

SOLAR SYSTEM

This is the gravitationally bound system of the sun and all objects which orbit the sun either directly or indirectly.

Our solar system is one of the 3,916 solar systems in the Milky Way galaxy

COMPONENTS OF THE SOLAR SYSTEM

The solar system is composed of the following;

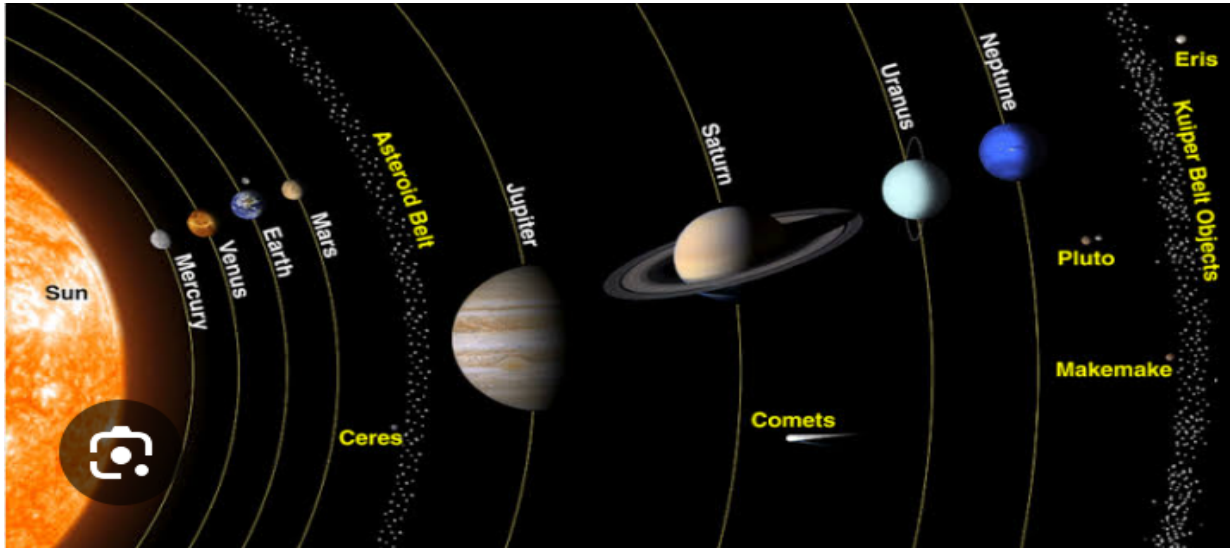


Figure 1:

Planets	Comets
Moons	Ceres
Sun	Dust
Stars	Dark matter
Asteroids	Dwarf planets
Asteroid belts	Meteors(Shooting stars)
Gases	Space between planets

PLANETS

A **planet** is a space body or celestial body that moves around the sun in a defined path called an elliptical orbit in the solar system

Celestial body:

These are objects in space/ sky of the solar system. (Moon, Planets, Stars and many others are celestial bodies)

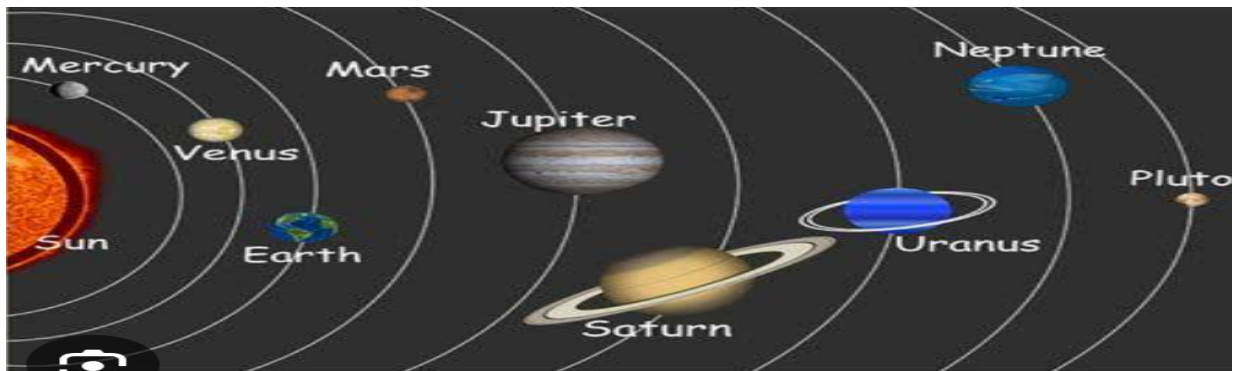


Figure 2:

CATEGORIES OF PLANETS

Planets in the solar system are categorized as follows;

1. Inner planets
2. Outer planets

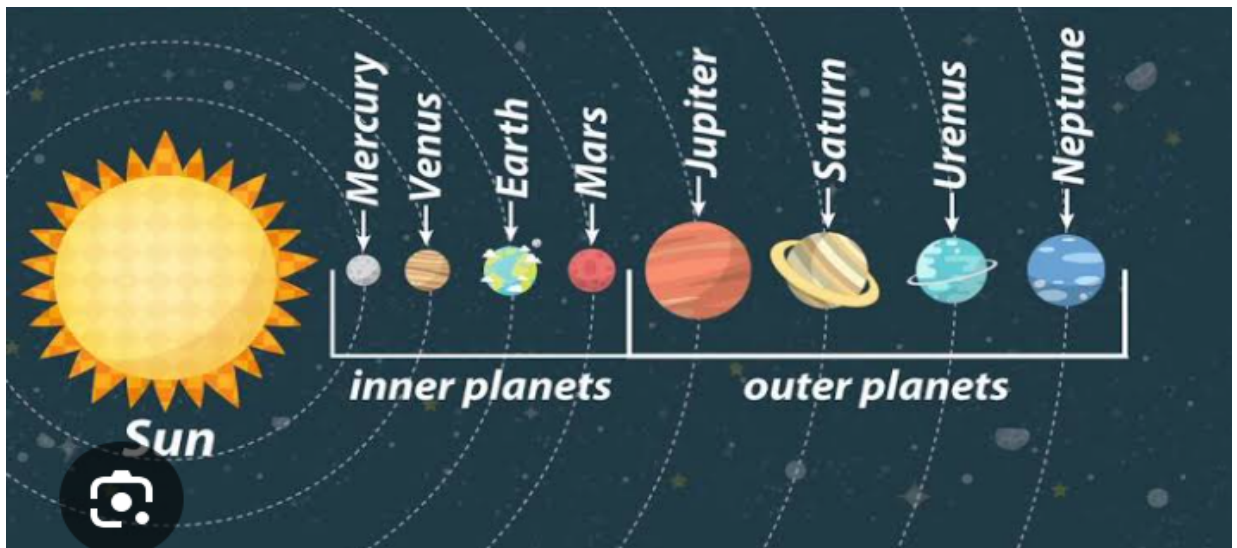


Figure 3:

Examples of planets

They are 8 planets so far discovered in the solar system. For example Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune

ARRANGEMENT OF PLANETS AND PLUTO IN THE SOLAR SYSTEM

Planets and Pluto in the solar system are arranged depending on their distance from the sun but not their sizes. Pluto was located and named in the year of 1930 as a planet but today Pluto is no

longer regarded as a planet.

Mean distance of planets from the sun

The mean distance of planets from the sun are all measured in unit called **Astronomical unit (AU)**

Planets	Distance(AU)	Period of Revolution	Period of Rotation
Mercury	0.4	88 days	59 days days
Venus	0.7	225 days	243 days
Earth	1.0	$365 \frac{1}{4}$ days	24 hours
Mars	1.5	687 days	24.62 hours
Jupiter	5.2	12years	9.92 hours
Saturn	9.6	29.46 years	10.66 hours
Uranus	19.2	84 years	17.2 hours
Neptune	30.0	165 years	16.1 hours
Pluto	39.5	249 years	6.387 days

CONDITIONS REQUIRED BY A PLANET TO BE CALLED A PLANET

- 1.The planet has to be massive enough for it's gravity to pull it to be nearly round.
- 2.It has to clear the neighborhood objects around it's path or orbit.
- 3.The planet should be of a larger size than it's moon/ moons

INNER PLANETS (TERRESTRIAL/SMALL ROCKY PLANETS)

These are planets near/ close to the sun inside the Asteroid belt in a solar system.

Examples of inner planets/ Terrestrial/Rocky planets

Mercury

Venus

Earth

Mars

Characteristics of inner planets/ Terrestrial/Rocky Planets

They are made up of mostly rocks and metals (Have rocky surface)

They are close to the sun and located between the sun and the Asteroid belt

They move very fast around the sun

They have a few moon if only

They have a high density hence they are heavy planets

They all lack the ring systems (All have no Rings around them)

The spin slowly in space about their own natural axis

They have high temperature

OUTER PLANETS (JOVIAN PLANETS/ GAS GIANT PLANET)

These are planets far away from the sun outside the Asteroid belt in the solar system.

Examples of Outer planets(Jovian Planets)

Jupiter

Saturn

Uranus

Neptune

Characteristics of Outer planets

They have very many moons or multiple moons

They are made up of gases especially helium and hydrogen (No solid surface)

They are big or immense in their sizes

They orbit the sun slowly

They are very far from the sun outside the Asteroid belt

They have Rings around them (like Saturn with the biggest Ring)

Their surfaces are normally made of ice

They have low densities

They spin (rotate) very fast about their axes

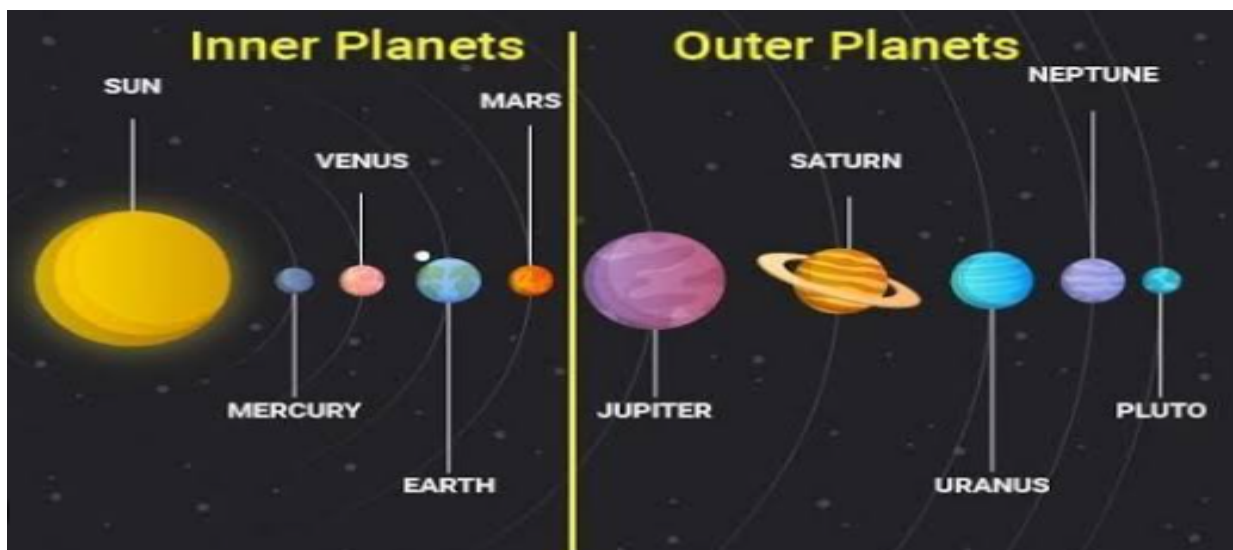


Figure 4:

CATEGORIES OF JOVIAN PLANETS

Jovian planets are grouped into categories and these are,

.Gas giants .Ice giants

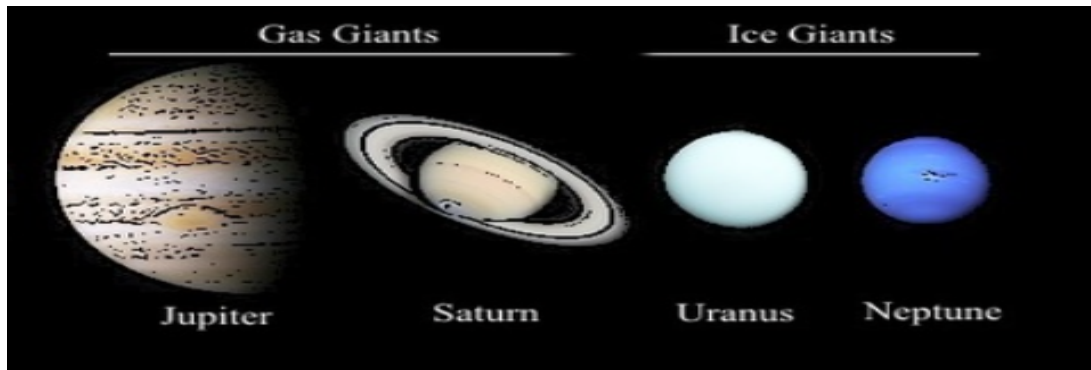


Figure 5:

The gas giants are predominantly made of Helium and Hydrogen gas
 The ice giants contain rocks, ice and a mixture of water, methane and ammonia.

MOTION OF PLANETS AROUND THE SUN

- All planets move around the sun in elliptical orbits with the sun at the center as the major focus.
- The motion of planets around the sun (orbit motion) is facilitated by the gravitational forces between the planets and the sun. A planet moves around the earth in a path called elliptical orbit.

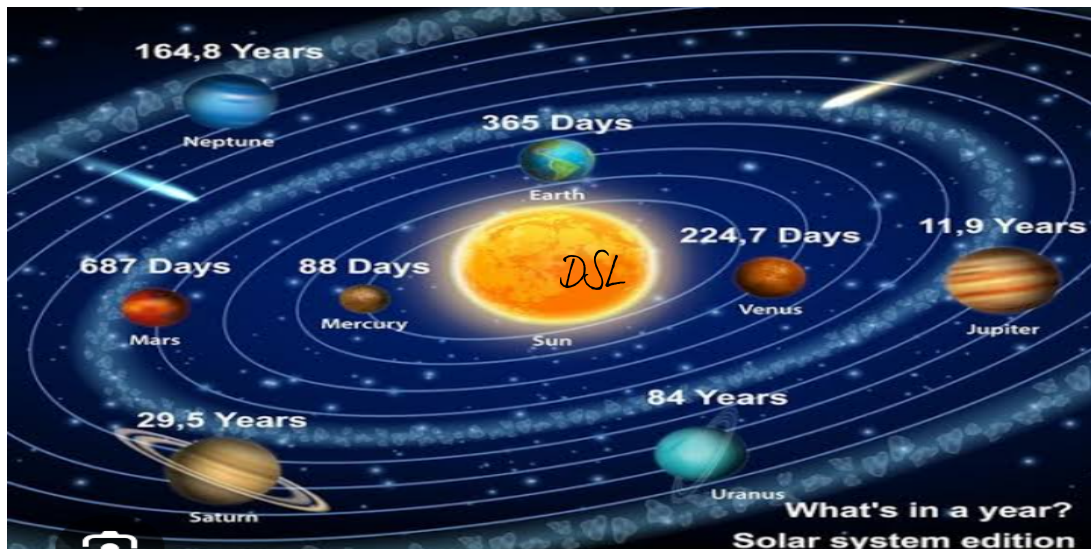


Figure 6:

TYPES OF MOTION OF PLANETS

1. Rotation (Spining Motion)

Rotation is the spinning motion of a planet about its own natural axis as it moves around the sun.

2. Revolution(Orbit motion/ Translation)

Revolution of a planet is the movement of a planet around the sun in an elliptical orbit.

MERCURY (Land of craters)



Figure 7:

It is closest planet to the sun

It has a revolution of 88 days (it takes mercury 88 days to make one complete revolution around the sun) and does not support life.

It is the smallest planet in the solar system and has no moon and no ring.

Because mercury is the closest planet to the sun, it is very difficult to observe it since most of the time hidden in the glare of the sun.

Mercury has no satellite of its own and it travels around the sun faster than any other planet because of its proximity (nearest)

It appears for a brief time as a morning object in the eastern sky rising just before sunrise and can be seen as an evening object in the western sky, setting just after the sunset.

Mercury is the second densest planet in the sun, it is not the hottest planet because there is ice on its surface protected from the sun's heat by the crater shadows.

N.B: No people have ever gone to mercury, but the first robotic space craft to visit mercury was mariner 10.

VENUS(Hell)

Venus is the **brightest object in the sky** after the sun and the moon because its atmosphere reflects sunlight so well. People often mistake Venus for a star.

It is the second planet from the sun and it takes Venus **225 days** to orbit the sun once (or make one complete revolution around the sun).

The atmosphere of Venus made up mainly of carbon dioxide, and the thick clouds of sulfuric and completely cover the planet hence called **Hellish place**.

Venus does not support life and once visited, air cannot be breathed in since its atmosphere is very hot to high temperatures that can melt lead metal and you can be crushed by the weight of the thick

atmosphere.

Venus is often called the "morning or evening star" though not a star because it appears in the eastern sky before sunrise in around 1-3 hours and sometimes in the western sky in 1-3 hours just after sunset. It has the longest day of 243 days to make one rotation.

It has no moons or satellites of its own. A day on Venus is longer than its year.

It is the hottest planet in the solar system although it is farther from the sun than mercury because it has a carbon dioxide thick atmosphere which traps the heat from the planet's surface and this is called the green house effect of Venus.

Venus is a very dry planet with thick clouds which contain sulfuric acids opposed to the earth's clouds which contain water.

Clouds on Venus are thick and astronomers cannot see the surface of the planet with their telescopes.

Spinning of Venus (rotation) is unusual as it spins from east to west about its axis while the earth spins from west to east about its axis.

Venus was named after the Greek **god of love and beauty**.



Figure 8:

EARTH (Planets of life)

Earth takes **365 days** to make one revolution (one complete orbit) around the sun which is a full year and it has a spinning motion (rotation) of **24 hours** about its axis which causes days and nights.

It is third planet from the sun and the largest inner (Terrestrial/Rocky) planet.

It is the only planet in the solar system that ²⁰supports life (living organisms) because it has an oxygen rich atmosphere with nitrogen and carbon dioxide and 71 percent water, oceans and seas which maintain earth's stable temperature and all are crucial to the earth's ability to support life.

Earth has one moon which is its natural satellites and has high mountains, valleys, volcanoes and even some craters, the earth's moon is the nearest celestial body to the earth.

The earth is called a blue planet.

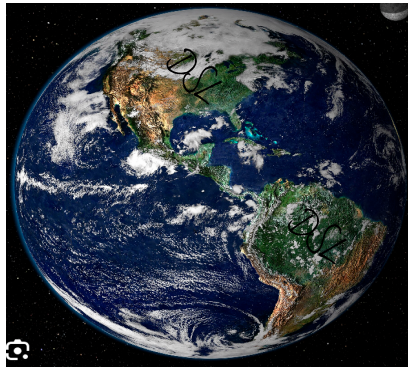


Figure 9:

MARS(The Red Planets)

Mars is the fourth planet from the sun and it's a hard Rocky planet, it's colder than earth

It is called a Red planet because it's soils contain Iron Oxide (Rust) which makes it's ground look Red.

It has the largest Volcano in the solar system called **Olympus Mons** approximately **15 miles**.

It takes mars **687 days** (approximately **2 earth days**) to orbit the sun once

It has an atmosphere made entirely of Carbon dioxide and traces of Nitrogen and there is no Liquid water on it's space.

Mars has two moons **Phobos** and **Deimos** which are two small natural satellites of mars.

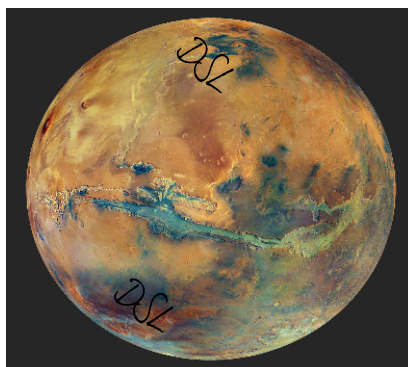


Figure 10:

JUPITER (The king of planets)

Jupiter is the largest and the most massive planet in the solar system and the fifth planet from the sun. It has the shortest day of 9.92 hours - 10 hours in the solar system.

It takes 12 earth years for Jupiter to make one complete revolution around the sun.

It has 53 named moons and 26 unnamed moons totaling to 79 moons orbiting Jupiter.

Its atmosphere is made up of Hydrogen and Helium gas just like the sun and these gases are pressed in the deep atmosphere and turn into liquid and the process causes a high surface of Jupiter as it will be crushed.

Jupiter has thin faint Rings around it and a "**Great Red Spot**" as its famous feature.



Figure 11:

SATURN (The Ring World)

It is the sixth planet from the sun and the second largest planet in the solar system.



Figure 12:

It is the least dense planet in the solar system with a density of about 0.7 gcm^{-3} less than the density of water (1 gcm^{-3}) hence can float on water in ocean and seas of the earth.

Saturn has many wide beautiful Rings which are made less than 1 mile thick and extend widely outwards to about 260,000 miles from its surface.

It takes Saturn approximately 30 earth years to complete one revolution around the sun.

It is made up of Hydrogen and Helium gas in its atmosphere similar to Jupiter with a high pressure which can crush the spacecrafts that can land on its surface.

It has 18 known moons and its largest moon is called Titan which is the second largest moon in the solar system and it is larger than some of the smallest planets in the solar system.

URANUS(God of Sky)

Uranus is the seventh planet from the sun in the solar system and it shares its name with the Greek God of Sky - Uranus.



Figure 13:

It is Blue in colour due to methane gas in its atmosphere.

It takes Uranus 84 earth years to make one complete revolution around the sun.

It has 27 known moons and like Venus, Uranus rotates from east to west about its axis.

It has 11 dark rings surrounding it and the third largest planet in the solar system.

NEPTUNE

This is the eighth planet from the sun and has the fastest wind in the solar system.



Figure 14:

It is Blue in colour because of methane gas in it's atmosphere.

It takes Neptune 165 earth years to orbit the sun once and is the outer most planet in the solar system.

It has 14 known moons orbiting it and has a "Great Dark Spot"

It has Five main Rings and Four prominent Ring arcs.

Neptune's largest moon is called **Triton** and it is one of the coldest planet ($-353^{\circ}F$)

PLUTO

Pluto was classified as a planet by the year 1930 but in the year 2006, it was disregarded to be a planet and it is a Dwarf planet by International Astronomical Union(AU).

It takes pluto 249 earth years to orbit the sun and has only one moon called Charon.

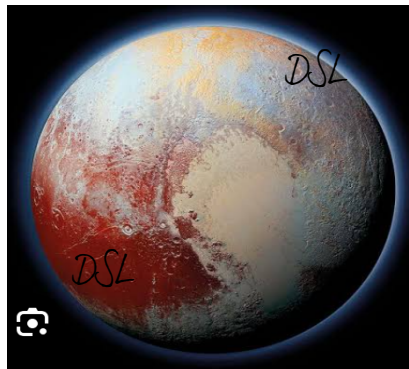


Figure 15:

Part of Pluto's orbit passes inside the orbit of Neptune and at times along Pluto's orbital motion, it comes close to the sun and Neptune becomes the farthest from the sun. It was named after "god of the underworld - Pluto".

Pluto is not a planet because it has not cleared its neighborhood region of other objects hence it has a lot of asteroids and other space rock along its path or orbit other than have absorbed them over time like the other planets have done.

A planet must clear all other space bodies in its path, have enough mass for its gravity to pull it nearly round and must orbit the sun. Those are the three condition for a celestial to be a planet but Pluto doesn't meet the first condition.

DWARF PLANETS

These are small planetary-mass objects in direct orbit around the sun and are massive enough for their shapes to be controlled by gravitation.

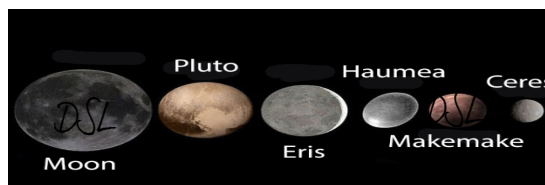


Figure 16:

Examples of dwarf planet

- Ceres -Eris -Haumea
- Pluto -Makemake -Sedna

Ceres reside in the Asteroid belt whereas other five above reside in the Kuiper belt and they are Kuiper belt objects(Trans- Neptunian Objects/TNO).

TRANS - NEPTUNIAN OBJECTS (KUIPER BELT OBJECTS)

These are objects in the Solar system that orbit the sun at a greater average distance than Neptune.

Examples:

-Eris - Sedna -Quaoar
-Pluto -Makemake -Orcus

Characteristics of Dwarf planets

They orbit the sun and they are not moons

Have enough mass so that their gravity pulls them to be nearly round in shape

They share orbits with other celestial bodies with similar size. Their paths are blocked by objects such as Asteroids and comets.

KUIPER BELT

This is a region of the outer solar system beyond the orbit of Neptune containing Ice bodies called Trans- Neptunian Object (**TNO**) or Kuiper Belt Objects (**KBO**).

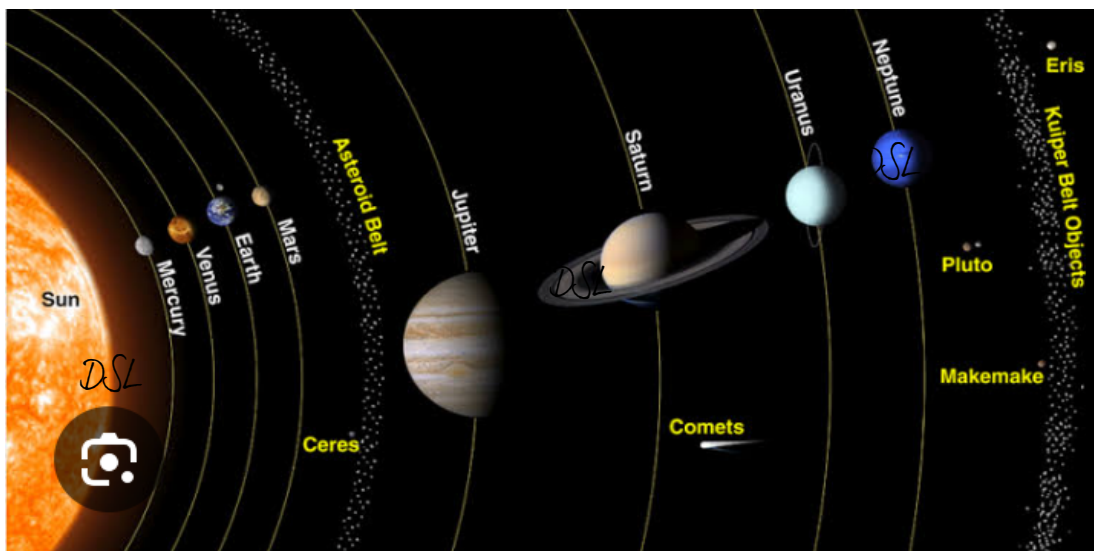


Figure 17:

ASTEROID BELTS

This is a ring - shaped region in the Solar System between the orbits of Mars and Jupiter containing many solid irregularly shaped bodies called Asteroids.

Many objects orbit the sun within the Asteroid belt ranging from microscope dust particles to the largest known object called **Ceres** (about the same size as Texas)

Asteroid belt was formed when Jupiter's gravity prevented planetesimals(many small Rocky objects formed from collision of other objects) between the orbits of Mars and Jupiter from forming a planet. It is about **2AU** to **4 AU** from the sun.

ASTEROIDS

These are small Rocky remains of the period of planet formation which orbit the sun in the asteroid belt (between orbits of Mars and Jupiter)

Example: Ceres

METEROID: Is rock in space of the solar system.

METEORITE: Is rock from space of the solar system that falls through the atmosphere of the earth.

METEORS(Shooting Stars): Is a bright trail (Streak of light) left by meteorites that heat up as they travel through the earth's surface.

COMETS: These are very small bodies made of ice, gas and dust which orbit the sun in the same way as planets in orbits that are far beyond the orbit of Pluto.

Some comets have orbits which bring them close to the sun and when they get close to the sun, their ices warm up and turn into gas.



Figure 18:

Kuiper belt is **30AU** to **50AU** from the sun, and it is sometimes considered the third Zone of the solar system. The Solar system has three Zones that is, the inner zone of terrestrial planets, the middle zone of Gas giant and ice giant planets and the third zone called Kuiper belt.

THE OORT CLOUD: Is a region beyond the kuiper belt which is a collection of ice debris or objects and it is the edge of the Solar System.

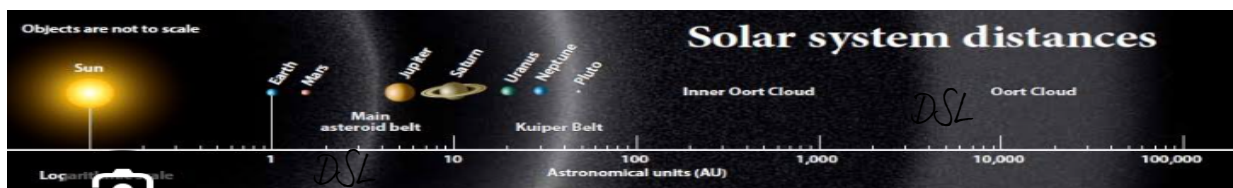


Figure 19:

The Oort cloud is a giant spherical shell surround the sun, planets and the kuiper belt. It is at a distance between 2000 AU and 100000 AU from the sun.

The Oort Cloud is divided into two regions, that is a **disc- shaped inner Oort Cloud** and the **Spherical outer Oort Cloud** and both regions lie beyond the kuiper belt.

The inner edge is between 2000 AU to 5000 AU from the sun and the outer edge is about 10,000 AU or even 100,000AU from the sun.

The outer extension of the Oort Cloud is considered to be the edge of our Solar system where the sun's physical and gravitational influence ends.

TIDES

These are periodical rises and falls in the levels of water in large water bodies like seas and oceans.
NB: Because the earth rotates on its axis, the oceans bulge near the equator than at the poles.
The oceans are not flung (thrown) completely off the earth because they are pulled by the earth's gravity.

LUNAR ATTRACTION (Water tides and the moon/ causes of sea or ocean tides)

Tides on seas and oceans are caused by the gravitation pull of the moon. The tidal forces cause the earth and its water to bulge out on the side closest to the moon and the side farthest from the moon. As the earth rotates about its axis, the regions of the earth which passes through both bulges experience high tides in those bulges and those areas not in the bulges experience low tides. These tides occur periodically along the coastline of the world and shores of larger water bodies each day.

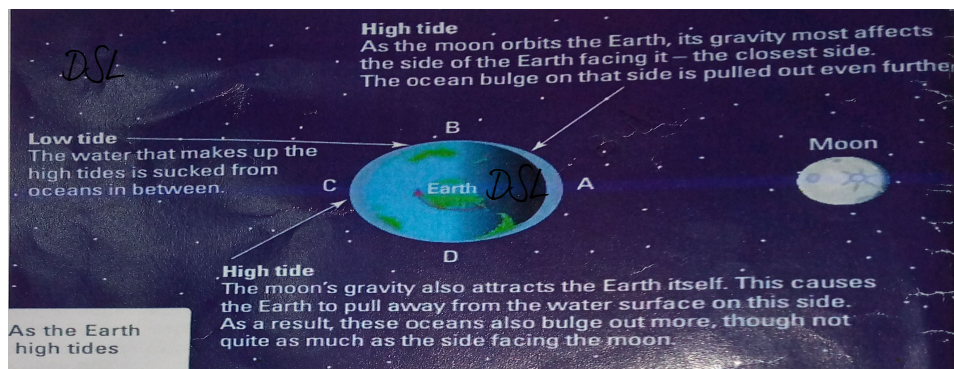


Figure 20:

The oceans at **A** closest to the moon are pulled strongly towards the moon taking water away from **B** and **D**.

The oceans at **C** farthest from the moon are pulled less strongly than the rest of the earth.

This makes **A** and **C** to be regions of **high tides** while **B** and **D** to be regions of **low tides**.

During one day, each place on earth experiences two high tides and two low tides

As the moon orbits the earth, its gravity most affects the side of the earth facing it (closest side). The bulge on that side is pulled out even further.

For the side farthest from the moon, the oceans bulge out more though not quite as much as the side facing the moon.

The water that makes up the high tides is sucked from oceans at **B** and **D**

EFFECTS OF THE SUN ON WATER TIDES

The sun also influences the tides but because it is further away, its gravity has much less effect than the moon's gravity.

Although the moon is much smaller than the sun in terms of mass (27 million times less than the mass of the sun), its gravitational pull on the earth is greater because it is much closer to the earth.

When the sun is on the same side of the earth as the moon (or on the opposite side), higher tides than normal are experienced.

Spring tides: These are tides of higher magnitude than normal which occur when the sun is either on the same side of the earth as the moon or on the opposite side. These tides occur when there is either a **full moon** or **New moon**

Neap tides: These are weaker tides which occur when the sun and the moon are no longer in the same line with the earth. The gravitational pull of the sun, the pull on oceans/ seas by the sun and the moon are working against each other.

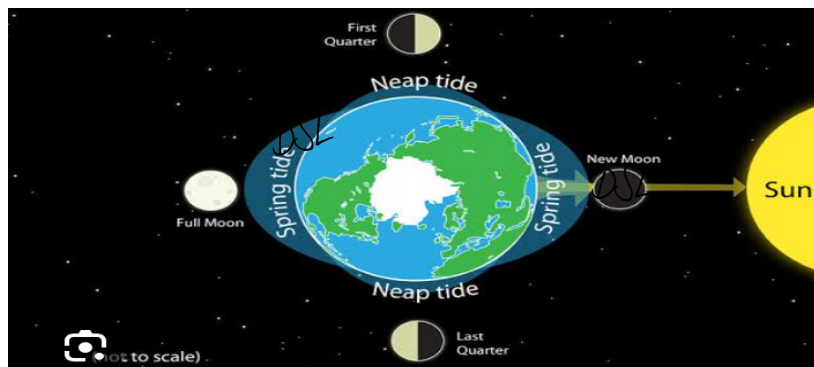


Figure 21:

NB: During each orbit of the moon around the earth ($29\frac{1}{2}$ days), there are two spring tides and two neap tides.

THE EARTH'S MOON

It is a natural satellite of the earth.

It orbits the earth 12 times in a year (12 months)

It takes ($29\frac{1}{2}$ days) for the moon to orbit the earth once (or make one complete revolution around the earth)

It takes ($29\frac{1}{2}$ days) for the moon to rotate about its own natural axis.

The moon is the brightest object in the earth's night sky and the second brightest object in the sky after the sun in the solar system.

It is the closest celestial body to the earth and it is a non-luminous object.

The mean distance from the moon to the earth is 240,000 miles (385,000Km or 385,000,000m), 3 days by space craft.

Surface temperature of the moon ranges from -175°C in darkness to 125°C in sunshine.

Why the same side of the moon faces the earth

The same side (or only one face) of the moon faces the earth or is seen from the earth because the moon takes the same time to complete one full turn about its own natural axis as it takes to orbit the earth ($29\frac{1}{2}$ days).

N.B: The face of the moon seen from the earth is less mountainous and rugged than the other side.

Sometimes, the edges of the far sides of the moon are seen because the moon wobbles (move unsteadily) a little during its orbit around the sun.

THE EARTH'S MOON AS A SILENT SATELLITE

The earth's moon is referred to as a silent satellite because the moon has no atmosphere and there is no air and no sign of water on its surface. This makes sound waves not to be transmitted or propagated on the surface of the moon.

N.B: There is no wind and no rain on the moon's surface meaning that there is no erosion on its surface.

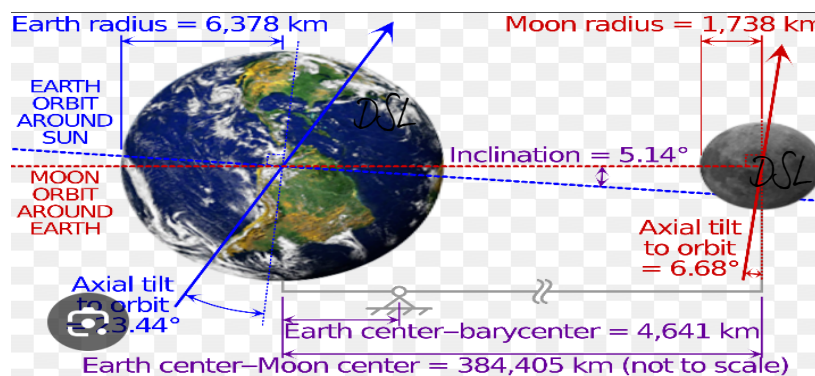


Figure 22:

MOTION OF THE EARTH'S MOON

The earth's moon has two different kinds or types of motion that is to say;

Rotation(Spinning motion): This is the spinning movement of the moon about its own natural axis. It takes ($29\frac{1}{2}$ days) for the moon to make one complete spin about its own axis.

Revolution (Orbit motion/ Translation): This is the movement of the moon around the earth in an orbit. It takes ($29\frac{1}{2}$ days) for the moon to orbit once (or make one complete revolution) around the earth.

N.B: As the earth orbits the sun, the moon also orbits or revolves around the earth.

It takes the same time for the moon to complete one full turn about the axis as it takes to orbit the earth ($29\frac{1}{2}$ days) and this is why the same face of the moon is seen from the earth.

PHASES OF THE MOON

The moon is visible from the earth only because it reflects the sunlight from the sun. As the moon orbits the earth, it turns so that the same side of the moon faces the earth.

N.B: Phases of the moon are different shapes of the moon seen from the earth.

The 8 Phases of the moon are;

- New moon
- Waxing crescent moon
- Full moon
- Waxing crescent gibbous
- Waning Crescent moon
- First Quarter Moon
- Waning Gibbous moon
- Last quarter moon

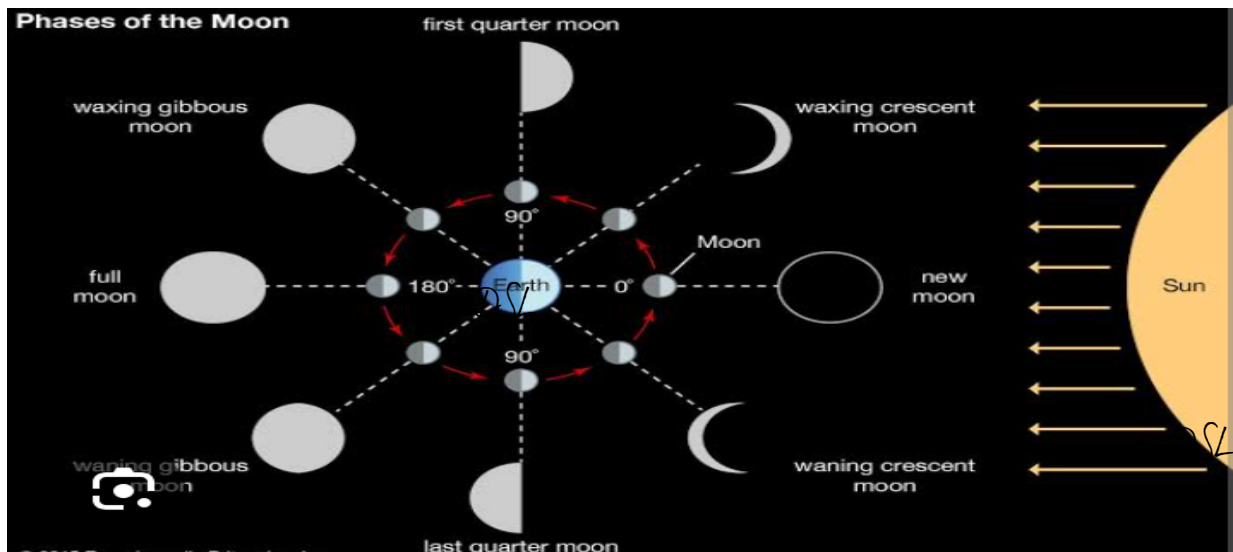


Figure 23:

FULL MOON

When all the side of the moon seen from the earth is completely bathed in sunlight, then we see a full moon.

OR

The moon appears as a full moon when all its visible side from the earth is completely in sunlight. The moon is one side of the earth and the sun is on the opposite side.

The sun illuminates all the face of the moon that faces the earth, directly and the moon looks like a full round circle.

NEW MOON

This is when the moon is between the sun and the earth and none of the illuminated side of the moon is seen or visible from the earth.

The side of the moon which faces away from the earth (face the sun) is in sun's light and cannot be seen from the earth while the side of the moon which faces the earth is in darkness and cannot be seen from the earth. This makes the moon not to be seen at all from the earth.

WAXING CRESCENT MOON

This is when a small part of the moon less than half of its surface facing the earth is lit up in sunlight and seen from the earth and the biggest part of the surface is shadowed and occurs after the new moon.

More than half of the moon's surface facing the sun earth is in darkness and cannot be seen from the earth.

The smallest part of the moon's surface facing the sun is bathed in sunlight and this part is seen from the earth.

We start to see a small part of the moon.

FIRST QUARTER MOON (First half moon)

The first quarter moon occurs when only one - half of the moon's surface facing the earth is bathed in sunlight and it is visible from the earth and keeps growing in sunlight as the moon approaches the full moon.

WAXING GIBBOUS MOON

This is when more than half of the moon's surface facing the earth is bathed in sunlight and left growing in light as the moon approaches its full moon. When seen from the earth.

The moon in this phase is between the first half moon and the full moon or the moon is between a semi-circle and a full moon in shape when seen from the earth.

This shows that there are just few days to the full moon.

WANING GIBBOUS MOON

This is when more than half of the moon's surface facing the earth is bathed in sunlight and this part keeps shrinking (becomes smaller) as the moon moves away from its full moon, when seen from the earth.

This shows that the full moon is just few days away.

LAST QUATER MOON (Third quarter/ half moon)

The third quarter moon is when only one half of the moon's surface facing the earth is bathed in sunlight and it is visible from the earth and keeps growing in shadow as the moon approaches the new moon.

WANING CRESCENT MOON

This is when less than one - half of the moon's surface facing the earth is bathed in sunlight and it is seen from the earth and the biggest part is bathed in darkness and not seen from the earth as the moon approaches the New moon and after the last quarter moon.

N.B:

1. Crescent moon occurs when less than one - half of the moon's surface the earth is bathed in sunlight. The moon is between the new moon and semi - circle when seen from the earth. Crescent moon is either waxing crescent (moon is approaching the first half moon after the new moon) or waning crescent (moon is approaching the new moon after the last half moon).

2. Gibbous moon occurs when more than one half of the moon's surface facing the earth is bathed in sunlight. The moon is between a semi - circle and a full moon.

Gibbous moon is either waxing gibbous (moon is approaching the full moon after the first half moon) or waning gibbous (moon is approaching the last moon after the full moon)

3. Quarter moon occurs when one half of the moon's surface facing the earth is bathed in sunlight and can be seen from the earth.

The first quarter moon is seen 7.4 days - 7 days after the new moon

The last quarter moon is seen 7.4 days - 7 days towards the new moon.

4. Waning moon occurs when after a full moon when the part of the moon's surface facing the earth's surface bathed in sunlight keeps on reducing as the moon.

Waning moon is either waning gibbous or waning crescent.

5. Waxing moon occurs after a new moon when the part of the moon's surface facing the earth and bathed in sunlight keeps on increasing as the moon approaches a full moon.

Waxing moon is either waxing Gibbous or waxing crescent.

Note: As the moon orbits the earth, different parts of it are seen from the earth.

MONTH

The word month comes from an old English word "Mona" meaning **moon**

Early calendars/ Lunar month / Lunar calendar

This was the length of time between two full moons

A lunar calendar is calendar based on monthly cycles of the moon's phases.

N.B:

The modern calendar was not worked out until the 16th century by Pope Gregory XIII

The Islamic, Hebrew and Chinese calendar are still based on the lunar month.

The Lunar chariot of Rome

The ancient Romans thought that the moon was "goddness" named "Luna", she drove across the sky at night in a chariot.

When the moon did not appear, Luna had driven her chariot down to the earth to visit her mortal lover - a shepherd named "Endymon"

THE SUN

The sun is the **biggest star** in the solar system and its 4.6 Billion years old.

It is the center of the solar system in plasma state of matter and the closest star to earth in the solar system.

The sun's gravity holds the solar system together and its fixed in one position with space objects (like planets) revolving around it.

The sun is the major source of energy in the Solar System and without its energy, life would not exist on planet earth.

NB: At night on earth, very many stars are seen in the dark sky but during day time when our star (The Sun) is shining, it light so bright that other stars cannot be seen.

Some stars in space are hotter, brighter and bigger than the sun while other are cooler, Some are smaller than our sun and because they are very far away from the earth, their light and heat does not reach the earth and they look like tiny star points of light. But in our solar system, the sun is the brightest, hottest and the biggest star.

The sun is 10 times bigger than the biggest planet - Jupiter and 109 times bigger than the earth.

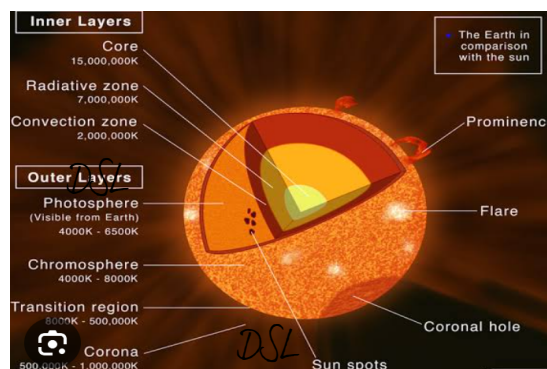


Figure 24:

Mean distance of the sun from the earth

The average distance (mean separation) of the earth and the sun is 93 Million Miles or 1AU. But 1AU = 150 Million Kilometers or 150 Billion meters.

ORIGIN OF SUN'S ENERGY

The sun's energy comes from Nuclear fusion reactions which take place within the sun's core, where Hydrogen gas atoms are fused to Helium gas atoms and in the process, a lot of energy in form of light and heat is given out.

Sun's radius: The radius of the sun is 7×10^8 m or 700 million meters

SUNRISE AND SUNSET

Each day, the sun rises in the east, moves across the sky and sets in the west.

EARLY THEORIES ABOUT SUNRISE AND SUNSET

The Ancient Egyptians: They believed that the "Sun god Re" sailed about a boat across the sky every day.

The Ancient Greeks: They believed that it was the journey of their "Sun god Helios" across the sky in a chariot (Two - Wheeled horse drawn vehicle)

THE OVERHEAD SUN

This is when the sun is directly overhead the earth and the sunlight rays fall at 90° on the earth's surface. Different locations of the overhead sun results into variations of the amount of solar radiations received in different areas on the earth at different periods.

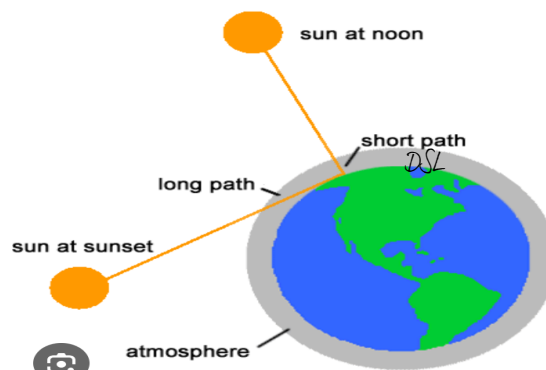


Figure 25:

The movement of the sun: The sun does not move across the sky at all. It is the rotation (spinning) of the earth that makes the sun to look like its moving across the sky. As the earth rotates from west to east, the sun appears to be rising or moving from east to west.

The earth's axis: The earth rotates on its own natural axis as do all other planets in the Solar system. The earth's axis is an imaginary straight line through the North Pole and South Pole of the earth on which it spins or rotates.

The earth's axis is tilted at an angle of 23.5° from the vertical.

MOVEMENT OF THE EARTH

The earth has two types of movements in the space of the solar system.

Rotation (Spinning motion): Rotation of the earth is the spinning motion or movement of the earth about its own natural axis. It takes the earth 24 hours (1 day) to complete one rotation about its own natural axis. As the Earth rotates or spins from West to East, the sun appears to rise or move from East to West across the sky. Spinning motion of the earth causes days and nights and formation of shadows.

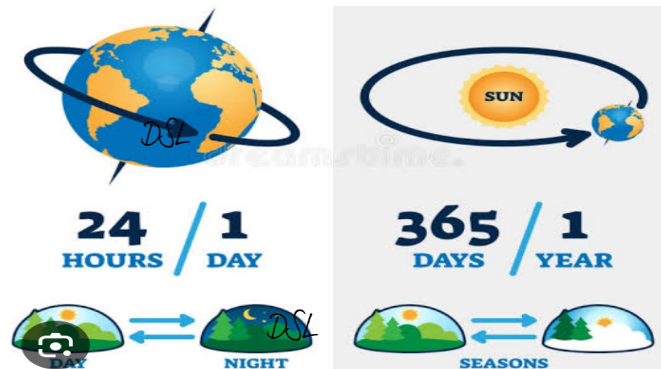


Figure 26:

1. Days and nights

Days and night on the earth's surface are caused by the rotation or spinning motion of the earth about its fixed natural axis. As the earth rotates on its axis, the side of the earth which faces the sun receives light and heat from the sun and this side experiences day time.

At the same time, the other part of the earth which faces away from the sun does not receive light and heat from the sun and this part is cooler and dark hence it experiences night time.

As the earth continues to rotate about its fixed axis, alternate days and nights are experienced bringing some countries in days time and others experiencing nights at the same time of rotation.

2. Shadows

As the earth spins or rotates about its fixed axis, objects on that part of earth's surface which are brought to sunlight (sunrise) have the longest shadows. As the earth continues to spin, the sun is seen rising and the shadows reduce in length and as the sun faces the earth directly due to continuous spinning of the earth (mid-day), the shadows are at their shortest length. As the earth continues to spin such that the sun is brought out of direct effect, the objects' shadows increase in length but on the opposite side and become longest just before sunset.

EARTH SPINS(ROTATES) FROM WEST TO EAST DIRECTION



Figure 27:

Revolution (orbit motion or Translation): This is the movement of the earth around the sun in an elliptical orbit with the sun at the center as the major focus.

It takes the earth $365\frac{1}{4}$ days to make one complete revolution around the sun. The period of $365\frac{1}{4}$ days is called a calendar year. To make the calendar simpler and since it is very hard to make a calendar with $\frac{1}{4}$ day, then 365 days are taken to make a calendar year.

A calendar year is a period of 365 days which is a revolution of the earth around the sun.

Leap year: A leap year is a calendar year that contains an additional day to make it 366 days compared to a common year.

A leap year has 366 days. For the calendar year of 365 days, every fourth year is a leap year. The extra $\frac{1}{4}$ day from each year are added to get an extra calendar day which forms the 29th of February, that is $(\frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4})$ days = 1 day, which is added to 365 days to get 366 days, hence fourth year to be a leap year. Each year contributes $\frac{1}{4}$ day and the fourth year contributes the last $\frac{1}{4}$ day to make four quarters $\frac{4}{4}$ which is a full day.

N.B: The earth revolves around the sun at about 108,000Km/hr but this speed is not noticed on earth because everything around us is also moving at the same rate.

THE SUN AND SEASONS OF THE EARTH

The earth experiences four seasons in a year and these are;

-Winter -Spring
-Summer - Autumn

When the sun appears higher in the sky, day light lasts longer. As the southern hemisphere of the earth is tilted away from the sun, then the northern hemisphere is tilted toward the sun. The hemisphere of the earth which is tilted towards the sun receives more hours of sunlight each day and it is in constant day light. This hemisphere becomes warmer due to longer period of sunlight and it experiences **summer season** (hot or dry season).

The hemisphere of the earth which is tilted away from the sun receives less sunlight and it is cooler hence it experiences **winter season** (wet season).

When neither northern nor southern hemisphere of the earth is tilted towards or away from the sun, then the earth experience **Autumn** or **Spring** season.

Autumn season is a season which is a transition from **Summer** to **Winter** and during this season, neither the Northern nor the Southern hemisphere of the earth is tilted towards or away from the sun.

Spring season is a season which is a transition from **Winter** to **Summer** and during this season,

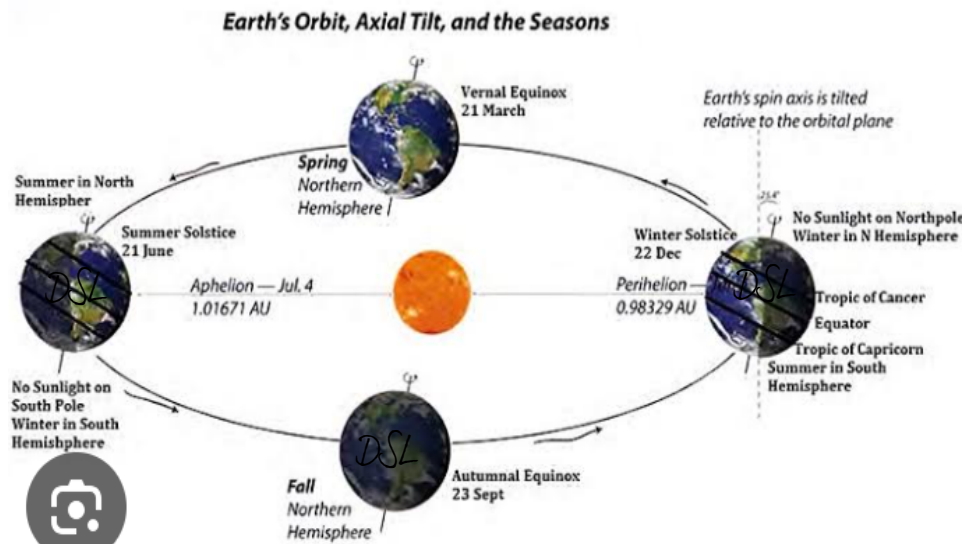


Figure 28:

neither the Northern nor the Southern hemisphere of the earth is tilted towards or away from the sun.

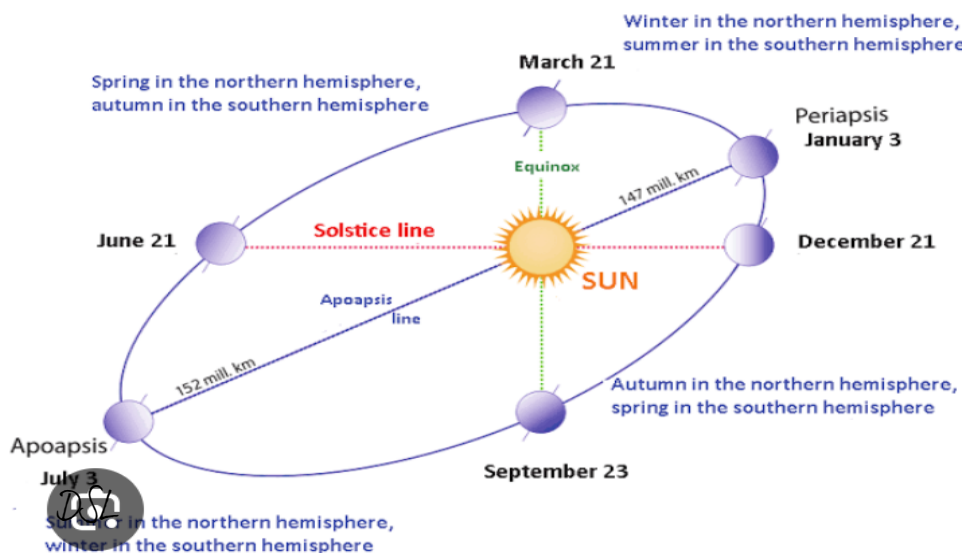


Figure 29:

Countries in the equatorial region

All countries in the equatorial region like Uganda experience only two seasons that is, the wet season (Winter) and dry season (Summer) and this is because , the tilting of the earth makes climatic and weather conditions in the equatorial region to be almost uniform with no extreme heat or coldness.

Seasons on earth occur due to the tilting of the earth which makes different areas on earth to receive more solar radiations than others leading to changes in climate and weather conditions of various

parts of the earth.

When the Northern Hemisphere is tilted towards the sun, then the Southern Hemisphere is tilted away from the sun. The Northern Hemisphere is in constant day sunlight hence it experiences **Summer season** while the southern Hemisphere receives less sunlight and is cooler hence it experiences **winter**.

When the Northern Hemisphere is tilted away from the sun, then it experiences **Winter** season and Southern Hemisphere experiences **Summer** since it is tilted towards the sun. Between Summer and winter, neither Hemispheres is tilted towards or away from the Sun and this makes the equatorial region to experience **Autumn** season.

From Winter to Summer, Neither Hemisphere is tilted towards or away from the Sun and this makes the equatorial region to experience **Spring** season.

(diagram)

N.B: The tilting of the earth causes the following.

Changes in temperatures of the earth throughout the year.

Changes in seasons on earth in a year.

NOTE: Seasons are determined by the angle at which the sun's rays strike the earth not the distance of the earth from the sun.

In summer, the sun is high in the sky

In winter, the sun is low in the sky and rises late in the morning and sets early in the afternoon.

SOLSTICE

The word solstice is from two Latin words "**Sol**" meaning "**Sun**" and "**Sistere**" meaning "**To stand still**" hence "**Sun stand still**"

Summer solstice (21st or 22nd June)

Summer solstice is the longest day of the year.

It occurs around 21 or 22 June and it is called the **mid summer**

The 21st **June** is the longest day and the shortest night of the year in the northern hemisphere of the earth and on this day, there is the most amount of sunshine if the weather is good.

Around the summer solstice, the northern hemisphere countries in the Arctic Circle (like Norway, Finland, Greenland and Alaska) in some of their parts have day light all day long and this is called the **Mid night sun** and in the Arctic Circle, the sun does not set at all.

N.B:

Summer solstice is the day the Northern Pole of the earth is closest to the sun each year and has most hours of sunshine.

It is also the day; the sun is highest in the sky.

The overhead sun is over the tropical of cancer and it receives the largest amount of solar radiations. The Northern hemisphere is in summer solstice and southern hemisphere is in winter.

The length of the day is **24 hours** at the Northern Pole and is the longest day in the year while that of the south pole is "**0**" hours and the shortest in the year.

The Northern hemisphere is tilted towards the sun and the Southern hemisphere is tilted away from the sun.

The arctic circle gets 24 hours of sunlight and Antarctic circle receives 24 hours of darkness.
The angle of the sun decreases towards the pole.

WINTER SOLSTICE (21st or 22nd December)

Overhead sun is over the tropical of Capricorn and receives the largest amount of solar radiations. The Northern hemisphere is tilted away from the sun and Southern hemisphere is tilted towards the sun.

The arctic circle gets 24 hours of darkness and Antarctic circle gets 24 hours of sunlight.

The Northern hemisphere is in winter solstice and Southern hemisphere is in the summer solstice.

The winter solstice is the day of the year that has the fewest hours of light and most hours of darkness.

Winter solstice has the shortest day and the longest night of the year.

It occurs on 21st or 22nd December.

Winter solstice is the first official day winter season.

Winter solstice is therefore the shortest day of the year.

The length of the time in the northern hemisphere is the shortest and that of the southern hemisphere is the longest in a year.

There are 24 hours of darkness at Arctic Circle and 24 hours of days light in the Arctic circle.

Summary

Summer solstice is the day when the Northern hemisphere of the earth experiences its longest period of daylight in a year.

Winter solstice is the day when the Northern hemisphere of the earth experience its longest period of night in a year.

From November to December in Norway and Iceland, Polar nights last almost all winter season and the sun does not rise at all. In some countries from May to July, the sun does not set and day light will continue day after day.

EQUINOXES

These are days in which the days and nights are of equal duration.

The two yearly equinoxes occur when the sun crosses the equator or when the sun is over head the equator.

N.B: The word Equinox comes from two Latin words "equi" meaning "equal" and "nox" meaning "night"

TYPES OF EQUINOXES

One equinox occurs between 21st to 22nd of March in a year which is the spring equinox and the other occurs between 21st to 22nd called Autumn equinox.

SPRING EQUINOX (March 22nd Equinox)

The overhead sun is at the equator and the equator receives sun rays at 90^0 .

Everywhere on earth experiences 12 hours of daylight and 12 hours of darkness hence the length of the day time is equal to the length of the night time on earth.

It occurs between 21st to 22nd of March in a year.

After the spring equinox, the day are longer than the night.

AUTUMN EQUINOX (September 23rd Equinox)

The overhead sun is at the equator and the equator receives sunrays at 90^0

Everywhere on the earth experiences 12 hours of light and 12 hours of darkness hence the length of the day and night is the same at all places on earth.

After the Autumn equinox, the night becomes longer than the day.

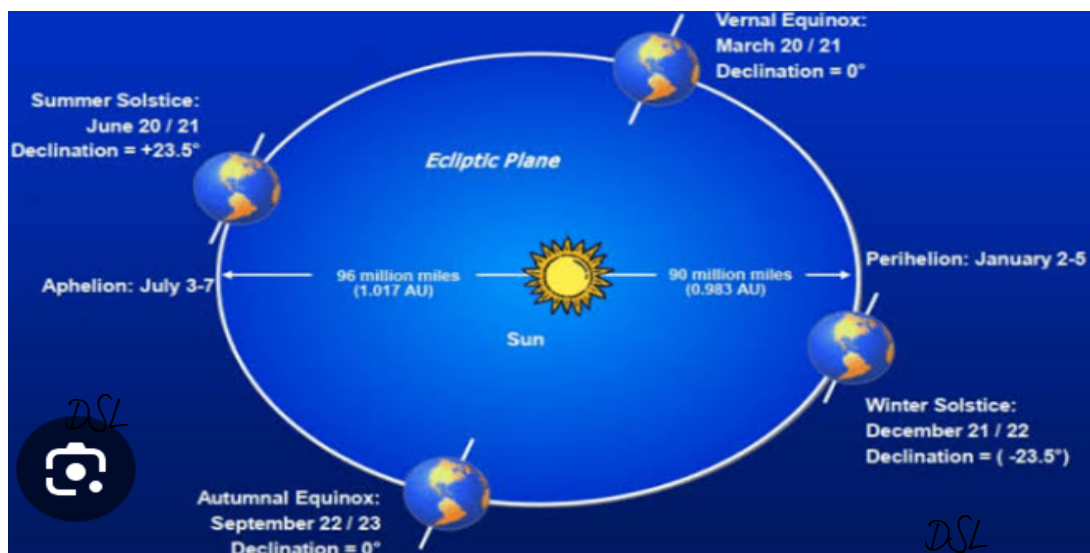


Figure 30:

CALCULATING TIME USING LONGITUDES

The Greenwich meridian is determination time because it is used as a point reference to other longitudes. Places on earth located East of Greenwich will be hours ahead of the places of earth in the West of the Greenwich.

Every 15^0 of longitude moved from the prime meridian Eastwards, a time of one hour is gained and every 15^0 moved from the prime meridian Westwards, at time of one hour is lost.

UNIVERSE

A **universe** is the whole of space, time and everything in it. Universe contains all the star systems, galaxies, space and time, gas and dust plus all the matter and energy that exist now, that exist in the past and that will exist in the future.

Cosmology: This is the study of the origin, structure, properties, process, future and evolution of the universe.

EXPANSION OF THE UNIVERSE

The stretching of space between galaxies increases the distances between them causing the expansion of the universe.

SCIENTIFIC THEORIES OF EVOLUTION OF THE UNIVERSE

The universe is believed to have originated from **singularity**.

Singularity is an infinite hot area with infinite pressure and density.

NB: None of the scientists knows where the singularity originated from. Before singularity, there was no space, time, matter and energy since they all begin inside it.

THE BIG BANG THEORY

The universe began from a single atom with high density and temperature and that the hot chaotic atom started to expand rapidly, cooled as it grew older that all matter, energy, space and time came from the expansion.

As the universe expanded, matter collected into clouds that began to collapse and rotate forming galaxies. Within galaxies, changes in pressure caused gas and dust to form different clouds. In some of the clouds where there were enough mass and right forces, gravitational attraction caused the

clouds to collapse compressing the mass in materials sufficiently for nuclear reactions to begin hence forming stars or stars are born.

The sun as star formed in the middle of the flattened spinning disk of materials where gas and dust within this disk collided and aggregated into small grains and these grains formed into larger bodies called **planetesimals** (very small planets) which coalesced (joined) into planets with their numerous satellites.

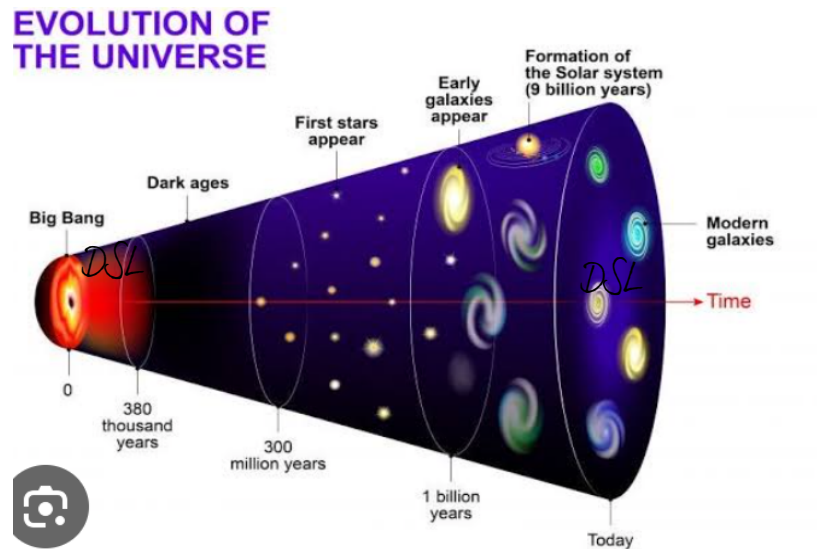


Figure 31:

STEADY STATE THEORY: The universe is always expanding but maintaining a constant average density. In this case, matter is continuously created to form stars and galaxies at an equal rate as the old ones become un-observable.

BIBLICAL THEORY: This states that God created the universe and various processes that drive physical and biological evolution. The earth was without form and void and darkness was over the face of the deep. (Genesis 1:1,2 and 3). The Quran states that the heavens and earth were joined together as one unit before exploding into sky and other materials.

STRUCTURE OF THE UNIVERSE

The Earth centered model(Geocentric model): It states that the Earth is at the center of the universe and all celestial bodies revolve around the earth. This model was embraced by both Aristotle and Ptolemy. Christianity taught that God placed the earth in center of the universe. In the model stars including the sun and planets revolve around the earth as seen by the sun rising in the East and Setting in the West every day, the second is the common sense perception that the earth is solid and stable; it is not moving but at rest.

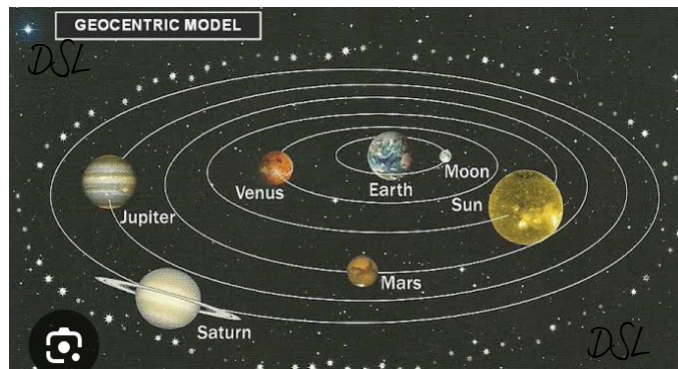


Figure 32:

The sun - centered model (Heliocentric model): The sun is at the center of the universe and all celestial bodies (space bodies) revolve around the sun. This model is the heliocentric model of Copernicus, Galileo and Kepler. This model became a major dispute between the Roman Catholic Church and scientists.

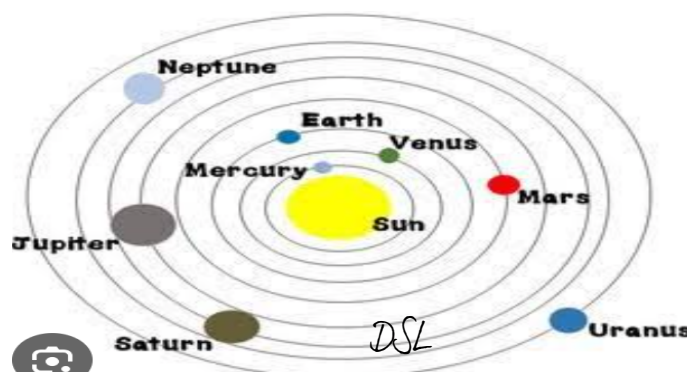


Figure 33:

Make more research about the following; Nicolaus Copernicus, Aristotle, Ptolemy, Galileo Galilei, Johannes Kepler and how each talked about the two above models. Research about the cosmic inflation theory, metaphysical cosmology and Quasi steady state theory.

STARS AND GALAXIES

Astronomers refer to a group of scientists that have interests focusing on study of stars and space. **Astronomy** is the branch of science that involves the study of visible celestial objects present in the

universe such as sun, stars, planet, moons, galaxies and nebulae.

The stars

A **star** is a luminous ball of gas, mostly hydrogen and helium, held together by its own gravity. Scientists estimate there exists roughly 10000 stars for every grain of sand on earth. we are all pretty familiar with stars, we see them on most clear nights as tiny, twinkling pinpricks of light in the sky.

The Nuclear fusion reactions in the star's core support it against gravity and produce light and heat, as well as small amount of heavier elements. **The biggest star in our solar system is the sun and is the closest star to our earth**

NEBULA

A nebula (Plural "Nebulae") is a large cloud of dust and gas in space. Most of the gas in the nebula is hydrogen gas. The word nebula comes from a Latin word for clouds.

SOLAR WIND

Solar wind is a low density stream of **charged particles** from the sun mostly electrons protons which propagate through the solar system.

Solar wind and high energy particles ejected by the solar flares can have dramatic effect on the earth such as electrical power surges and radio interference among others.

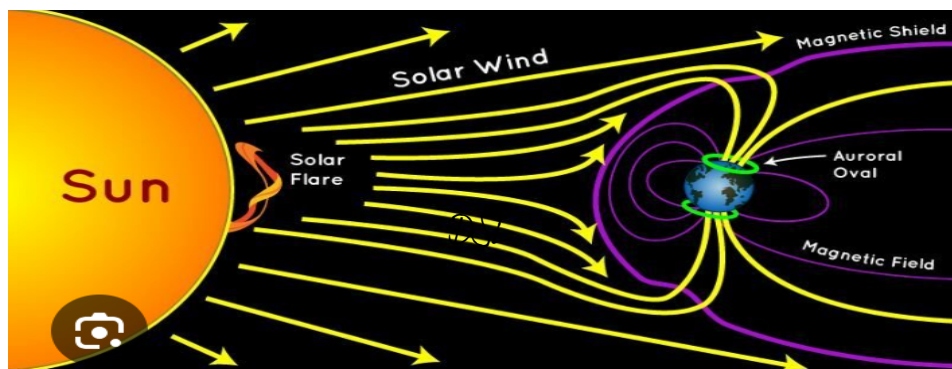


Figure 34:

Source of energy in stars.

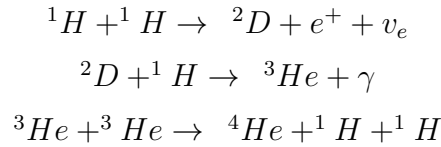
A star, like our sun, must also generate energy, otherwise it would shrink into a very dense and small body.

The sun and its source of energy.

Solar energy is created by **thermo-nuclear fusion** reactions that takes place in the sun's core, releasing vast amount of energy through two distinct reactions in which four hydrogen nuclei may eventually result in one helium nucleus. These are the **proton-proton chain** reaction by which

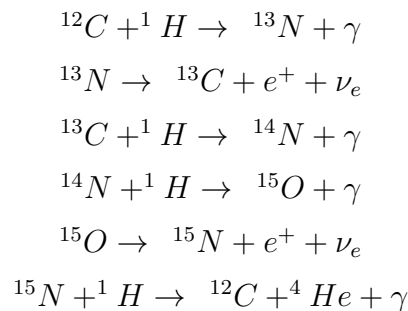
most of the Sun's released energy and the **Carbon Nitrogen Oxygen (CNO) cycle**. During the fusion process, radiant energy is liberated. In its core, the sun fuses 620 millions metric tons of hydrogen and makes, 616 million metric tons of helium each second.

The proton-proton chain reaction:



where 1H is a proton, 2D is Deuterium (hydrogen isotope), e^+ is a positron, ν_e neutrino, 3He is Helium-3, γ gamma ray photon and 4He is Helium-4. The total energy released by these reactions in turning 4 hydrogen atoms into 1 helium atom is 26.7 MeV.

The second sequence of reactions is **CNO cycle** in which 4 H nuclei may form one He nucleus. This cycle generates less than 10 percent of the total solar energy output. It is a reaction which involves carbon atoms which are not used up in the reaction process.



Nuclear fusion is the combination of small nuclei to form bigger ones with release of energy. The sun is the source of almost all energy on Earth, it produces too much energy and the earth only receives about over billionth of the sun's total energy output. The Earth reflects back a bigger percentage to the space.

Approximate amount of energy produced by the sun per second.

The sun releases $3.84 \times 10^{26} W$ per second equivalent joules of energy 426 million metric tons (3846 septillion watts)

Proportion of the sun's energy reaching the earth's surface

Proportion of the sun's energy that is captured for photosynthesis.

How energy produced in the core is transferred to the outer surface of the sun.

The energy produced in the solar core is in form of gamma rays, which diffuse very slowly occasionally colliding with other particles as they travel outward. On collision, they lose their energy, liberating another gamma ray. Slowly the energy is transferred outward and it may take millions of years for photons to diffuse to the top of the **photosphere**. In the **radiative zone**, radiative diffusion dominates the outward flow of heat. The next layer of the Sun is the **convective zone** where convection dominates the outward flow of heat. The outer layer of the Sun is the photosphere

at which the temperature falls to around $5500K$

Stellar Atmospheres

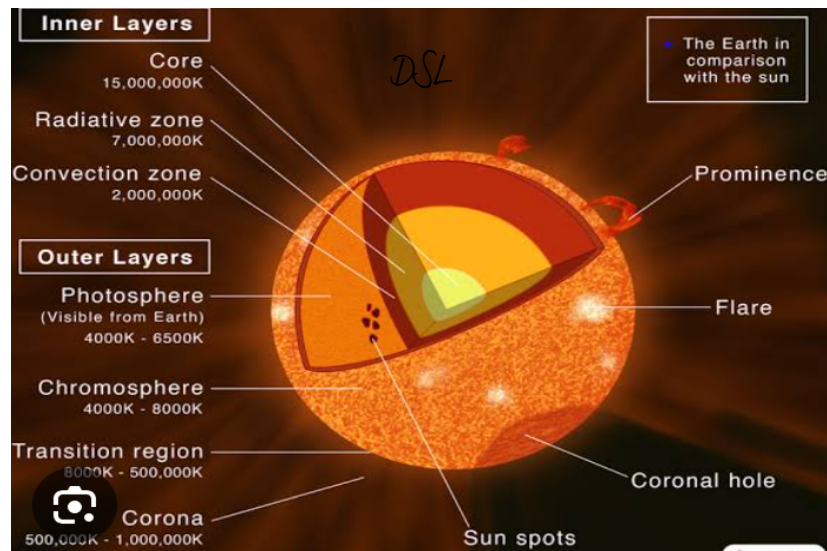


Figure 35:

The stellar atmosphere is the outer visible region of a star, lying above the star's **core**, **radiation zone** and **convection zone**.

The stellar atmosphere is divided into several regions of distinct character.

The photosphere

The photosphere is the stellar atmosphere's lowest and coolest layer, is normally its only visible part. Light escaping from the surface of the star stems from this region and passes through the higher layers. The Sun's photosphere has a temperature in the $5,770\text{ K}$ to $5,780\text{ K}$ range. Star spots, cool regions of disrupted magnetic field lie on the photosphere.

The chromosphere

Above the photosphere lies the chromosphere which is about 400 km above the solar surface (the photosphere). This part of the atmosphere first cools down and then starts to heat up to about 10 times the temperature of the photosphere. The temperature in the chromosphere varies between about 4000 K at the bottom and 8000 K at the top.

Transition Region

Above the chromosphere lies the transition region, where the temperature increases rapidly on a distance of only around 100km . The transition region is a very narrow layer between the chromosphere and the corona, where the temperature rises dramatically from approximately 8000 to $500,000\text{K}$.

The Corona

The outermost part of the stellar atmosphere is the corona, a tenuous plasma which has a temperature above one million Kelvin. While all stars on the main sequence feature transition regions and corona, not all evolved stars do so. It seems that only some giants, and very few super giants, possess corona. The corona can be heated to such high temperatures due to magnetic field activity, but the exact mechanism remains unclear.

During a total solar eclipse, the photosphere of the Sun is obstructed, revealing its atmosphere's other layers. Observed during eclipse, the Sun's chromosphere appears briefly as a thin pinkish arc, and its corona is seen as a tufted halo. The same phenomenon in eclipsing binaries can make the chromosphere of giant stars visible.

Different energy changes that take place in the sun

Nuclear fusion, involves the combination of hydrogen nuclei to form helium with a tremendous release of energy in form of heat and light.

Electromagnetic radiation, such as visible light, ultra-violet and infrared radiation are emitted by the sun traveling through space in form of photons. Thermal energy from the sun's core is converted into electromagnetic radiation in the sun's radiative zone.

Gravitational energy. The sun's immense mass and gravity cause it to contract under its own weight releasing gravitational energy in the process. This gravity contributes to the sun's internal heat which in turn fuels nuclear fusion.

Importance of Solar Energy

However much the earth receives a very small portion of the energy from the sun (solar energy), it is this proportion that accounts for most life sustaining and energy consuming process on Earth. Without the solar energy life would not exist on Earth.

Solar energy helps to support natural processes like photosynthesis, transportation, germination, evaporation and percolation etc.

Photosynthesis. Solar energy provides the necessary light energy for plants to convert carbon dioxide and water into glucose and water. This process is essential for the growth and survival of plants.

Transpiration. By heating the air and causing water to evaporate from the leaves of plants which helps in the movement of water and nutrients throughout the plant.

Germination. By providing the warmth necessary for seeds to sprout and begin growing.

Evaporation. By heating bodies of water causing water to change from liquid to vapour which is crucial for the water cycle.

Percolation. By warming the soil, which aids in the movement of water through the soil layers.

Energy sources that come from the sun

Solar Photovoltaic System which directly convert sunlight into electricity using the photovoltaic effect.

Solar Thermal Energy harnesses the sun's heat to produce electricity or provide heating e.g solar concentrations.

The size of the sun

When viewed from earth, the sun appears smaller than the earth, this is because the sun is too far away from the Earth (about $147,000,000\text{ Km}$). The sun is about 150 million Km far away from the earth. But the sun is far much bigger than all the components of the solar system you could fit almost 1320 Earths inside Jupiter, but the sun is far much bigger than Jupiter.

Size of the sun relative to other stars

The sun is an averaged sized star. There are both larger and smaller stars that exist, some large stars have a diameter that is 100 times greater than that of the sun. However, there are also stars that are a tenth of the sun.

Why do the other stars appear smaller than the sun to an observer on Earth?

This is because the sun is much closer to the Earth compared to other stars.

CLASSIFICATION OF STARS

1. Average stars
2. Massive stars

AVERAGE MASS STARS (MEDIUM MASS STARS)

These are star whose mass is 0.5 to 8 times the mass of the sun

Our sun is the average star and average stars have longer life than massive stars. These stars do not have enough mass to have enough mass to fuse elements beyond helium and they do not get hot enough.

Examples include; Proxima Centauri, Bernard's star, Luyten's star.

MASSIVE STARS

These are stars which are extremely heavy, hot and bright.

Their mass can be as many as 30 times bigger than the mass of the sun and greater than 100000 times brighter than the sun.

Examples: Carina nebula, at a distance of 8500 lightyears containing dozens of hot massive stars.

SIZES AND MASSES OF STARS

Stars vary in their size and mass. The smallest stars are slight bigger than the Jupiter. Most stars are smaller and less massive than the sun. Most stars are smaller and less massive than the sun.

Many stars also have about the same mass as the sun but some stars are significantly more or less massive than the sun and stars that are very dense may have more mass than the sun and still be smaller than the sun.

Variation in colour and Brightness of stars

Absolute Magnitude is the measure of a star's brightness as it is viewed at a standard distance from the earth.

Class	Star colour	Approximate temperature	Sample Star
O	Blue	30000K or more	Zeta Ophiuchi
B	Blue - white	10000 - 30000K	Rigel
A	White	7500 - 10000K	Altair
F	Yellowish - White	6000 - 7500K	Procyon A
G	Yellow	5500 - 6000K	Sun
K	Orange	3500 - 5000K	Epsilon Indi
M	Red	2000 - 3500K	Betelgeuse, Proxima Centauri

Others are the F-type (yellow-white), B-type (Blue-white)

CLASSIFICATION OF STARS

Stars are classified depending on the Hertzsprung -Russell diagram (H-R diagram)

The Hertzsprung - Russell diagram (H-R diagram)

This is a graph of the stars' luminosity (brightness) against their surface temperature (colour)

The star's luminosity is the total amount of energy a star gives out each second.

The H-R diagram was named after Ejnar Hertzsprung and Henry Norris Russell.

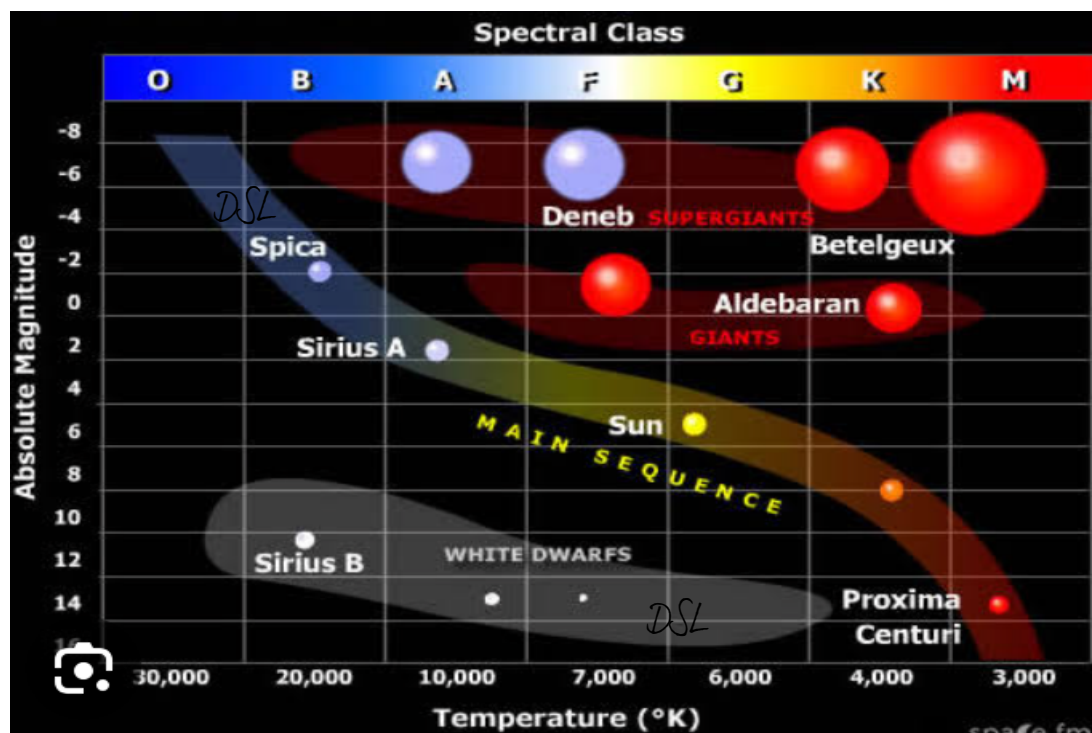


Figure 36:

The main sequence of stars

This is a band running diagonally from the lower right cool- Red stars to the upper left hot bright- Blue stars obtained when luminosity of stars is plotted against the surface temperatures of the stars. (obtained on the H-R diagram).

The main sequence stars

These are stars which lie within the band main sequence of the stars on the H-R diagram and these stars fuse hydrogen atoms to form Helium atoms in order to produce their energy.

The sun (our sun) is the main sequence star. A star is on the main sequence if it can balance the inward force of gravity with the outward force of nuclear fusion in its core. The more massive a star, the more it burns its fuel to generate more energy which prevents gravitational collapse. Because massive stars burn more fuel, they have highr temperatures and run out of fuel sooner than small stars.

Examples of main sequence stars are; Our sun, Vega, Spica, Proxima Centauri.

The star's equilibrium or stability is achieved when the outward pressure due to nuclear fusion within the core of a star balances with the inward force of gravity pushing down on it and this keep the star alive.

The H-R diagram is alternatively drawn as shown below

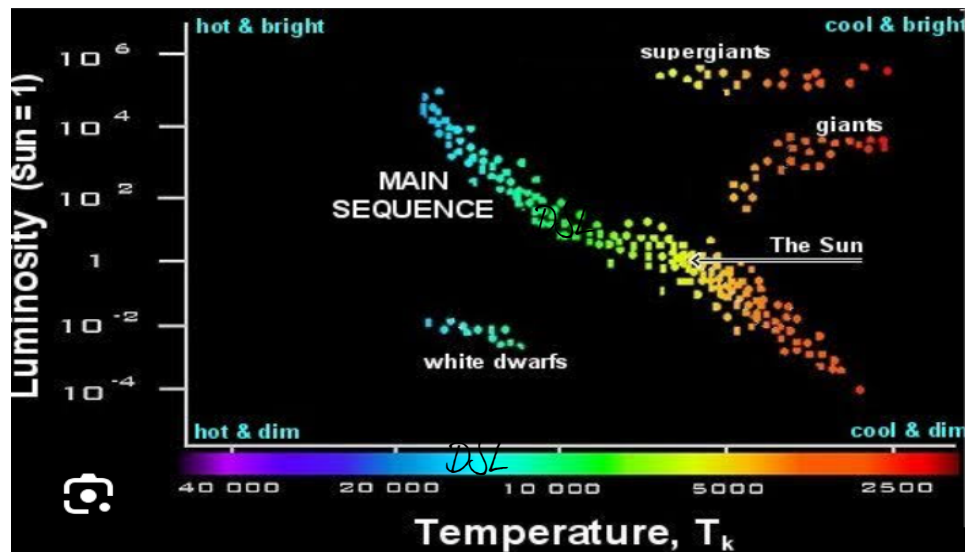


Figure 37:

N.B: The second largest stage in the life of a star is the main sequence stage where energy continues to be generated in the core of the star as hydrogen fuse to form Helium.

A star with mass about the same as the sun's mass stays on the main sequence for only 10 million years. More mass stars fuse Hydrogen so rapidly that they stay on the main sequence for only 10 million years. Less massive stars which are at the bottom right of the H - R diagram are to exist for hundreds of billion years.

BLUE STARS: These are stars which contain a high amount of fuel (Hydrogen) and are the hottest stars.

RED STARS: These are older stars than blue stars which are still burning fuel and are the coolest stars.

Leaving the main sequence

A star enters its third stage when about 20 percent of its Hydrogen atoms with in core have fused to form Helium atoms. The core of the star begins to contract under the force of its own gravity which increases the temperatures in core and its core becomes hot.

As the core becomes hotter, it transfers energy into a thin shell of hydrogen surrounding the core and this energy causes hydrogen fusion to continue in the shell of gas. The on - going fusion of hydrogen radiates large amount of energy outwards which causes the outer shells of the star to expand making the star larger and cooler which causes it to either become giant star or super giant star hence moving off the main sequence of the stars.

Giant star: Giant stars are very large and bright stars than the main sequence stars at the same surface temperature and whose hot core has used most of its hydrogen during nuclear fusion. **Red giant star** is a red - large cooler star formed when a massive star uses up all its fuel and cannot resist the inward gravitational force which makes it to collapse such that the outer layers grow outward

and cools to red colour. Because their large surface area, giant stars are bright. **Examples** include: **Arcturus**

Super giant stars are highly luminous stars which are larger than the giant stars in the third stage and are formed the main sequence stars that are more massive than the sun. Example is Betelgeuse. **Red super giant** are the largest and have cooler surfaces ^{DS}temperatures as they have used up all the core hydrogen and hydrogen fusion occurs in the outer shells which expands and cool to red cooler since cooler stars take on red colour.

NB: Bigger stars produce more energy making their surfaces hotter hence they tend to Bluish- white. Small stars produce less energy and their surfaces are less hot hence they tend to yellowish. **Factor that determine the brightness**

1. The composition and distance from the earth
2. Size and temperature of the star

The apparent brightness of a star varies with distance from it , for instance the sun appears brighter when viewed from Venus than from the Earth because venus is closer to the sun than the Earth.

There are many stars in space as there are grains of sand in seas, the luminosity of a star is measure its brightness. Astronomers measure a star's brightness by examining the amount of energy it emits per second. The more energy emitted, the higher the brightness . this energy emitted per second is measured in **watts**

The brightest star in the sky is **Sirius**, also known as the "Dog star" or the Alpha Canis Majoris, because of its position in the constellation Canis Major.

Parsec is the distance from which the radius of the earth's orbit, 1AU, subtends an angle of 1".

Light year(ly). is the distance traveled by light through a vacuum in one Julian year.
($1ly = 9.4607 \times 10^{15} m$).

One parsec is equivalent to 3.226ly.

The **radiant flux** is the total amount of light energy of all wavelengths that crosses a unit area oriented perpendicular to the direction of the light's travel per unit time.

Imagine a star of luminosity, **L** surrounded ^{DS}by huge spherical shell of radius r. Then assuming that no light is absorbed during its journey out to the shell, the radiant flux, **F** measured at distance, **r** is related to the star's luminosity by:

$$F = \frac{L}{4\pi r^2}$$

, where $4\pi r^2$ is the area of the sphere. **Inverse Square law** of light states that the radiant flux is inversely proportional to the square of the distance from the star.

FINAL STAGES OF SUNLIKE STAR

When fusion in the core of a star stops after helium atoms have fused into carbon dioxide and oxygen, energy will no longer be available from fusion and stars becomes a planetary nebula and finally a White dwarf star.

Planetary nebula: This is where star's outer gases drift away and the star remains with a core

which heats these expanding gases leading to a cloud of gas that forms around the dying sunlike star.

White dwarf stars: These are stars formed when the planetary nebula disperses and gravity causes the remaining matter in the star to collapse inwards until it cannot be pressed further together leaving a hot extremely dense core of matter called a white dwarf which shine for billions of years before they cool completely.

NB: A white dwarf star is small, hot and dim star which is a leftover center of an old sunlike star. When a white dwarf stops growing, it becomes a black dwarf star which is the last stage in the star's life and the star dies.

NOVAS: A nova is explosions of white dwarf star due to pressure build up caused by accumulation of gases on its surface when it revolves around a Red giant star making the white dwarf star to suddenly become brighter than it normally is.

NB: If the white dwarf revolves around a red giant star, the gravity of the dense white dwarf captures loosely held gases from the red giant. As these gases accumulate on the surface of the white dwarf, pressure begins to build up causing a large explosion called a nova which releases energy and stellar materials in space. A nova may cause a star to become many thousands times brighter than it normally is.

SUPERNOVA: This is a massive explosion when a white dwarf becomes a nova several times which completely destroy the white dwarf star and may even destroy much of the giant star in their binary star system.

NB: Supernova leads to the formation of either black holes or neutron stars but massive stars form black holes, pulsars and neutron stars after supernova explosion.

STELLAR NEBULE (Stellar Nursery)

This is a gigantic cloud of gas and dust from which new young stars are born. Therefore a stellar nebula is a planetary cloud of gas and dust from which new stars are formed after a giant star (massive star) explodes to leave some materials of it behind. The word "**stellar**" means "**a star**".

NEUTRON STAR: This is a star that has collapsed under gravity to the point that electrons and protons smash together to form a ball of neutrons when a giant dying star is compressed and becomes denser. A neutron star is the densest substance in the entire universe. Neutron stars are smaller but denser than the white dwarf star and it rotates very rapidly.

PROTOSTAR: A protostar becomes a star when its hydrogen begins to fuse to form Helium such that a lot of energy is given out. This is a very young star that is gathering mass from its parent molecular cloud. This is the earliest phase of the process of stellar formation. A protostar becomes a main sequence star when its core temperature exceeds 10 Millions of Kelvin. This is the temperature for nuclear fusion to occur efficiently.

STAR GROUPS

Constellation: This is an easily recognized group of stars or satellites that appear to be located close together to form patterns in the sky.

Multiple star system (star system): This is a system where two or more stars are closely associated and orbit each other. Multiple star systems sometimes have more than two stars and are often close together that they appear as one star or can be distinguished as a pair by a telescope.

Binary Stars: These are pairs of stars that revolve or orbit around each other and are held together by gravity.

STAR CLUSTERS

These are group of hundreds and thousands of stars formed from the collapse of the nebula.

TYPES OF STAR CLUSTERS

There are two types of star clusters that is; **Open star cluster** and **Globular star Cluster**.

Open star cluster: These are groups of stars up to few thousand stars that are loosely held together by the gravity. Open star clusters tend to be Blue in colour often containing glowing gas and dust. They are made up of young stars that are formed from the same nebula and these stars may eventually be pulled apart by gravitational attraction of other objects.

Globular star cluster: These are groups of tens to hundreds of thousands of stars held tightly together by gravity. These clusters have a definite spherical shape and contain mostly of Reddish stars. Stars are close together, close to the center of the cluster. Globular star clusters donot have much dust in them because the dust has already formed into stars.



Figure 38:

BLACK HOLES

A **black hole** is a region in space where gravitational forces is so strong that matter like gas clouds are pulled inwards and nothing can escape from it not even light itself can escape this pull of the black hole.

A black hole is a massive star that has collapsed onto itself, it is very dense , its gravity is so strong not even light can escape from it. It is invisible since no light can escape from the black hole, black holes do not give off light.



Figure 39:

Black holes can be identified by the effect they have on objects around them and the radiations mostly X-Rays that can leak out around their edges and Astronomers identify them by detecting these radiations (X-Rays) they release.

Why Star Appear to twinkle?

This appearance is due to the effect of the atmosphere, when light from the stars enter the atmosphere, it is continuously refracted by regions with different temperatures and optical densities.

LIFE CYCLE OF A STAR

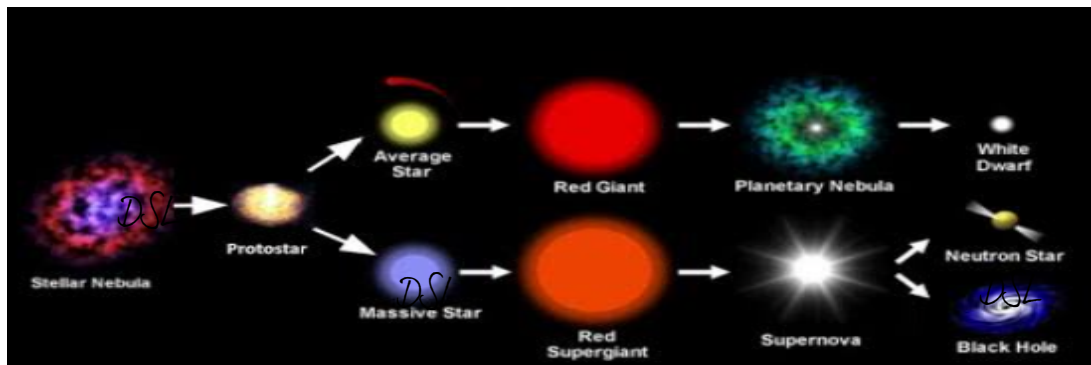


Figure 40:

Stars and humans share similar phases in their life cycles, stars begin their lives as dense clouds of gas and dust.

Like humans, stars spend most of their life in the Main Sequence stage (adulthood). If a star begins its life with a great amount of mass, it burns hot and fast to maintain equilibrium. So fuel runs out so quickly. The star dies young with a super massive explosion, an average sized star lives longer (about 10 billion years) and dies a quiet peaceful death.

A star life cycle is determined by its mass, the larger its mass the shorter in its life cycle. A star's mass is determined by the amount of matter that is available in its nebula, the giant cloud of gas and dust from which it was born.

Stages in the life cycle of a star

Stellar nebula. Stars are formed from massive clouds of gas and dust called nebulae. The process begins when a region with a nebula becomes denser due to gravitational forces. As the density increases the temperature rises nuclear fusion reactions are ignited, leading to birth of a star.

Protostar stage

This is the first phase, **Protostar** is a collection of gas that has come from a collapsed giant molecular cloud. After many years, the gravity and pressure increases, causing the collapse of the protostar. The gravitational pressure holding the star together is the source of all the energy released by the protostar. At this stage, nuclear fusion reactions have not yet been ignited. This phase of a star lasts for 100,000 years.

T-Tauri Star

At this stage, the stars do not have enough pressure and temperature to ignite nuclear fusion in their cores. The stars are like the main Sequence stars in terms of their temperature, but they are brighter and larger. T-Tauri stars can experience high geomagnetic activity. This is exhibited by the presence of sunspots, high intensity, X-rays flares and powerful stellar winds. This stage of the star lasts about 100,000,000 years.

Main Sequence Star

Most of the stars in the Milky way Galaxy and in the universe fall under this category. Our sun and its nearest neighbors sirius and Alpha Centauri are main sequence stars. The source of all the energy released by the star at this stage is fusion of hydrogen to form helium in the star's core. The star is in a state of hydrostatic equilibrium whereby the star's gravitational pressure and the light pressure due to the thermo-nuclear fusion reactions in the core counter balance each other. In this case, the star is able to maintain a spherical shape due to this balance.

Red Giant Star

After some time, a star can use up all its stock of fuel (hydrogen in its core). When this happens, the thermo-nuclear fusion reaction in the core stop and the star collapses under its own gravity. This is because there is no longer outward light pressure from fusion reactions to counter balance the inward pressure due to gravity.

Then a shell of hydrogen around the core is forced to ignite fusion reactions to extend the life of this star. This causes the star to dramatically increase in size, hence becoming a red giant star which can be hundred times larger than a main sequence star.

Still, this shell of hydrogen can also get used up. When this happens, the aging star forces further shells of helium and even heavier elements into fusion reaction to preserve the life of the star. this phase of star last about a few hundred million years.

Planetary Nebula or Supernova Stage

For average stars such as the sun, it sheds its outer layers to form a planetary nebula. The remaining core becomes a white Dwarf, Massive stars undergo **catastrophic supernova explosion** at the end of their lives. These explosions disperse heavy elements into space and can result in the formation of **neutron stars or black holes**.

White Dwarf Stage

Eventually the star will run out of the fuel in its core. Further, if the star lacks the mass to force higher elements into fusion reactions, it becomes a white dwarf. In this case, the fusion reactions in the core have stopped and there is no longer outward light pressure to counter balance the inward gravitational pressure. Hence the star collapses under its own gravity. During collapse, however an electron degenerate gas forms in the core. This provides sufficient degeneracy pressure as it is compressed to resist further collapse.

White dwarfs are luminous because they have trapped a large amount of heat. A white dwarf shines because it was once a hot star. It eventually cools down to the ambient temperature of the background universe. White Dwarfs take billions of years to cool down.

Red dwarf Star

These are the most common stars in the universe. They are a "type" of main Sequence stars that are much cooler than the main sequence stars because they have low mass. Such stars are able to keep nuclear fusion of hydrogen in their cores and can conserve their longer than most other stars. Some red dwarfs can last up to about ten trillion years.

Neutron stars or black holes formation

Stars with masses between 1.35 and 2.1 times the mass of the sun do not form white dwarfs after nuclear fusion stops in their cores. Such a star dies in a catastrophic supernova explosion, retaining a core which becomes a neutron star which is entirely composed of neutrons. The intense gravity of the neutron star force electrons and neutrons together, forming neutrons. For more massive stars, such supernova explosions result into black holes instead of neutron stars.

Supergiant Stars

These are the largest stars in the universe, they are much bigger than the sun in terms of mass. These kind of stars are consuming their hydrogen fuel at a much faster rate than other stars, hence they end up consuming all the fuel in their cores within a few billion years. They tend to live fast and die young by catastrophic supernova explosions.

Briefly; **Neutron star** is the collapsed core of a massive star that has undergone a supernova explosion. Neutron stars are incredibly dense, with a mass about 14 times that of the sun but a radius of only, about 10Km. They are composed almost entirely of neutrons and possess extremely strong gravitational and magnetic fields. **Black hole** is a region in space where gravity is so strong that nothing not even light can escape from it. It forms when a massive star, typically with a mass greater than 20 times that of the sun, reaches the end of its life cycle. As a massive star collapses in on itself at the end of its life, it causes its outer layer to explode as a supernova, while its dense core keeps collapsing under the force of gravity. The extreme density of the core compresses the atoms and subatomic particles to a point where they are crushed into an infinitely small space forming a singularity. The boundary surrounding the a singularity is known as the "event horizon", which marks the point of no return. **A supernova**, is a violent and spectacular explosion that occurs at the end of a star's life. It is the result of a star running out of nuclear fuel and collapsing under its own gravity. The intense gravitational compression heats and ignites the remaining mass, causing a tremendous explosion that can outshine an entire galaxy for a brief period. **Brightness of supernovae**, supernovae are spectacular events that can be so bright to a point of outshining their entire galaxies for a few days or even months. They can be seen across the universe.

Difference between a white dwarf and black hole

A white dwarf is a dense compact celestial object formed from the remnants of low or medium mass stars composed primarily of carbon and oxygen while a black hole is a region in space where gravity

is so strong that nothing not even light can escape from it.

Factors that determine the life expectancy of a star

Mass. This affects its gravitational pull and the pressure and temperature at its core. Average stars last longer than massive stars.

Composition. The amount of hydrogen and helium it contains. Where a star exhaust its hydrogen supply, it can no longer produce energy through fusion.

Rate of Nuclear fusion. Heavier stars burn their fuel more quickly causing them to exhaust their nuclear fuel and collapse more rapidly than their lower mass counter parts.

SOLAR ENERGY: This is the energy produced by the sun

SOLAR POWER: This is the energy produced by the sun per second. Solar power is the power the sun.

SOLAR CONSTANT (SOLAR FLUX/SOLAR UNIT/SOLAR INTENSITY)

This is the amount of solar energy produced by the sun which is received on the planet(like the earth) per unit area.

Energy from the sun reaches the earth by **radiation process**.

GALAXIES

A galaxy is a huge collection of gas, dust, and billions of stars and their solar systems, all held together by gravity. OR Is a massive system that is bound together by gravity, consisting of stars, stellar remnants, interstellar gas, dust and dark matter.

Galaxies range from dwarf to super giants with stars, all orbiting the galactic centre of mass. Our galaxy, the Milky Way galaxy, has a supermassive black hole in the middle. In a galaxy, there are very many stars arranged in a recognizable shape called constellations. Different galaxies have constellations e.g. elliptical, spiral and others are irregular.

How Galaxies are formed

The current cosmological models of the universe are based on the big bang theory. Thousands of years after the big bang, light elements like hydrogen and helium started to form in a process called recombination. Density fluctuations in the this earliest matter led to the formation of larger structures. The primordial structures eventually become galaxies. The first halo stars then appeared.

The halo stars may have been massive and could have quickly consumed their fuel and detonated in supernova explosions, releasing heavier elements into the interstellar space. This was followed by ionization of the neutral hydrogen by the first population of stars. This created expanding bubbles in space that could allow light to go through readily.

"After a Big Bang, the universe was composed of radiation and substantial particles. Did the small particles slowly team up and gradually form stars, clusters and eventually galaxies. Or did the Universe first organise as immense dumps of matter that later subdivided into galaxies."

Evolution of Stars

Key structures in a galaxy begin to appear after about a billion years. These include; globular clusters, the central supermassive black hole and the galactic bulge of population II stars. The supermassive black hole limits the total additional matter added unto a galaxy, hence regulating the growth of galaxies. During the early stages of the galaxy, it undergoes a major burst of star formation.

In the following billions of years, the accumulated matter and structures settle and form a galactic disc. Throughout the lifetime of a galaxy, absorption of incoming matter for example high velocity clouds and dwarf galaxies continues. As the stellar matters forms and dies, the abundances of heavy elements increases until planets are allowed to form.

Galaxies can be modified by interactions and mergers, hence affecting their content and morphology. Galaxies are more prone to mergers during their earliest stages of formation. For example, the Milky Way galaxy and the neighboring Andromeda galaxy are moving towards each other at about 10 km/s . Depending on their movement, they may collide in the next six billion years.

CLASSIFICATION/TYPES OF GALAXIES

Galaxies are classified depending on their shape and the shapes are:

- Elliptical - Spirals
- Lenticulars - Irregular galaxies

EXAMPLES OF GALAXY

Milky way galaxy which contain our solar system and its spiral

Andromeda galaxy which is the nearest galaxy to the milky way

Ciger galaxy

Pinwheel galaxy

The sombrero galaxy

Galaxies which are not elliptical and spiral are called irregular galaxies. Therefore, there are three main categories or types of galaxies in the universe and these are spiral, elliptical and irregular galaxies.

The other two irregular galaxies close to our milky way galaxy are the **Large Magellanic Cloud** and the **small Magellanic Cloud**.

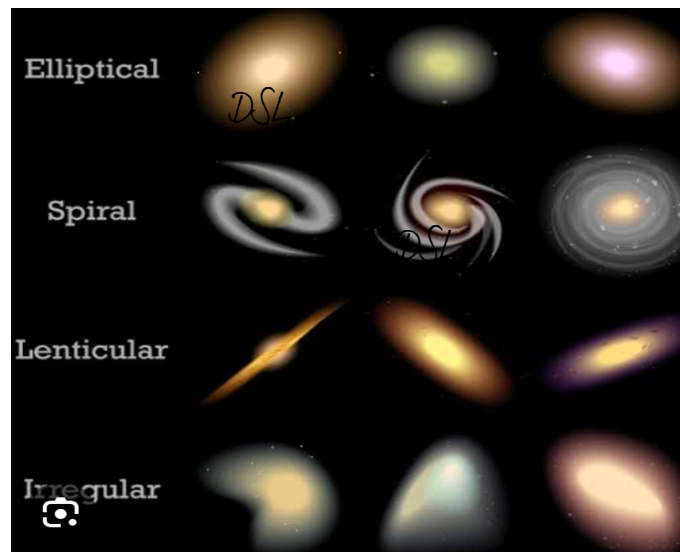


Figure 41:

SPIRAL GALAXIES: These have nuclear of bright stars and flattened arms that spiral around the nucleus. The spiral arms contain billions of young stars, gas and dust. Barrel spiral galaxies have a straight bar of stars that runs through the center. Our solar system is in the spiral arm of the Milky Way galaxy. The Milky Way galaxy is shown below.

Examples of spiral galaxies include the following.

- Milky Way galaxy named due to its milky - like appearance at a dark clear night sky.
- Sombrero galaxy.

ELLIPTICAL GALAXIES: These are extremely bright in the center and donot have spiral arms. They have few young stars and contain little dust and gas because the dust and gas has already formed into stars.

IRREGULAR GALAXIES: These have no particular shape and usually have low total masses. They are fairly rich in dust and gas.

Galaxies are below;

LENTICULAR GALAXIES: These are galaxies which are intermediate between elliptical and spiral galaxies. They have a central bulge and disk common to spiral galaxies but with no arms. They have older stellar population and little ongoing star formation.

QUASARS

These are very luminous objects that produce energy at a very high rate in galaxies. Galaxies that have Quasars in them differ from others in that Quasars in their centers are very bright.

Other galactic Morphologies

Peculiar Galaxies

Peculiar galaxies are those with unusual properties that arise from tidal interactions with other galaxies. For example the ring galaxy forms when a smaller galaxy passes through the core of a spiral galaxy. A ring galaxy possesses a ring-like structure of stars and interstellar matter surrounding a bare core. The Andromeda galaxy also exhibits ring-like structure if viewed in infrared part of the electromagnetic spectrum.

Lenticular Galaxy

Lenticular galaxies are intermediate forms that possess properties of both spiral and elliptical galaxies. These are classified in the Hubble scheme as type 'S0'. They have ill-defined spiral arms as well as an elliptical halo of stars. The barred lenticular galaxies are identified by the Hubble classification as 'SBO'.

Irregular Galaxies

These galaxies have no symmetry

There are several galactic formations that cannot be classified into the elliptical or spiral morphologies. These kinds are known as irregular galaxies, with two broad categories. The Irr-I galaxies possess some structures, however they do not align well with the Hubble Classification Scheme. Whereas the Irr-II galaxies do not have any structure that resembles a Hubble classification.

Dwarf Galaxies

Most galaxies in the universe are dwarf galaxies. They are relatively small compared with other galactic formations, containing fewer numbers of stars as well. Many such galaxies orbit larger galaxies. For example the Milky Way galaxy has such satellites. Dwarf galaxies may as well be classified into elliptical, spiral or irregular. Small dwarf elliptical galaxies are called dwarf ellipsoidal galaxies and they barely resemble large elliptical galaxies.

Galactic Morphologies Due to Unusual Dynamics and Activities Interacting Galaxies

Galaxies exist in clusters, within which their average separation is about an order of magnitude larger than their diameters. Therefore, interactions between galaxies are frequent and such processes play an important role in their evolution. Interacting galaxies are of three kinds:

- **Collisions** occur when two galaxies which have sufficient relative momentum not to merge pass directly through each other. The stars within these interacting galaxies will pass through without colliding. However, the gas and dust within the two galactic forms tend to interact. As the interstellar medium becomes disrupted and compressed, bursts of new star formation are triggered. Collisions distort the shape of one or both galaxies, forming bars, rings, or tail-like structures.
- **Galactic mergers** occur under extreme interactions. The relative momentum of the two interacting galaxies is insufficient to allow them to pass through each other. They gradually merge together to form a single larger galaxy. Mergers result in significant changes in morphology, as compared to the original galaxies.

• **Cannibalism** occurs in cases where one of the galaxies interacting is much more massive than the other. The larger galaxy will remain relatively undisturbed by the merger, while the smaller galaxy is torn apart. For example the Milky way galaxy is currently in the process of cannibalizing the Sagittarius dwarf elliptical galaxy and the Canis major dwarf galaxy.

Starburst Galaxies

Stars are created within the galaxy from a reserve of cold gas that forms giant molecular clouds. They exhibit an increase in star formation rate as compared to other galaxies. At that rate, the stars consume their reserve of gas in a lifespan lower than that of other galaxies. Hence starburst galaxies last for a relatively short period of time of approximately 10 million years.

These galaxies consist dusty concentrations of gas and newly formed stars, including massive stars. Massive stars are known to trigger supernova explosions, resulting in expanding remnants that interact with the surrounding gas. This in turn ignites chain reaction of star formation that spread throughout the gaseous region. This activity stops when the gas is completely used up.

Active Nucleus Galaxies

In an active galactic nucleus, a significant portion of the total energy output from the galaxy is emitted by a source other than the stars, dust and interstellar medium. The standard model for an active galactic nucleus is based upon an accretion disc that forms around a supermassive black hole (SMBH) at the core region. The radiation from an active galactic nucleus comes from gravitational energy of matter as it falls toward the black hole from the disc.

In some cases a pair of energetic jets ejects particles from the core of the galaxy at velocities close to the speed of light for example:

- Seyfert galaxies are active galaxies that emit high-energy radiation in form of x-rays.
- Blazars are active galaxies with a relativistic jet that is pointed towards the Earth.
- A radio galaxy is one that emits radio frequencies from relativistic jets.
- Low-ionization nuclear emission-line regions (**LINERs**): The **LINNER-type** galaxies emission is dominated by weakly ionized elements

SATELLITES AND COMMUNICATION

Satellites

This refers to space-based object moving in a curved path (an orbit) around a larger object at a constant velocity in the space of the solar system.

- A satellite which orbits or revolves around the star is called a **planet**
- A satellite which orbits or revolves around a planet is called a **moon**.



Figure 42:

PERIOD OF A SATELLITE

This is the time taken by the satellite to make one complete revolution around a large body in the space of the solar system.

The satellites are primarily grouped;

Natural satellites

Artificial satellites

The satellites follow different paths (orbit) at varying altitudes. These are determined by the purpose of a satellite. The satellite orbits are largely categorised into three basic groups as follows.

1. Low Earth Orbit (LEO)

This is an orbit positioned relative to the centre of the earth within an altitude range of 2000 Km(1200miles) or less.

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Most of the artificial space objects are found in the low earth orbit, **they are fast moving which enable them to overcome the gravitation pull.**

2. Medium Earth Orbit (MEO)

This is referred to as an intermediate circular orbit positioned at an altitude of about 20000 Km (12000 miles). It is above the low earth orbit but below geosynchronous orbit. This is where most artificial satellites are stationed.

3. High Earth Orbit (HEO)

This is at an altitude of 36000Km and this gives the satellite benefit of taking exactly one day to orbit the earth and return to the same position above it at the same time of the day. Examples of satellites found in this orbit are communications and weather satellites.

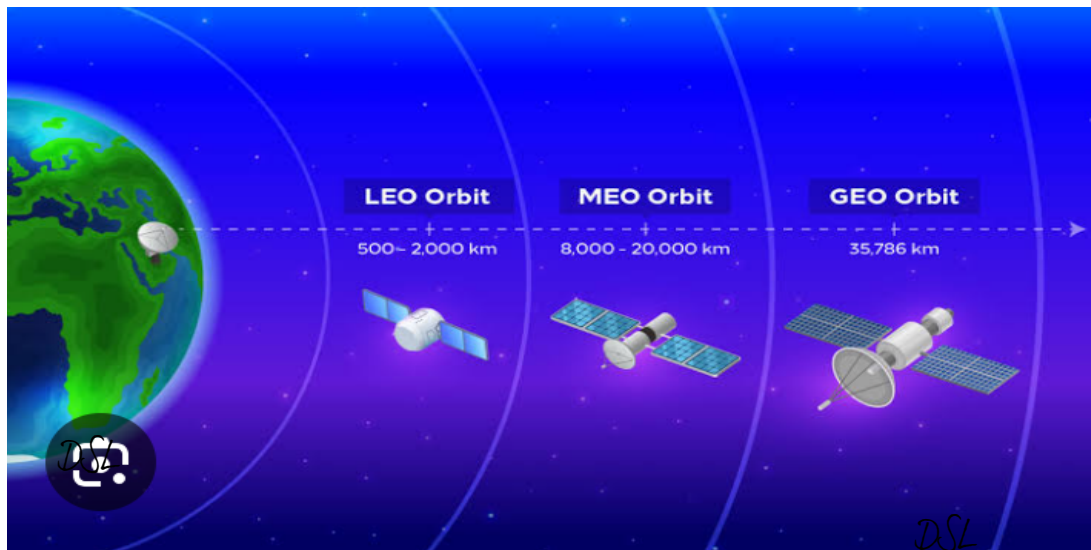


Figure 43:

QUESTION

How satellites hold in their positions in the space without falling back to the earth.

Artificial satellites

These are man-made objects that orbit the earth and other planets in the solar system. They are usually semi-independent computer controlled systems, i.e the satellites can operate by themselves or as part of a larger system, this is called a **satellite formation** or **satellite constellation**.

Broad categorization of artificial satellites.

1. **Fixed satellites system.** These are satellites used in handling of billions of voice, data and video transmission tasks across countries and continents between the points on the earth's surface.
2. **Mobile satellites system.** These are used in remote regions, tracking of vehicles, ships, people and air crafts in reference to the rest of the world and other mobile or stationary communication units. They serve as navigation systems.
3. **Scientific research satellites(commercial and non- commercial).** These provide meteorological information information, land survey data(e.g remote sensing) and other different scientific research applications such as earth science, marine science and atmospheric research.

Artificial Satellites are of great importance in the following ways.

They are used for communication. These help in relaying of data signals, voice and videos.
They are used in weather forecasting system.
They are used in the global positioning systems (GPS)
They are used for making star maps and maps of planetary surfaces.

The following are examples of artifical satellites and their uses.

Astronomical satellites

These are used for observing distant planets, galaxies and other outer space objects **Bio-satellites**

These satellites are used to carry living organisms into space for scientific experimentation.

Communication satellites

These satellites facilitate telecommunications process.

Earth observation satellites

These satellites are generally used for environment related activities such as environmental monitoring, meteorology and map making.

Navigation satellites.

These satellites use radio signals. the signals allow mobile receivers on the ground to determine their exact location with good measure of accuracies in real life.

Killer satellites

These are satellites which are specially designed to detect and destroy enemy warheads, satellites and other space assets with high level of precision.

Miniaturized satellites

These are satellites of low masses and small sizes categorized as mini satellites (500 - 1000 Kg), Micro satellites (below 100kg) and nano satellites (below 10kg).

Crewed space craft (spaceships)

These are satellites made with capacity to safely carry human beings into space and back to the earth. These satellites can also be used a transport to and from the orbital stations. **Reconnais-**

sance satellites

These are either observation satellites or communication satellites deployed for military or intelligence activities. Information gathered by these types of satellites are treated as highly confidential by such states.

Space stations

These are artificial orbital structures designed in such away that they can support human life when on exploration in the outer space. i.e the International Space Station, the space stations are differentiated from other crew spacecrafts by lack of landing facilities and and are designed from medium-term living in the orbit ranging from periods of weeks, months or years.

Recovery satellites

These are satellites that provide recovery of reconnaissance, biological, space-production and other pay loads from orbit to earth.

Weather satellites

These satellites help in gathering crucial weather data such as pictures of cloud formations which help meteorologist to interpret and predict the earth's weather and climate pattern.

Tether satellites

These are satellites which are connected to another satellite by a thin cable called a **tether**.

GEOSTATIONARY SATELLITES

A **geostationary satellite** is an earth orbiting satellite. It is positioned directly over the equator and revolves in the same direction as the earth (west to east) then returns to the same position after each complete day.

A geostationary satellite is stationed in a **geostationary orbit/ Parking orbit** (**Parking Orbit is a circular orbit in space about the earth in which a satellite revolves at the same period as the earth's rotation in the same direction.** OR **This is a circular orbit in space about the earth in which a satellite appears to be stationary as seen by the observer on the earth's surface**), these satellites form a geosynchronous network and its a communication based network. They also have an **advantage** in that they remain permanently fixed in exactly the same position in the sky as viewed from any fixed location on earth and this implies that ground based antennas/usually a small dish positioned such that it aims at the hover, does not need to track them but can remain fixed in one direction without further adjustment. Another **advantage** the geostationary satellites experience minimal interferences from surface- based sources and other satellites due to highly directional antennas.

NB: If a satellite is sent out into its orbit slowly, it will fall on the earth and if it's sent out too quickly, then the gravitational force will not be enough to hold the satellite in the orbit and it will fly off into space. A satellite maintains its orbit by balancing it's velocity it takes to travel in a straight line and the gravitational pull of the earth. A satellite orbiting closer to the earth requires more velocity to resist the strong earth's gravitational pull.



Figure 44:

ESCAPE VELOCITY: This is the vertical with which a body is projected from the surface of a planet so as it goes beyond its gravitational influence.

WORLD WIDE SATELLITE COMMUNICATION

Three synchronous (geostationary) satellite are set in parking orbits about the earth as shown above. Radio signals (waves) are generated at one station on the earth's and are first sent to a satellite, S_1 . This satellite re-sends the signals to the near satellite S_2 which also resend to the signals to another satellites S_3 . That satellite S_3 then sends the signals to another earth station B where there is a

receiver.

NB: Telecommunications use artificial satellite communication links to transmit information between various points on the earth's surface.

Communication satellite act as "**space mirrors**" to reflect radio, TV, internet data and other kind of information from one side of the earth to the other.

Satellite communication has two major components that are; the space component (**satellite**) and the ground components (**transmitter and receiver**).

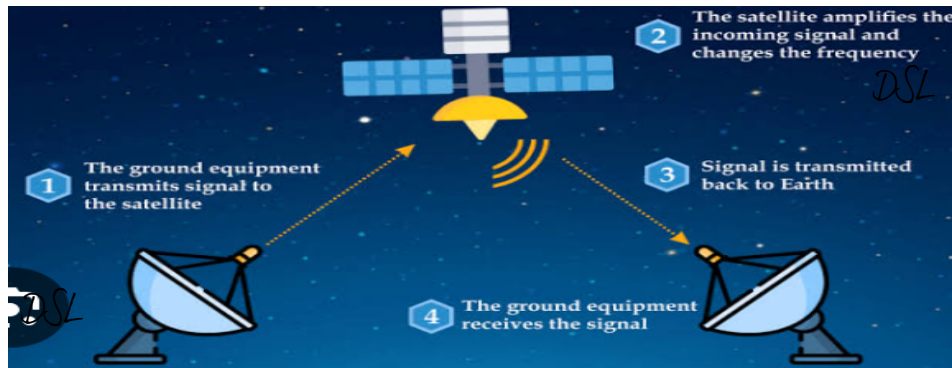


Figure 45:

UPLINK: This is the sending of communication signals from the earth ground transmitters to the communication satellites.

DOWNLINK: This is the sending of reflected signals from the satellite to the earth ground receiver.

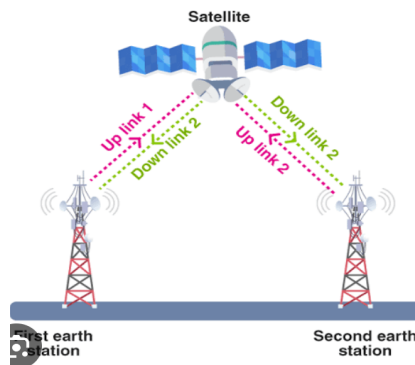


Figure 46:

Classification of geostationary satellites

Most of the satellites are earth orbiting satellites, they are categorised as follows;

1. Communication and Broadcasting satellites
 2. Global positioning satellites
 3. Remote sensing satellites
- Handwritten note 'DSL' is present near the first item.

Communication and Broadcasting satellites

Are artificial satellites that relay and receive signals from an earth station and then retransmit the signals to other earth stations.

They move in a geostationary orbit, **every communication satellite involves the transmission of information from an originating ground station to the satellite, followed by a retransmission of the information from the satellite back to the ground. This retransmission can be either to select number of ground stations or broadcast to everyone in a large geographical area.**

Communication and broadcasting satellites are **generally used to relay radio waves from one place to another, they catch signals from ground stations (earth - based satellites dishes) and amplify them to possess enough strength to continue their motion until they bounce back to second ground station.**

Uses of signals transferred in the communication and broadcasting satellites.

They are used to transfer telephone calls , internet data, radio and television broadcasts.

Communication satellites are very useful in facilitating communication to and from remote areas where ordinary wired or wireless communication cannot reach. Therefore such remote areas do not necessarily need telecommunication masts. e.g NASA communication satellite.

In Uganda to day, satellite communication is heavily employed in digital television Broadcasting. This is done under the regulation and supervision of Uganda Communication Commission (UCC).

Below are some of the satellite technologies used in television communication in Uganda;

(a) Digital Terrestrial Television (DTT)

Is the technology for broadcast television in which land based television stations broadcast television content by radio waves to television in consumer's residences in a digital format.

The television signals are beamed by surface- based stations to land - based receivers that decode signals to the television sets. Examples are GoTV, Star times, DSTV, AZAM TV, ZUKU TV and Free to Air set-top boxes.

(b) Direct to Home (DTH) or satellite TV

Satellite TV transmission is a service that delivers television programming to viewers by relaying it from a communications satellite orbiting the earth directly to the viewer's location. These signals are received by a satellite dish mounted on one's premises which are connected to a decoder. These signals are then decoded into a format that is viewable on a television set. Example of such service providers include: DSTV, StarTimes, Zuku TV e.t.c

Global Positioning Systems (GPS)

This is a global navigation satellite system (GNSS) that provides location, velocity and time synchronization. GPS is commonly used in cars, smart phones, smart watches e.t.c

The GPS provides critical positioning capabilities to military, civil and commercial users around the world.

GPS is made up of three main components called segments that work together to provide site or location information. The segments include;

Space (satellite). The satellites circling the earth, transmitting signals to users on the geographical position and time of the day.

Ground control. The control segment is made up of earth based monitor stations, master control stations and ground antennas. Control activities include tracking and operating the satellites in space and monitoring transmission.

User equipment. These are GPS receivers and transmitters such as smart watches, smart phones and telematics devices.

How global positioning system works

GPS works through a technique called **trilateration**. This is determining a position by knowing your distance from at least 3 known points. In GPS, those known points are the satellites themselves. Trilateration connects signals from satellites to output location information. Satellites send signals which are read and interpreted by GPS device on or near the earth's surface.

How to calculate the location of a GPS device using the Satellites

The GPS device reads signals from at least four satellites. Each satellite in a network circles the earth two times a day and each sends a unique signal, Orbital parameters and time, At any one time, a GPS device can read signals from six or satellites.

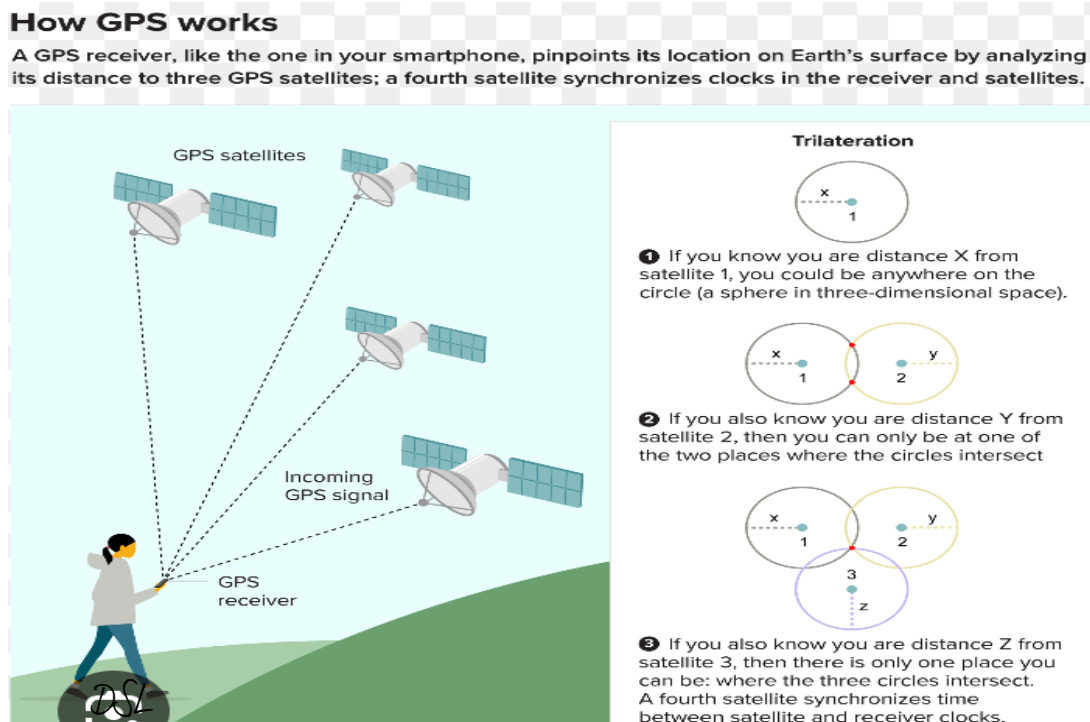


Figure 47:

How this works

When a satellite sends a signal, it creates a sphere with a radius measured from the GPS device to the satellite. When a second satellite is added, it creates a second sphere and location is narrowed down to one of the points where the spheres intersect. With the

addition of third satellite, the device location can finally be traced because the device is now at the point of intersection of the three circles. This means that each satellite produces a sphere and the intersection of the three spheres produces two points from which the point nearest to Earth is chosen.

As the device moves, its radius (distance to the satellite) changes. When the radius changes, new spheres are produced, giving us a new position. We can use that data, combined with the time from the satellite, to determine velocity, calculate the distance to our destination and the estimated time of arrival(ETA).

GPS consists of constellation of 24 satellites in orbit meant to provide real time position and location of places on earth.

Qtn: Suppose you're driving and you reach unknown junction, how will you be able to locate your route assuming there are no people around.

Qtn: How can you get your way using technology if you're lost in a big city?

Qtn: Which technology enables mobile smart devices to locate positions on earth?

ANTENNA: This is an electrical device which converts electrical power into electrical signals and vice versa. It is used in radio transmitters and radio receivers.

TRILATERATION

-About 4 satellites are required to locate the exact position of a point.

-Signals are sent from each satellite to the user.

-The distance, d traveled by the a signal is calculated from;

$distance(d) = speed\ of\ light\ (C) \times time\ taken\ (t)$

-A circle whose radius is the same as d is drawn.

-The location of the user is any where within the circle drawn

To determine the exact location of the user, more circles are drawn from each satellite depending on their distances from the point (user).

-The location of the user is the point of intersection of all the circles.

NB: Satellite have atomic clocks to measure the time taken for signals to travel and the speed of a signal is the same as the speed of light ($3 \times 10^8 ms^{-1}$) as signals are electromagnetic waves. Each circle has a different radius because each of the four satellites is at different position from the required user or position.

Uses of global Positioning System (GPS)

1. Surveyors use the GPS information to help them carry out accurate surveys and mappings.
2. Navigation, It helps people to easily move from one place to another.
3. Tracking of Objects. Wildlife organisations often use this technology to locate whereabouts of some wildlife when carrying out population counts.
4. Determining location of people. Smartphone being GPS device has often been used to precisely locate whereabouts of individuals.
5. Timing. GPS is useful aid in taking accurate time measurements.

Applications of the global Positioning System

Emergency response

During an emergency or natural disaster, first responders often use GPS for mapping the affected area. They assess and predict what weather conditions are likely to be, and to keep track of emergency personnel.

Health and fitness

Smart watches and wearable technology can track fitness activity (such as running distance) and benchmark it against a similar demographic. This technology was employed during the COVID period to help athletes in different countries to compete without coming together.

Construction, mining, and off-road tracking

From locating equipment to measuring and improving asset allocation, GPS enables companies to increase return on their assets.

Transportation

Logistics companies implement telematics systems to improve driver productivity and safety.

Research

GPS are used in monitoring earthquakes and shifting of tectonic plates. It's also helpful in research device in precise identification of individuals' locations at any point in time during research activity. Geographical Information System (GIS) has proved to be of great assistance to researchers in mapping the x-tics of the surroundings.

GIS and GPS allowing effective methods of examining the relationship between the natural and built environment and location based physical activity.

Hubble Space Telescope

Is a space craft traveling around the earth. Its is estimated that it moves at a speed of about 5 miles per second. It faces towards space and takes photograph of planets, stars, comets and galaxies e.g NASA's Hubble Space Telescope was taken on the fifth servicing mission to the observatory in 2009.

"Hubble space telescope is the world's largest telescope. It is based in the space. It was named after the **American astronomer Edwin P Hubble who lived between 1889 and 1953**. Dr. Hubble postulated about an expanding universe which led to the **Big bang theory**.

Hubble has seen stars being born and die. It has seen galaxies that are trillions of miles away. It has seen comet pieces crash into the gases above Jupiter. Scientists are learning a lot about space from Hubble Pictures. The Hubble space telescope does not travel to stars, planets or galaxies. It takes pictures of them as it whirls around the earth at about 17000 meters per hour.



Figure 48:

INTERNATIONAL SPACE STATION (ISS)

Is a large space craft which orbits the earth. It is placed at average altitude of approximately 250 miles. ISS serves as a home for crews of astronauts and cosmonauts when living in the space. It travels at 17500 miles per hour.

It is a collaborative project by several countries which include; United States of America, Canada, Japan, Russia and countries from the European Space Agency.

The space station also serves as a unique science laboratory. NASA is using the Space Station to learn more about living and working in space.



Figure 49:

Role of International Space Station.

Physical Sciences

The space environment allows accelerated materials testing. The micro gravity effects on fluid physics easily exposes underlying mechanisms with in physical systems.

Life Sciences

Researchers study effects of spaceflight on living organisms which allow them to advance pharmaceutical development and to augment earth- based studies in fundamental biology medicine, agriculture and biotechnology.

Remote sensing

ISS can be used as a platform for earth observation and remote sensing. This facilitates broad range studies in basic and applied science across many fields including the study of earth's surface and atmosphere. *DSL*

Technology development

The ISS provides a suitable platform for researchers to validate technologies for space crafts, satellites and materials which require to withstand harsh conditions on earth.

Education

ISS National Lab & D is unique and exciting, providing a new resource for project- based learning and for using modern breakthrough to illustrate traditional science concepts and inspire a new generation of innovators.

SHORT ESSAY FUNDAMENTAL QUESTIONS SOLAR SYSTEM

- 1.If you're 13 years old, how many times have you gone round the sun
- 2.How can you distinguish between a planet and stars
- 3.Which planet in our solar system supports life.
- 4.Why is the planet named in No.3 above supports life or living organism.
- 5.Which is the hottest planet in the solar system.
- 6.What makes the hottest planet hot
- 7.Why is mercury not the hottest planet in the solar system yet it is the closest planet in the solar system. *DSL*
8. Why mars called a red planet
9. If you werw planning a trip to mars, what would you carry on your trip.
- 10.Which planet has the largest moons in the solar system.
- 11.Name the two largest moons and their planets which they orbit
- 12.Which planet has the most extensive ring structure
- 13.State the largest planet in the solar system
- 14.Which planet is closet to the sun
- 15.What is a celestial body
- 16.Which name is given to a celestial body that revolves around a planet.
- 17.In which orbits of planets are Asteroids found
- 18.What are the components of the solar system
- 19.What is the smallest planet in the solar system
- 20.Which instrument is used to focus planets and other celestial bodies in space of the solar system.
21. Which part of the sky can you find Venus if its visible as an evening star. *DSL*
22. Why are planets outside the Asteroid belt referred to as Gas giant planets.
23. Why are planets inside the Asteroid belt referred to as Rocky planets.
24. Which planet can float on the water of earth's oceans and explain why.

SOLSTICE

- 1.What is the equator
- 2.What are the areas above and below the equator called
- 3.How long does the earth's orbit around the sun take
- 4.During the earth's orbit, *DSL* why are some places closer to the sun than others
- 5.What is summer solstice
- 6.What does the word solstice come from and what does it mean
- 7.When does the summer solstice happen
- 8.What is the summer solstice also known as
- 9.What happens to the hours of days light in the northern Hemisphere at summer solstice
- 10.Why do some countries of the northern Hemisphere have 24 hours of daylight around summer
- 11.If you live in far north, how does the time around summer solstice affect your day
- 12.Why do you think people in ancient times celebrated the summer solstice
- 13.Explain the term Equator, Northern Hemisphere and Southern Hemisphere mean
- 14.Explain what the earth's axis mean
- 15.Why is the tilt of the earth's axis significant.

-
16. When would it be a good time to visit countries in the far North of Northern Hemisphere? Explain your answer?
 17. When would it be good time to visit countries in the far South of Southern Hemisphere? Explain your answer?

STARS

1. What distinguishes a nebula from a star
2. Which kind of reaction provides a star with energy
3. Stars are massive, why don't they collapse under the weight of their own gravity
4. Which stars have the highest temperature and which stars have the lowest temperature
5. List seven main classes of stars from the hottest to the coolest
6. What is the main characteristic of the main sequence star
7. What kind of star will the sun be after leaving the main sequence
8. Black holes are invisible, how do astronomers know that they exist.
9. What is a light year and an astronomical unit
10. What is a binary star and a star clusters
11. Explain the main two types of a star cluster
12. Distinguish between Open star cluster and Globular star cluster
13. What is meant by a nova and supernova

GALAXIES AND SATELLITES

1. What is a galaxy and name the three main types of galaxies
2. List three main features of the spiral galaxy
3. What galaxy do you live in and what kind of galaxy is it.
4. (a) What are the uses of artificial satellites?
(b) Discuss how people's lives would be disrupted in the absence of satellites.
5. (a) What is GPS and how does it work?
(b) What are the uses of GPS?
6. (a) What is Hubble space telescope?
(b) What makes Hubble Space telescope different from telescopes on earth?
(c) What is NASA and other space agencies learning from the Hubble Space Telescope?
7. (a) Describe any three areas of research on the International Space station?
(b) Why is the Space Station important?

ACTIVITY OF INTEGRATION

1. Many people in Uganda own vehicles and motor cycles which are brought after hard work and several years of saving, These vehicles need to be monitored for guaranteed security. Unfortunately, many Ugandans are not aware of how to do this.
As a student of physics, Prepare a write up of not more than one page sensitising them on how they can easily monitor the vehicles.

2. Information in Uganda is passed onto the citizen through radios, mobile phones and televisions. Despite the advent of the internet and social media, radio and televisions remains extremely popular in most parts of Uganda. Unfortunately, the network signals in some areas cannot enable this to be done with ease. As a student of physics, write a report to media houses in Uganda showing how the signals can easily be relayed without loss so that each and every Ugandan gets access to information.

3. 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

Using 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.

DIGITAL ELECTRONICS

A **diode** is a two - terminal electronic component that conducts current in only the forward bias. **OR** Is a semi conductor device that essentially acts as a one - way switch for current. It allows current to flow through easily in one direction, but severely restricts current from flowing in the opposite direction.

Components of electronic systems.

- Diodes -Capacitors
- Resistors - Transistor
- Led - Switches
- Inductors - Sensors
- Relays - Electronic power

Some of the electronic devices in many instances in everyday life;

- Telephones
- Television
- Radio

-Computer and all digital electronic devices, we are to learn how signals are generated from the above devices and how they are applied in a variety of system that solve daily life problems.

Identifying components of electronic circuits

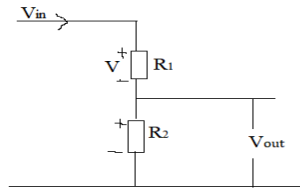


Figure 50:

The electronic components in the above circuit are;

-Resistor

-Electric power

The circuit is used for **dividing potential**

Other ways of performing the same function that is done by the circuit in the figure are **variable resistor** or a **potential divider**

Since the circuit is a series circuit, the current flowing through out the circuit is the same. From ohm's law, the potential differences V_1 and V_2 are.

$$V = IR_1 \quad \dots\dots(1) \quad \quad V_{out} = IR_2 \dots\dots(2)$$

$$\text{But, } V_{in} = V + V_{out} \quad \dots\dots(3)$$

Putting equation (1) and equation (2) into equation (3)

$$V_{in} = IR_1 + IR_2$$

$$I = \frac{V_{in}}{R_1 + R_2} \quad \text{Now, the potential difference through, } R_2.$$

$$V_{out} = \left(\frac{V_{in}}{R_1 + R_2} \right) R_2$$

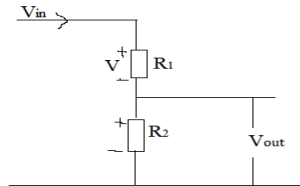
$$\text{Hence, } V_{out} = \left(\frac{V_{in} R_2}{R_1 + R_2} \right)$$

and p.d through R_1

$$V = \left(\frac{V_{in} R_1}{R_1 + R_2} \right)$$

POTENTIAL DIVIDER

Is a simple circuit that uses resistors(thermistors or LDR'S) to supply a variable potential difference. Two resistors divide up the potential difference (p.d) supplied to them from a cell. The proportion of the available p.d that the two resistors get depends on their resistance values.



22

Figure 51:

where, V_{in} - the p.d supplied by the cell

V_{out} - the p.d across the resistor R_2

R_1 - the resistance of resistor R_1

R_2 - the resistance of the second resistor

To determine the output voltage, V_{out} , the following equation can be used.

$$V_{out} = \left(\frac{V_{in} R_2}{R_1 + R_2} \right)$$

Potential dividers may be used to;

- Control audio volume
- Control the temperature in a freezer
- Monitor change of light intensity in a room.

22

How does a potential divider/ variable resistor control the volume of a radio.

Simple circuit that is used to control the volume of a radio.

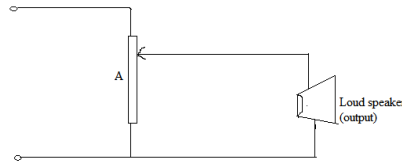


Figure 52:

where, component, **A** is a **variable resistor** or **Potentiometer**

How, A is used to control the volume of radio.

Part **A**, is a potentiometer. Which is a variable resistor that changes the amount of electrical current flowing through it based on its position. When the volume control (**A**) is turned up, the resistance decreases, allowing more electrical current to pass through and resulting in a louder sound from the speaker. When the volume control (**A**) is turned down, the resistance increases reducing the current and lowering the volume of sound from a loud speaker.

DIGITAL AND ANALOG SIGNALS

A **digital signal** is a signal that can take on only discrete (specific) values. It is encoded in binary for example signals used by devices like; Smart phones, Smart watches, digital clocks e.t.c

An **analog signal** is a signal that can take on a continuous range of values. Devices that use such signals are Analog watches, clocks, Pendulums, steam engine governors e.t.c.

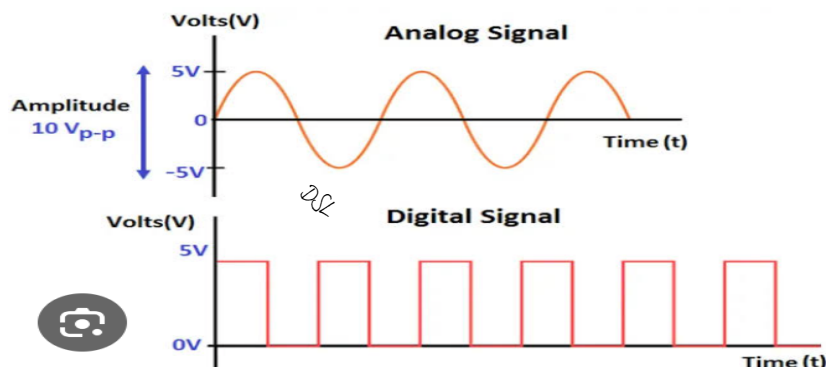


Figure 53:

Elementary logic gates and memory circuits.

A **logic gate** is a building block for a digital system, having one or more inputs and only out put.

The relation between the input and out put is based on logic. Logic gates are named as AND, NAND, OR, NOT, AND Buffer. In logic gates at any given moment, every terminal is in one of the two binary conditions, False(0) or True (1) i.e (False represents 0 and true represents 1)

The binary output will differ depending on the type of Logic gate being used and the combination of inputs. A logic gate can be taken to behave like a light switch, where in one position, **the output is off (0)** and in another, **it is on (1)**. DSL

BASIC LOGIC GATES

Logic gates are switching circuits. They are used in computerised and electronic systems. They are built using transistors combined with resistors and diodes. Logic gates are the electronic circuits in a digital system.

The components are wired together to ensure they transform the inputs in the way we expect. These gates are manufactured in form of electronic parts which are very small. Logic gates are interpolated using truth tables.

Truth tables helps to show a logic gate functions, logic gates are used to carry out logic operations on single or multiple binary inputs and give one binary output.

Logic gates have a lot of applications based upon their mode of operations or their truth table. Basic logic gates are often found in circuits such as safety thermostats, push- button locks, automatic watching systems, light- activated burglar alarms e.t.c.

Basic logic gates can be used in a mixture of different combinations if the operations are advanced. Besides, there is no limit to the number of gates that can be used in a single device. Integrated circuits (ICS) have a logic gate are unit.

How the logic gates are used in control circuits.

In a circuit, logic gates work based on a combination of digital signals coming from its inputs. Most logic gates have two inputs or more inputs and one output, and they are based on Boolean algebra. At any given moment, every terminal is in one of the two binary conditions: True or False. False represent 0 and True represent 1. DSL

TYPES OF BASIC LOGIC GATES

There are several basic logic gates used in performing operations in digital systems. The common ones are;

OR Gate

AND Gate

NOT Gate

XOR Gate or Exclusive OR

Additionally, these gates can also be found in a combination of one or two. Therefore we get other gates such as NAND Gate, NOR Gate, XNOR or Exclusive or Equivalence (EXNOR) Gate, Buffer.

THE; AND GATE

The output is true(1) if and only if both inputs are true(1).

Boolean expression

$$Y = A.B = AB = \text{"A and B"}$$



Figure 54:

Truth table

A	B	A.B
0	0	0
0	1	0
1	0	0
1	1	1

DSL

THE; OR GATE

The output is true(1) if either or both inputs are true(1).

Boolean expression

$$Y = A + B = \text{"A" or "B"}$$

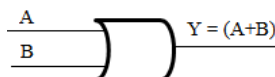


Figure 55:

Truth table

A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

THE; NOT

The output is true(1) if the input is False(0)

Boolean expression

DSL

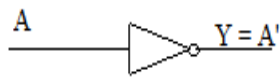


Figure 56:

$Y = A' =$ "Not A " **Truth table**

A	A'
0	1
1	0

DSL

BUFFER

The output is true(1) if the input is true(1)

Boolean expression

$Y = A$ **Truth table**

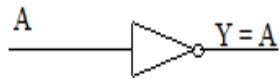


Figure 57:

X	A
0	0
1	1

THE; NAND GATE

The output is false(0) if both inputs are true(1).

Boolean expression

$Y = (AB)' =$ "Not A and B" **Truth table**



Figure 58:

A	B	(A.B)'
0	0	1
0	1	1
1	0	1
1	1	0

DSL

THE; NOR GATE

The output is false (0) if either or both inputs are true(1)

Boolean expression

$Y = (A + B)' = \text{"not (A or B)"}$ Truth table

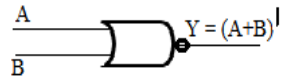


Figure 59:

A	B	$(A+B)'$
0	0	1
0	1	0
1	0	0
1	1	0

DSL

THE; XOR GATE

The output is true(1) if either but not both inputs are true(1)

Boolean expression

$Y = A \text{ XOR } B$

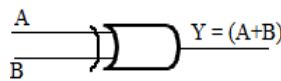


Figure 60:

Truth table

A	B	$(A \text{ XOR } B)$
0	0	0
0	1	1
1	0	1
1	1	0

THE; XNOR GATE

The output is false(0) if either but not both inputs are true (1).

$Y = (A \text{ XOR } B)' = (A \text{ XNOR } B)$

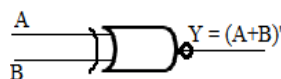


Figure 61:

DSL

Truth table

A	B	(A XNOR B)
0	0	1
0	1	0
1	0	0
1	1	1

DSL

Advantages of digital signals

- Digital signals can convey information with less noise, distortion, and interference.
- Digital circuits can be reproduced easily in mass quantities at comparatively low costs.
- Digital signal processing is more flexible because DSP operations can be altered using digitally programmable systems.
- Digital signal processing is more secure because digital information can be easily encrypted and compressed.
- Digital systems are more accurate, and the probability of error occurrence can be reduced by employing error detection and correction codes.
- Digital signals can be easily stored on any magnetic media or optical media using semiconductor chips.
- Digital signals can be transmitted over long distances.

Disadvantages to using digital signals, including digital signal processing (DSP) and communication systems, include the following:

- A higher bandwidth is required for digital communication when compared to analog transmission of the same information.
- Digital Signal Processing (DSP) processes the signal at high speeds, and comprises more top internal hardware resources. This results in higher power dissipation compared to analog signal processing, which includes passive components that consume less energy.
- Digital systems and processing are typically more complex.

Advantages to using analog signals, including analog signal processing (ASP) and communication systems, include the following:

- Analog signals are easier to process. DSL
- Analog signals best suited for audio and video transmission.
- Analog signals are much higher density, and can present more refined information.
- Analog signals use less bandwidth than digital signals.
- Analog signals provide a more accurate representation of changes in physical phenomena, such as sound, light, temperature, position, or pressure.
- Analog communication systems are less sensitive in terms of electrical tolerance.

Disadvantages to using analog signals, including analog signal processing (ASP) and communication systems, include the following:

- Data transmission at long distances may result in undesirable signal disturbances.
- Analog signals are prone to generation loss. 
- Analog signals are subject to noise and distortion, as opposed to digital signals which have much higher immunity.
- Analog signals are generally lower quality signals than digital signals.

A few analog signal applications are listed below:

- Audio recording and reproduction
- Temperature sensors
- Image sensors
- Radio signals
- Telephones
- Control systems

BOOLEAN ALGEBRA

A **Boolean expression** is composed of **Literals** (variables and their complements) e.g A,B and C e.t.c and **Logical operators** e.g (+), (.) e.t.c

From a Boolean function, a logic diagram can be constructed using AND, OR, and NOT

This can be done using

Discrete components

- Standard Logic Gates 

programmable devices

- Read-only Memories (ROM)
- Programmable Logic Devices (PLD)
- Field Programmable Gate Arrays (FPGA)

Data sheets provide essential information:

This information is necessary when building logic circuits from discrete components.

- Logic Function
- Truth Table
- Pin-out
- Electrical Characteristics
- Timing Characteristics
- Package Description(s)

A **truth table** defines the value of the output of a logic function for each combination of the input variables.

Each row in the truth table corresponds to a unique combination of the input variables. For n input variables, there are 2^n rows

Each row is assigned a numerical value, with the rows listed in ascending order. The order of the input variables defined in the logic function is important.

Construct a truth table for the logic circuit of a combination of logic gates below.

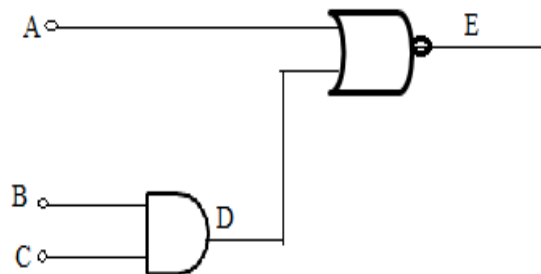


Figure 62:

The truth table

A	B	C	D	E
0	0	0	0	1
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	0

Use of logic gates in control circuits

Logic gates are decision- making devices,they can be used to control an electronic system. Many electronic systems are designed in three or four parts. These are;

- Input sensor - The memory(absent in some system)
- Process (electronic system) - Output (transducer)

The circuit diagram, shows an automatic switch for a fan for cooling the house.

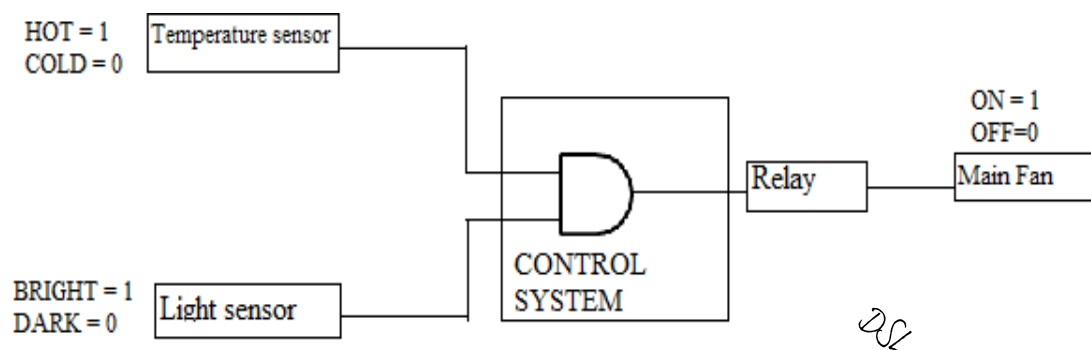


Figure 63:

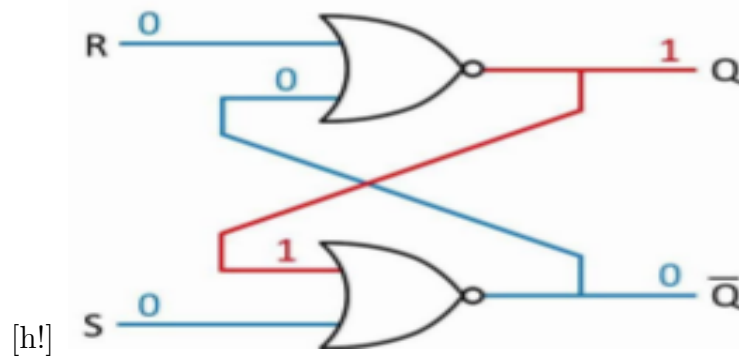


Figure 64:

Under what conditions does the system turn on the fan.

The system requires that both inputs to the AND gate are true(1) for the fan to be turned on. This can be obtained from the truth table of AND gate. Therefore the fan will be switched on when the temperature indicates **HOT** and the light sensor indicates **BRIGHT**.

What is the disadvantage of the switch.

The fan will not be switched on when the temperature indicates **HOT** and the light sensor indicates **DARK** even when the fan is required.

STABLE AND BI-STABLE SWITCHES

Distinguish between a stable and bi-stable Switch/multivibrator.

A **MULTIVIBRATOR** is an electronic circuit that generates square, rectangular, pulse wave forms, also called nonlinear oscillators or function generators.

Multivibrator is basically a two amplifier circuits arranged with regenerative feedback. There are three types of Multivibrators / switches.

A **stable Switch**: Circuit is not stable in either state-it continuously oscillates from one state to the other. (Application in Oscillators)

Monostable Switch: One of the state is stable but the other is not. (Application in Timer)

Bistable Switch: Circuit is stable in both the state and will remain in either state indefinitely. The circuit can be flipped from one state to the other by an external event or trigger. (Application in Flip flop). This concept is fundamental in digital electronics, particularly in memory storage and various types of electronic devices.

Think of a bistable switch like a light switch that can either be ON or OFF. Once its ON, it stays ON until you turn it OFF and vice versa.

One of the simplest types of bistable is called **SR Latch**. It's made from two NOR gates or two NAND gates. The SR latch is a basic memory circuit used to store a single bit of data. By combining many of these circuits, we can form larger memory devices such as those used in phone and computers.

SR LATCH

The inputs are S(set) and R(Reset).

When S-1 and R-0, Q-1 (Set state)

When S-0 and R-1, Q-0 (Reset state)

When S-0 and R-0, Q stays in its previous state (either 0 or 1)

When S-1 and R-1, its an invalid state for NOR gate SR Latch

Truth Table

S	R	Q	$\bar{Q}$
0	0	1,0	0,1
0	1	0	1
1	0	1	0
1	1	0	0

TRIAL QUESTIONS

1. Draw the logic circuit for an alarm that will ring if either smoke is detected or a high temperature is detected . Draw the truth table for your circuit.
2. Draw a logic circuit which will automatically switch on security lights when it is dark. 22
3. Draw a logic circuit which will automatically when it detects that a learner has washed or sanitized his or her hands and to remain closed when the learner has not washed or sanitized his or her hands. Draw a logic circuit you can use to operate the gate. Construct a truth table for your circuit.
4. Name the gates used in the combinations below and write the truth table for each combination.

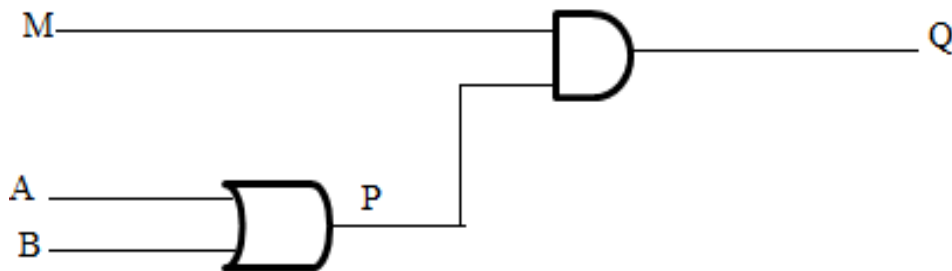


Figure 65: (a)

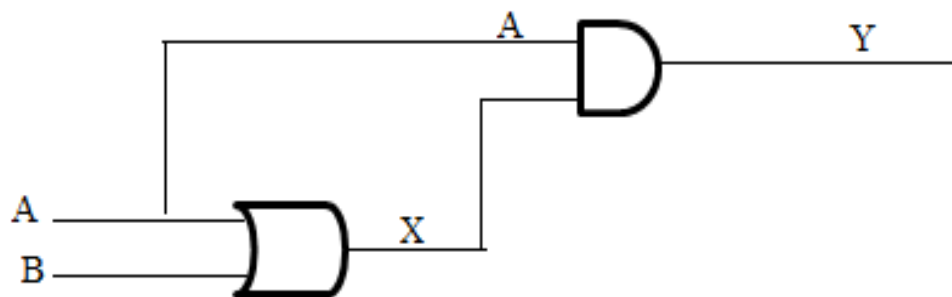


Figure 66: (b)

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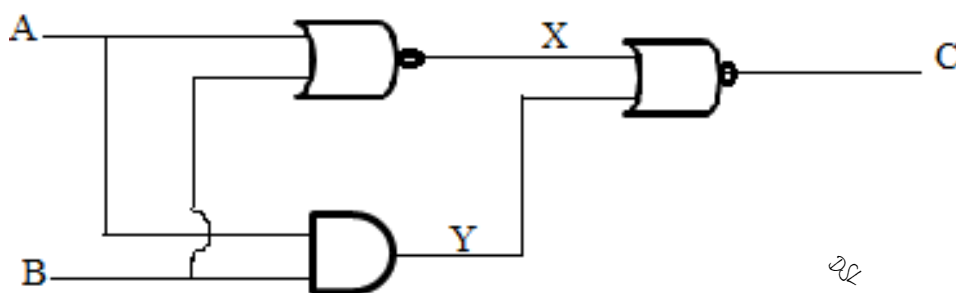


Figure 67: (c)

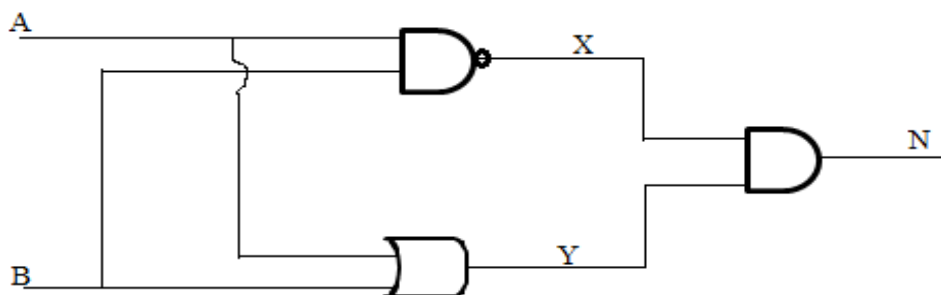


Figure 68: (c)

ACTIVITY OF INTEGRATION

1. At a certain red cross, traffic flow is uncontrolled and this has led to many road accidents some of which are fatal. The community has raised concern and asked the authorities to come up with a solution. As a physics student, you have been contacted by one of the community leaders to design a street light circuit to control the flow of traffic at that junction. Design your proposed traffic light control circuit and indicate the circuit components you will need.

2. You live in a residential area of a town commonly called the estate. Families in the estate sometimes go on holidays, especially during the festive seasons. Thieves, who usually move around at night, identify unoccupied buildings with no security lights switched on and target them for robbery. The estate management has approached you, a physics student, to advise residents of the estate on what to do about their lighting to prevent their houses from being targeted for robbery. Write a speech you would use to advise residents of the estate.

3. As a physics student, you are tasked to design a home security light control circuit using the basic logic gates, the light should be activated by either manually pressing a switch or automatically by a light sensor, the sensor works as follows, when there's sunlight outside, it switches off the light but when there is darkness, it switches on the light. Draw a logic circuit diagram and truth table for all the possible operations.

4. A greenhouse farmer has 2 sensors in his green house; temperature sensor and a humidity sensor, the plants in his greenhouse can't give good yields if the temperatures are above 35°C or if the humidity is HIGH. He wants an alarm to be sounded if the plants are not having appropriate conditions for giving good yields, using any logic gate or a combination of logic gates, describe how this can be achieved.

5. An indian investor Ramesh sells expensive watches in Kampala, he however faces a problem that sometimes, customers lift of watches from their shelves and steal them. He has been advised to place

each watch on an electronic button switch which should be ever on (due to the weight of the watch that will be pressing it down) he wants the circuit to operate such that when a watch is lifted off from the shelf, an alarm is activated. Using logic gates, show how this can be achieved; include a truth table for your diagram.

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END