon are caused by **the changing positions of the Moon, Earth, and the Sun**. As the Moon goes around the Earth, different parts of it are illuminated by the Sun.

There are eight phases of the Moon beginning with the new Moon, followed by waxing crescent, first quarter, waxing gibbous, full Moon, waning gibbous, third quarter and finally waning crescent.

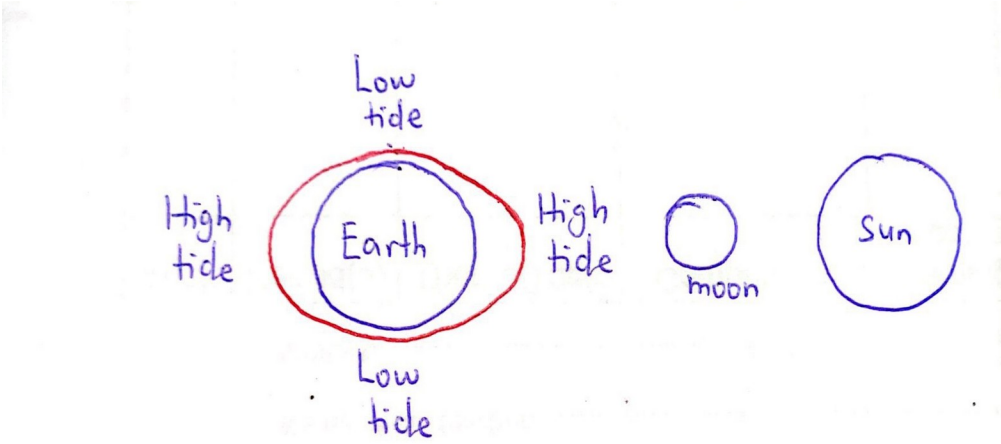


OCEAN TIDES

Areas around oceans often experience a daily rise and fall of ocean waters along the shores, this phenomenon is known as **Tides.**

Tides are categorized into **High tides** and **low tides**.

The moon's gravitational pull is greater on the side of the earth facing the moon. This makes the ocean waters to bulge outwards on either side of the planet resulting into high tides.



The other sides of the earth not facing the moon experience low tides. The sun's gravitational pull raises tides on earth. However, that of the moon is the strongest because the moon is closer to earth compared to the sun

ORIGIN AND STRUCTURE OF THE UNIVERSE

1. BIBLICAL THEORY

According to the Holy Bible (Genesis 1:1, 2 and 3), God created the heavens and earth

It is believed that the earth was without any form and darkness was over the face of the deep. It is from this that Christians believe that the universe was created by God.

2. THE STEADY STATE THEORY

This proposes that the universe was not only uniform pace but also unchanging in time. This implies that the universe today is similar to what it was yesterday and will remain the same tomorrow.

3. THE BIG BANG THEORY (Scientific theory of evolution)

It is the idea that the universe began just as a simple point, then expanded and stretched to grow as large as it is right now, and it is still stretching.

TOPIC 2: STARS AND GALAXIES

When you look into the sky in a clear night, you see very many stars. These appear in different sizes, brightness and color.

A STAR

A star is a massive, luminous (shining) sphere of plasma (hot gas) held together by gravity.

Nature of stars

Stars are made up of large amounts of hydrogen atoms. Stars radiate huge amounts of energy per second into space.

They emit light and heat due to nuclear reactions happening in its core.

Nuclear fusion is a source of this energy, i.e, hydrogen nuclei combine to form helium with release of energy. Thus leads to increase in temperature.

THE SUN

The sun is a luminous ball of gas hence it is a star.

It is located in the Milky Way galaxy

The sun is the largest object in the solar system. It is the nearest star to the planet earth.

The energy generated supports it against collapsing by its own gravity, otherwise it would shrink into a very dense and small body.

QN. How does the sun generate its energy?

The sun generates energy through nuclear fusion of hydrogen nuclei into helium.

In its core, hydrogen nuclei are fused together under extreme pressure and temperature to form helium nuclei. This fusion process releases a large amount of energy in form of electromagnetic radiation , including visible light and heat.

ENERGY PRODUCED BY THE SUN

Quantity	Approximate Value	Explanation
Energy produced by the Sun per second	3.8×10^{26} J s^{-1}	Total solar output (luminosity)
Energy reaching Earth per seco	1.7×10^{17} J s^{-1}	Tiny fraction intercepted by Earth
Energy reaching surface	1.2×10^{17} J s^{-1}	After reflection and absorption by atmosphere. 30% is reflected back and 70% reaches the earths surface.
Energy used in photosynthesis	4.0×10^{13} J s^{-1}	Very small fraction captured by plants. About 0.0023% of the energy that reaches the earth is used in photosynthesis.

THE SUN AS THE MAJOR SOURCE OF ENERGY ON EARTH

The sun is the major source of most of the energy found on earth because almost all forms of energy on earth originate directly or indirectly from it.

Eg 1. Solar panels use sunlight to produce electricity and heat.

2. The Sun's heat causes water to evaporate, form clouds, hence powering the water cycle and allowing the generation of hydroelectric energy.

The approximate amount of energy produced by the sun per second is 3.8×10^{26} W, the proportion of the sun's energy reaching the Earth's surface is 1.7×10^{17} W and the proportion of that which is captured for photosynthesis is 1.7×10^{15} W (approximately 1%).

QN. State the importance of energy produced by the sun to earth.

QN. What are the disadvantages of the too much energy of the sun to the earth?

SIZE OF THE SUN

The sun is 330,000 times the mass of the earth.

The sun looks smaller than the earth because it is too far away from the earth (about 150 million km). The sun is far much bigger than all the objects in the solar system.

SIZE OF THE SUN COMPARED TO OTHER STARS

There are both larger and smaller stars compared to the sun.

The sun is an average sized star.

Some stars are much bigger than the sun eg Betelgeuse is about **700–1,000 times larger** in diameter than the Sun.

VARIATION IN COLOUR AND BRIGTNESS OF STARS

Factors that determine the brightness and colour of stars to an observer

1. *Luminosity*
   It is the total energy radiated by a star per second.
   The higher the luminosity, the higher the brightness.
   Hottest stars shine dull orange or red.
   Luminosity is a measure of a stars' brightness.
2. *Distance from the observer.*
   The smaller the distance, the more the brightness. E.g. The sun appears brighter and hotter when viewed from Venus than from the earth since Venus is closer to the sun than earth.
3. *Temperature*
   A star's colour depends on its surface temperature.
   Cooler stars appear reddish in colour.
   Hotter stars appear bluish.
   4. *Size of a star.*
   Larger stars have a greater surface area, so even if their surface temperature is the same as a smaller star's, they emit more light hence they are more bright.

Qn. Why do stars appear to twinkle?

Stars do not twinkle but appear to twinkle. This is because stars are **very far** and due to **refraction** of light from the star to the observer by regions with different temperatures and optical densities.

TYPES OF STARS

Recall: O B A F G H K M

O (blue)

B (blue-white)

A (white)

F (yellow-white)

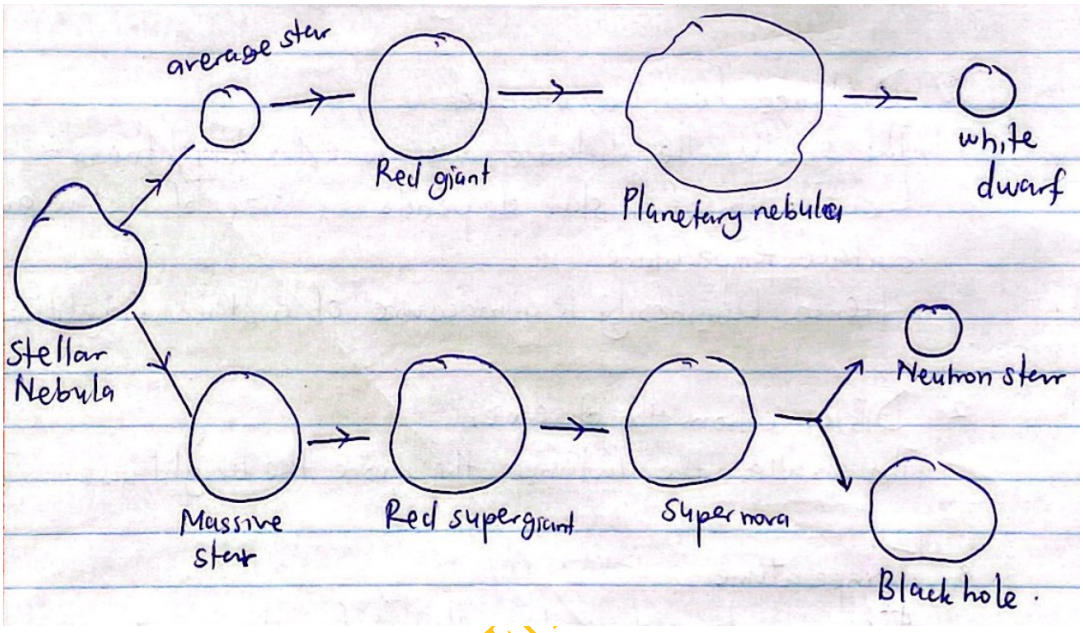
G (yellow)

K (orange)

M (red)

- O-type stars are **blue** in colour and are the brightest.
- Brightness increases from B-type to M-type stars
- The sun is a G-type star

THE LIFE CYCLE OF A STAR



1. Stellar Nebula

- A **stellar nebula** is a large cloud of gas (mostly hydrogen) and dust in space.
- Under gravity, the gas and dust collapse and begin to form a **protostar**.
- This is the **birthplace of all stars**.

Path A — Life of an Average Star (like the Sun)

Average Star

- The star begins to shine as **nuclear fusion** starts — hydrogen turns into helium, releasing energy.
- The star remains stable for billions of years (like our Sun now).

Red Giant

- When hydrogen runs out in the core, the star expands and cools, becoming a **red giant**.
- The outer layers swell, and the core contracts.

Planetary Nebula

- The outer layers are blown away, forming a glowing shell of gas called a **planetary nebula**.

White Dwarf

- The remaining hot core becomes a **white dwarf**, a small, dense star that slowly cools and fades over time.
- This is the **end of an average star's life**.

3. Path B — Life of a Massive Star eg Betelgeuse

Massive Star

- Starts the same way as an average star, but with much more mass and higher temperature.
- Burns hydrogen much faster.

Red Supergiant

- When the hydrogen is exhausted, it expands into a huge **red supergiant**.
- Fusion continues with heavier elements in the core.

Supernova

It is an explosion of a very large star which are so bright. Too much energy is given up

- The core collapses violently, and the outer layers explode in a brilliant burst of energy — a **supernova**.

After the Supernova: Two Possible Outcomes

1. **Neutron Star:**
    - If the remaining core is moderately heavy, it becomes a **neutron star** which is extremely dense and made mostly of neutrons.
2. **Black Hole:**
    - If the core is very massive, gravity pulls it inwards so strongly that not even light can escape forming a **black hole**. The gravity is so strong because matter has been squeezed into a tiny space.

PROTOSTAR

A protostar is what you have before a star forms. It is a collection of gas that has collapsed down from giant molecular cloud.

Qn. What is the difference between Red giant and Red supergiant star?

- A red supergiant is bigger, brighter and older tar compared to a red giant.
- A red supergiant is formed from a massive star while a red giant is formed from average stars.
- A red super giant is formed from a massive star while a red giant is formed from average stars.

Qn Explain why stars get hotter as they age.

- The **core contracts** after hydrogen depletion → gravitational potential energy converts to thermal energy hence temperature rises.

QN Explain how the nuclear reactions that provide the energy in stars change as they grow older?

As stars grow older, their nuclear reactions shift from fusing lighter elements to heavier elements because the core gets hotter and denser.

Young stars (main sequence) primarily fuse **hydrogen into helium** in their cores.

Red giant: Helium → carbon

Massive star (late stages): Carbon → oxygen → neon → silicon → iron

GALAXIES

- Galaxies are a collection of nebulae, stars and star clusters.
- Examples include; Milky Way galaxy, Andromeda galaxy, among others.
- The sun is located in the Milky Way galaxy

NB: In a galaxy, very many stars are arranged in recognizable shapes called constellations.

These constellations include elliptical, spiral and some galaxies have no particular shapes (irregular galaxies)

TOPIC 3: SATELLITES AND COMMUNICATION

A satellite is an object that moves around a large object.

Satellites are grouped into two; namely;

1. Natural satellites.
2. Artificial satellites.

Natural satellites.

These are natural objects that orbit large bodies. Example include;

- The moon which orbits the earth
- The earth which orbits the sun
- Triton (Neptune's largest moon)
- Asteroids
- comets

NB: Some planets have many moons for example Neptune has 16 moons, Jupiter has 95 moons.

Artificial satellites

These are man-made satellites which are moving around other planets. Examples include;

- Global Positioning System (GPS)
- Geostationary Operational Environmental Satellite (GOES)
- Military Strategic and Tactical Relay Satellite (MILSTAR)
- TERRIERS

Uses of satellites

- Navigation e.g. GPS
- Earth observation – including weather forecasting, tracking storms and pollution, spying and satellite photography.
- Communication – satellite television and phone calls.
- Astronomy – looking into outer space from our solar system.

SIZE AND ALTITUDES OF SATELLITES.

Size

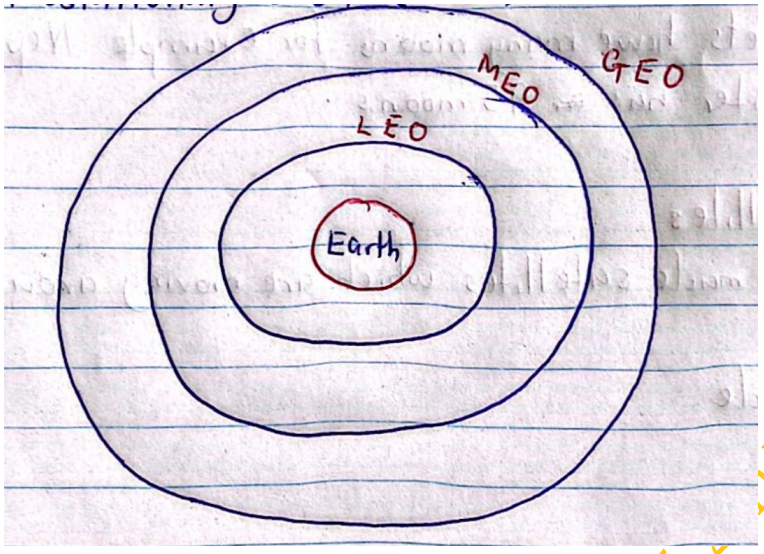
- Artificial satellites vary in sizes ranging from a few centimeters to tens of meters.
- The largest artificial satellites is the international space station (ISS) which is as big as a five-bedroom house

Altitude

The altitudes of artificial satellites vary depending on their use.

The commonly used orbits are;

i) Low Earth Orbit (LEO)
ii) Medium Earth Orbit (MEO)
iii) Geostationary Orbit (GEO)



1. Low Earth Orbit (LEO)

These are at an altitude of about 200km to 2,000 km.
The ISS whose orbit is at 400km of altitude is located in this range.

2. Medium Earth Orbit (MEO)

These are at an altitude of about 20,000km
Time for one orbit is 12 hours.

3. Geostationary orbit (GEO)

These are at an altitude of about 36,000km above the earth.
Time for one orbit is 24 hours which matches the rotation of the earth hence the satellite appears to be stationary to an observer on the Earth's surface.
Geostationary means that the satellite appears nearly stationary in the sky as seen by a ground-based observer.
Geostationary satellites are used for many communications and weather satellites
These orbits are also called parking orbits or synchronized orbits.

GLOBAL POSITIONING SYSTEM (GPS)

This is a satellite-base system that consists of 24 orbiting satellites.
Each satellite orbits the earth twice every 24 hours. GPS allows users anywhere on earth to determine their exact location.

QN Explain how GPS helps in locating the location of a person on earth?

The main components of the satellite system are :

1. Space Segment (Satellites)
2. Control Segment (Ground Stations)

3. User Segment (GPS Receiver)

The GPS receiver determines its position through a process called **trilateration**.
Trilateration is a method to determine your **exact position** by knowing your **distance from at least three known points.**
The GPS powered device eg smartphone, computer, GPS tracker is powered ON.
The phone's GPS chip receives **radio signals** from at least **four GPS satellites** orbiting Earth.
Your phone measures time taken by radio signals to reach the phone.
Then, for each satellite: Distance=Speed of light X time .
This gives the **distance** between the phone and each satellite.

The first satellite places you somewhere on a sphere centered on that satellite.

The second satellite gives the intersection of the two spheres that give a circle of possible positions.

With the third satellite, the intersection of the circle with the third sphere narrows it down to two possible points.

Usually, one of these points is **far out in space**, so it's discarded, leaving your position on Earth.

The fourth satellite is used to correct your phone's internal clock error (since it's not as accurate as satellite atomic clocks).
Once the time error is fixed, your phone calculates your precise latitude, longitude, and altitude.

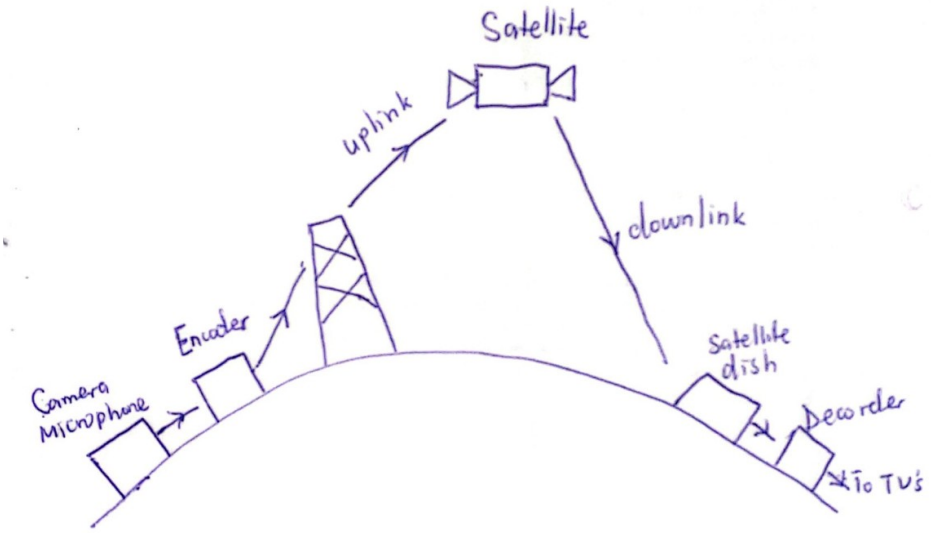
These coordinates are then shown as your **location on the map**.

COMMUNICATION SATELLITES.

These are used for television, phone or internet transmissions.
An example is Optus D1 satellite.
Communication satellites relay and amplify radio telecommunication signals via a transponder.
They create a communication channel between the source transmitter and a receiver at different locations on earth.

Uplink: refers to sending of communication signals from around transmitters to communication satellites.
Downlink: refers to sending of reflected signals from the satellite to the ground receivers.

Qn:How are live events for example live football broadcast



Camera and Microphone:

The video and audio to be broadcast is captured by cameras and microphones. (e.g. a news broadcast or live event).

- **Encoder:**

The captured The content to be broadcast is captured by cameras and microphones.video and audio signals are sent to an **encoder**, which **converts** them into a **digital signal** suitable for transmission.

- **Uplink Station (Transmitter):**

The digital signal is transmitted to a **satellite** in space using a **high-frequency radio wave** — this is called the **uplink**.

- **Satellite:**

The satellite **receives the uplinked signal**, **amplifies** it, **changes its frequency** and then **retransmits** it back to Earth . This is called the **downlink**.

- **Satellite Dish (Receiver):**

The **satellite dish** on the ground receives the **downlink signal** from the satellite.

The dish focuses the weak signal onto a receiver (LNB – Low Noise Block converter) that amplifies and converts it to a lower frequency.

- **Decoder:**

The signal is then sent to a **decoder** (such as a TV set-top box), which **decodes** the digital signal back into **audio and video** formats.

- **Television Set:**

Finally, the decoded signal is sent to the **TV**, where the program is displayed to viewers.

CLASSIFICATION OF ARTIFICIAL SATELLITES.

1. Communication satellites
2. Weather satellites
3. Earth observation satellites
4. Astronomical satellites

INTERNATIONAL SPACE STATION (ISS)

It is a habitable space laboratory at an altitude of 400km traveling at speed of 28,000km/h that orbits the earth once every 92 minutes.

The purposes of the ISS are :

- Scientific Research Laboratory eg **Earth and space observation** in monitoring climate, oceans, and natural disasters.
- Testing technologies for future missions
- Education and Inspiration

THE HUBBLE SPACE TELESCOPE (HST)

It is a space telescope that was launched into low earth orbit in 1990

It is one of the largest space telescopes. It takes sharp pictures of objects in the sky such as planets, stars and galaxies.

The values of these photograghs are:

- Studying the Universe's structure by revealing **galaxies, nebulae, and star clusters.**
- Observing the birth and death of stars
- Used in textbooks, lectures, and research papers for Educational and Research Value

END