Stars and the Solar System

Phases of Moon and Tides

Did you know that in the cities, the stars are not clearly visible because of high pollution levels? The same night sky in the outskirts of these cities is bright because the air is less polluted!

Different shapes of the bright part of moon are visible on different days of a month. These different shapes of the moon are observed during what is known as the different **phases of moon.**

On close observation, you will notice that the shape of moon changes everyday.

It follows the following pattern:

- Moon is observed to be completely round in shape. This phase is called the **full moon.**
- The brighter side of the moon reduces gradually.
- On the 15th day after the full moon, also called the **new moon day**, it disappears completely.
- On the following day, a small thin portion is visible at the edge of the moon. This is called the **crescent.**
- On the 15th day, the moon appears completely round, thus, completing the cycle.

Did you know that the months were first calculated on the basis of the phases of moon? The entire cycle of moon extends to more than 29 days.

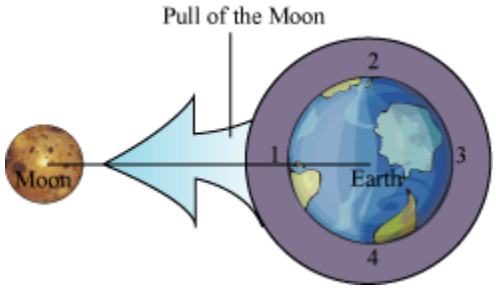
Did you know that the rotation of moon and its revolution around the Earth takes the same amount of time?

Formation of tides

In large water bodies (such as ocean, sea and river), the water level alternately rises and falls several times during a day. This rise and fall of water level in seas and oceans at regular intervals (of about 12 hours and 24 minutes) is called a tide. Tides occur because of the gravitational force of attraction of the moon.

Pytheas was the first man to relate tides to the Moon in 325 BC. After Pytheas, a **Babylonian astronomer**, **Seleucus of Seleucia**, correctly described the phenomenon of tides in 2nd century BC.

The Moon attracts the Earth with its gravitational force and vice-versa. The water bodies on the Earth's surface also get attracted by the gravitational force of the Moon. Consider the four places marked 1, 2, 3 and 4 on the surface of the Earth in the given figure.



At 1, the gravitational pull of the Moon is the strongest because it is nearest to the Moon. Hence, water level at 1 rises or bulges. This rise in water level is called high tide.

At 3, the gravitational pull of the Moon is the least. However, due to Earth's rotation, the water bodies at 3 experience an outward force. This outward force results in the bulging of water bodies at 3. Thus, a high tide occurs at 3.

At 2 and 4, the gravitational pull of the Moon is the minimum. Thus, sea water is at low level at the places marked 2 and 4. This decrease in water level is called low tide.

Advantages of Tides

- Bigger ships can move into harbour and unload during high tides because of the rise in the water level.
- Seashores get cleared of garbage by the water during high tide.
- High tides are also used for generating electricity.

Tides occur because of the Sun's gravitational pull as well. When the Sun, the Moon and the Earth are in the same line during their orbital revolutions, a very high tide occurs.

Eclipse

We know that the Moon revolves around the Earth, and the Earth revolves around the Sun. Sometimes, during their revolutions, the Sun, the Moon and the Earth come in the same line. In such a situation, the shadow of one heavenly body falls on the other. The

phenomenon of heavenly bodies casting shadow on one another is called an eclipse. Now, there are two things that might possibly occur:

1. The Moon comes between the Sun and the Earth

   In this case, the Moon's shadow falls on the Earth for some time. Thus, for some time, the Sun is not visible from the Earth. This is called the solar eclipse.

2. The Earth comes between the Sun and the Moon

   In this case, the shadow of the Earth falls on the Moon's surface. Thus, for some time, the Moon is not visible from the Earth's surface. This is called the lunar eclipse. Lunar eclipse only happens on full-moon nights. It lasts for about two hours. Due to the Earth's huge size, the Moon takes quite some time to move out of the Earth's shadow.

Surface of Moon

We always associate the moon with beauty. **Are there beautiful lakes and flowers on the moon? How does the surface of the moon look? What are the things found on its surface?**

Just like us, many people have been curious about the moon. To find out more, some scientists decided to explore the surface of the moon.

On 21st July 1969, American astronaut Neil A. Armstrong, from the space mission Apollo 11, descended on the surface of the moon. Another American astronaut, Edwin E. Aldrin Jr, also landed on the moon along with Armstrong.

What did they find? They observed that the surface of the moon

- Was dusty with no plants and trees
- Had lots of craters of different sizes
- Had many mountain ranges with steep slopes, some of them as high as the mountains on the face of the Earth

    - Another interesting fact is that if we talk on the surface of moon, we cannot hear each other! **Do you know why?**
    - We know that sound waves travel through air. The moon's surface does not have any air. Therefore, we cannot hear each other on the moon.
    - The moon does not have any oxygen too! That is the reason why we see astronauts carrying oxygen cylinders and wearing oxygen masks.

Apollo 11 took 8 days, 3 hours, 18 minutes, and 35 seconds from the Earth to the moon and back. The distance between the Earth and moon is 384403 kms.

Facts about Stars

We see many bright twinkling stars in the night sky. **Do you know what the source of their light is?**

The stars emit light because of the nuclear reactions that occur inside them. But **why do some stars look very bright and appear to be larger in size than others?**

The brightness of a star depends on its distance from the observer and the rate of nuclear reactions going on inside them. For example, the Sun which is also a star, is actually a medium-sized star. However, it looks much bigger than any of the other stars in the universe. This is because it is very close to the Earth as compared to the other stars. The other stars are not visible in the day because their light is overshadowed by the bright light of the Sun.

An object that lies near us appears much larger in size than an object that lies far away from us.

The Earth and the Sun are 150,000,000 km or 1.5×10^8 km apart.

Such large distances are measured in **light years**. One light year is the distance traveled by light in one year. The speed of light is equal to 3×10^8 m/s or 300000 km per seconds.

After the Sun, the Alpha Centauri is the nearest star from the Earth. It is situated at a distance of approximately 4.3 light years from the Earth. In kilometers, this distance is equal to 40,000,000,000,000 km.

Sunlight takes about 8.5 minutes to reach the Earth. It means that if the Sun suddenly stops glowing, then people on the Earth would know that the Sun has stopped glowing only after a lapse of 8.5 minutes.

Observe the position of a particular star or a group of stars. Now, try to locate the same star or group of stars at the same position, after about four to five hours. What do you observe?

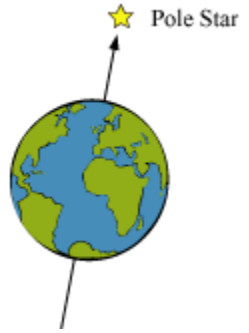
Do the stars move or do they remain fixed in their positions?

If you observe the stars closely, you will notice that they do not remain stationary. They appear to move from the east to the west; this is the result of the rotation of the Earth.

Thus, since the Earth moves on its axis from the west to the east, the stars appear to be moving from the east to the west.

This is also the reason why the Sun appears to rise in the east and set in the west!

Thus, the stars do not actually move, but only appear to move as a result of the movement of the Earth on its axis.



What about the star that is in line with the axis of the Earth? Does it move too?

No, it does not move. The **Pole Star is one such star** which appears to be stationary in the sky. This is because the Pole star is situated at the point through which the axis of Earth passes.

Let us understand this better.

Observe a merry-go-round closely. The seats of a merry-go-round can be considered as stars.

When the merry-go-round starts rotating, all the stars (seats) also change their positions. **Can you locate a position that remains stationary during the rotation?**

The axis or the center of a merry-go-round always remains stationary. Hence, a star (seat) that is located on it will appear to remain stationary.

Did you know that since the Pole star remains stationary, it was used in earlier times by sailors for navigation?

There are various types of stars in the universe, some of which are stated below:

Sun-like Stars: These are particularly similar to the sun in size but there is a lot of variation in terms of temperature. Examples are Alpha Centurai, Tau Ceti etc.

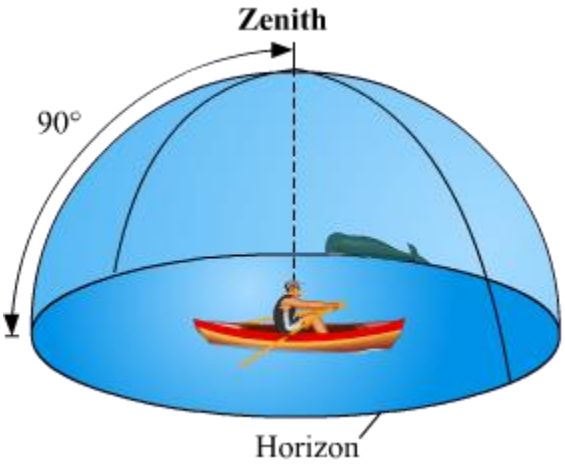
Red Giants: These stars do not have as hot outer layer as that of the Sun with temperature ranging from 3000 ^{o}C to 4000 ^{o}C but they have a very high luminance than the Sun. They are red in color and their diameter is 10 to 100 times that of the sun.

Super Nova: They are larger and even brighter as compared to the red giant stars and even the Sun. They are also considered as the primary source of heavy elements in the universe.

Binary or Twin Stars: A pair of two stars in which one revolves around the other or they both revolve around a common center is known as binary or twin stars.

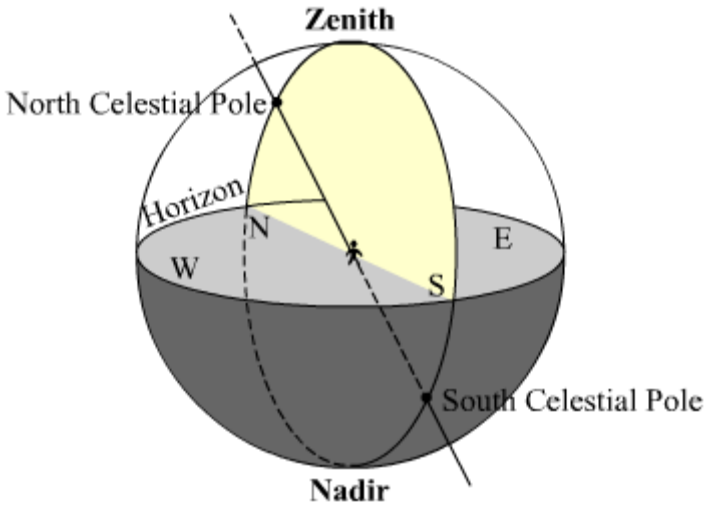
Variable Stars: These stars have a variable shape and brightness i.e it keeps on changing whenever they expand or contract. Their brightness decreases when they expand and increases when they contract. Example Polaris or Pole Star.

Have you ever seen the intersection of sky and ground?



The imaginary line where it seems that sky and the ground are meeting with each other is known as the **horizon**. And it can be assumed while looking up at the sky that a sphere is formed and all the stars and planets are moving in this sphere. This imaginary sphere is known as the **celestial sphere**.

Different points on the celestial sphere



Zenith: The point directly above the observer's head on the celestial sphere is called zenith.

Nadir: The point exactly below the feet of the observer on the celestial sphere is called nadir.

Celestial poles: The points at which the extended axis of rotation of earth intersects the celestial sphere are called celestial poles which are celestial north and south pole.

Meridian: The great circle passing through the celestial poles, the zenith and the nadir is known as a meridian.

Celestial equator: An imaginary circle on which the earth's extended equator intersects the celestial sphere is called the celestial equator.

Ecliptic: The circle on celestial sphere that represents the apparent path of the sun when seen from the earth is known as the ecliptic.

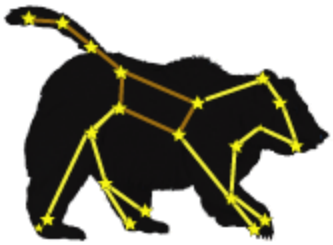
Constellations

Observe the night sky. Can you see the stars form any shapes and figures?

The shapes and figures formed by stars are known as constellations. A group of stars that forms a recognizable figure or shape is called **constellation.**

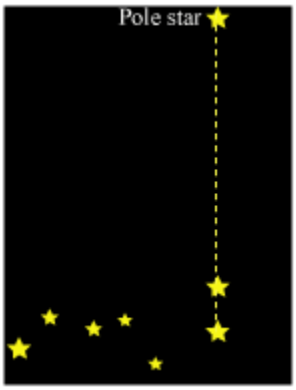
If you look at the sky on a clear night and observe carefully, different constellations will be visible. Some of the famous constellations that are visible in the night sky are

[1] Ursa Major



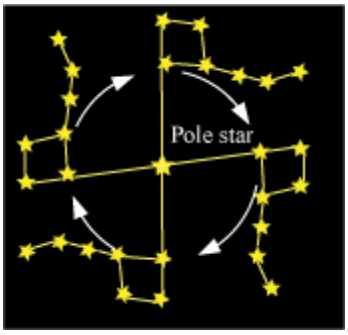
This constellation is visible in the sky during the summer months in the Northern hemisphere. It cannot be seen from the Southern hemisphere. Ursa Major moves around the pole star. It is also known as the **Great Bear.** This constellation is composed of seven bright stars and appears like a big-spoon. These seven stars are together known as the **Big Dipper** and the***Saptarshi***.

In earlier times, these constellations were used to locate the stars. Let us locate the Pole star.



Observe the two stars of the spoon that lie in a straight line in the constellation of Ursa Major. Now, join these two stars by an imaginary line and extend this line toward the northern direction for about five times the original distance between these two stars.

This line will appear to touch a star; this star is the Pole star.



Observe the position of this constellation with respect to the Pole star after every four hours. What do you see? You will observe that the Ursa Major appears to revolve around the Pole star.

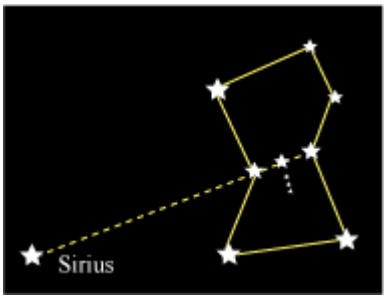
Since the Pole star appears stationary, all the other stars and constellations appear to revolve around this star.

[2] Orion

This constellation is visible during the winter season. It is composed of eight bright stars that are arranged in such a way that they resemble the ray diagram of a hunter. The three stars at the centre appear to form the belt of a hunter, and it is because of this resemblance that this constellation is also known as the **Hunter.**

Sirius is the brightest star in the night sky.

Let us locate the Sirius.



Draw an imaginary line passing through the belt of Orion toward the east. This imaginary line leads us to a bright star called the Sirius.

[3] Cassiopeia

This constellation is visible in the Northern hemisphere during the winter season. It resembles the letter 'W' or a distorted 'M'.

A constellation is actually composed of a large number of stars. However, with our naked eye, we can see only the bright stars among them.

Do you know:

- The total number of stars in the universe far exceeds the total number of grains of sand on Earth!?

- The colour of a star is determined by its internal temperature. The hottest star is blue in colour while the coolest is red in colour.

Do you know:

Zodiac

You might have learned that sun, the visible planets and moon appear to move along the elliptical path from east to west. This apparent path is known as the Zodiac belt. There are twelve constellations located in this belt. These are known as zodiac constellations. These constellations include:

1. Aries (Mesha)

2. Taurus (Vrishabha)

3. Gemini (Mithuna)

4. Cancer (Karka)

5. Leo (Simha)

6. Virgo (Kanya)

7. Libra (Tula)

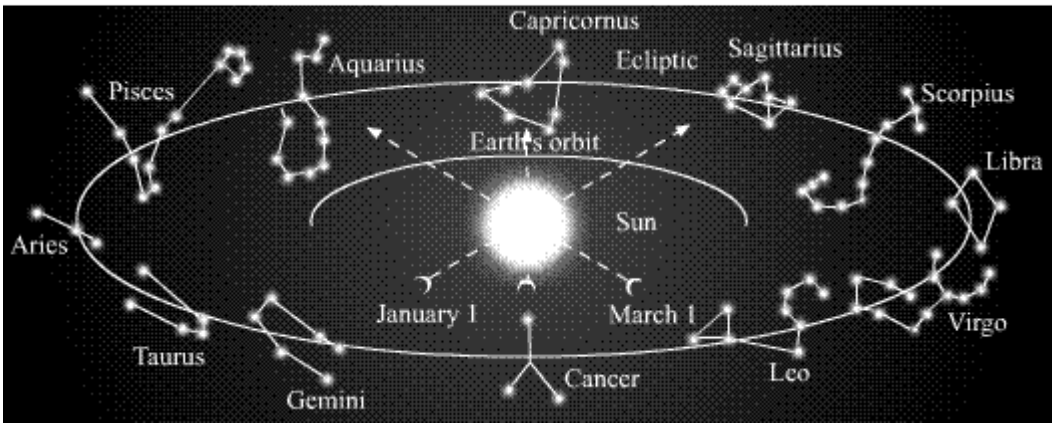
8. Scorpius (Vrishchika)

9. Sagittarius (Dhanu)

10. Capricornus (Makara)

12. Aquarius (Kumbha)

13. Pisces (meera)



Contradictory to the popular belief that there are only twelve constellations, there exists one more i.e 13th constellation known as Ophiuchus. It is located on the celestial equator. It is also known by the name Serpentarius meaning Serpent- Bearer.

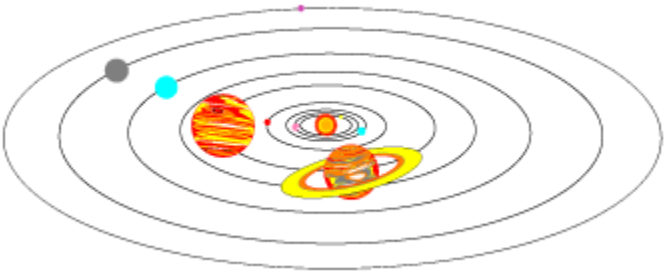
Nakshatra

The moon orbits around the earth in the segment in approximately 27.3 days. This lunar mansion is termed as a nakshatra. It is one of the 28 sectors along the ecliptic. Nakshatra contains yogatara which is the brightest star from where it is known. Each nakshatra covers 13 degrees and 20 minutes.

Sun and Planets

Sun and the heavenly bodies that revolve around it together comprise the solar system.

The gravitational force between the Sun and the other components of the solar system such as the planets, asteroids, comets etc. causes them to revolve around the Sun.



Let us study each component of the solar system in detail.

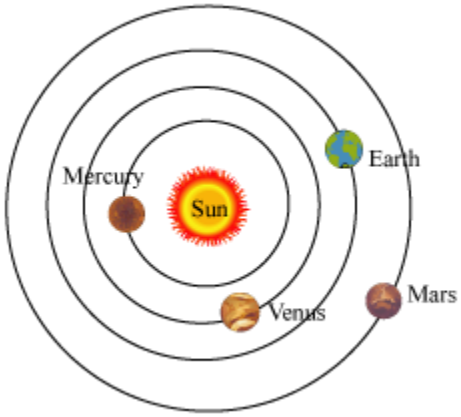
Sun

It is the star that is closest to our solar system and the planet Earth. It provides a continuous supply of heat and light to all the other components of the solar system. It is the source of almost all the energy that is available on the Earth. The existence of life on Earth depends on the Sun.

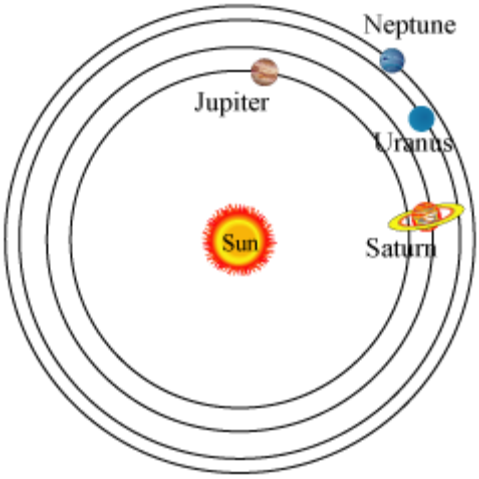
Sun contributes about 98 % of the total mass of the solar system. Its mass is approximately equal to 1.989×10^{30} kg.

The planets

Our solar system consists of eight planets. The order of these planets, in ascending order, according to their distances from the Sun is **Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune**.



The first four planets of the solar system viz, Mercury, Venus, Earth, and Mars are known as the **inner planets**.



The next four planets of the solar system are Jupiter, Saturn, Uranus and Neptune. They are also referred to as the **outer planets**.

These planets are composed mainly of gases and hence, are also known as gas giants. They are bigger in size and consist of a large number of natural satellites.

These planets can also be categorised as terrestrial and jovian planets.

- Planets which are found inside the orbit of mars are known as **terrestrial planets.** The surface of these planets is dense and rocky. They are very small in size in comparison to the other remaining planets and consist of a fewer number of natural satellites.
- Planets which are found outside the orbit of mars are known as **jovian planets.** They have composition similar to jupiter. These planets have big size, less density and are made up of helium, ammonia and hydrogen mainly.

Is it possible to observe planets in the sky? Do planets appear as stars in the sky? When you carefully observe the sky just before sunset or just prior to sunrise, you may be able to see planets such as Venus and Mercury.

How do we know whether the object observed is a star or a planet? The planets can be differentiated from the stars because unlike stars, the planets do not twinkle, since they do not emit their own light. They also keep changing their positions.

Let us observe planets in the sky.

Venus is the brightest celestial object in the night sky after the Sun and moon. Since it appears in the sky just before sunrise and after sunset, it is also known as the **morning** or the **evening star**.

These planets keep revolving around the Sun in a definite path, which is referred to as the orbit. For example, the Earth completes one revolution around the Sun in approximately 365 days. Hence, the Earth's period of revolution is 365 days.

Thus, the time taken by a planet to complete a single revolution around the Sun is known as its period of revolution.

It is important to know that the orbital period of a planet increases as its distance from the Sun increases. This consequently increases the length of its orbit around the Sun.

Observe the motion of a top (***Lattu***). You will find that besides rotating on its axis, it also revolves in a circular path on the ground.

The planets of the solar system show a similar characteristic. In addition to rotating on their axes, they also revolve around the Sun in a circular path**.**

The time taken by a planet to complete one rotation on its axis is known as its period of rotation. The Earth's period of rotation is 24 hours.

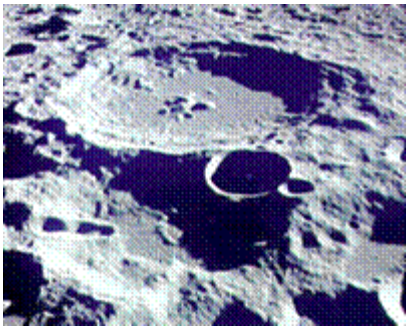
Satellites

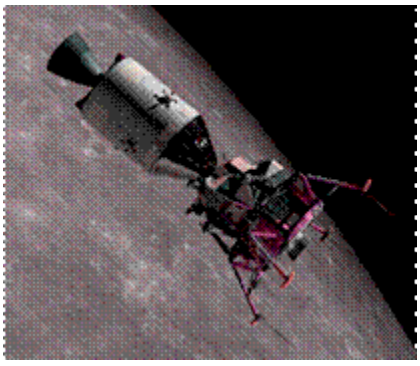
Satellites are the celestial bodies that revolve around other celestial bodies such as planets in orbits. They also rotate about their respective axis like planets.
For example, the moon is the only satellite of the Earth.

Moon

The moon is the only known natural satellite of the earth. The surface of the moon has many huge craters. It has no atmosphere and water. It appears as the large bright object on the full moon night and sometimes can be seen during day also.

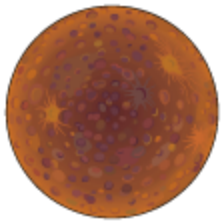
On July 21, 1969, an American astronaut Neil Armstrong became the first man to land on the surface of moon. He went to moon in a spacecraft known as **Apollo 11**. He was followed by Edwin Aldrin. India explored moon in the year 2009 by its programme known as "**Chandrayana I".**





Let us study the features of each planet in detail.

Mercury



Mercury

It is also called *Budh.* It is the planet closest to the Sun. It is also the smallest planet in the solar system. It does not have any satellite.

As a result of its proximity to the Sun, the temperature of Mercury rises up to 427°C. This planet mostly remains hidden under the bright glare of the Sun and is therefore best viewed at sunrise or sunset.

The period of rotation of Mercury is 59 days. In other words, a day on Mercury is equal to 59 days on Earth! It completes one revolution around the Sun in 88 days.

Venus

Venus

It is also called *Shukra*. It is the second nearest planet in the solar system from the Sun. Venus is also the planet that is closest to the Earth. It does not have any natural satellite.

Venus is the hottest planet in the solar system. Its surface temperature is about 464 °C. It revolves around the Sun from East to West and takes 224 days to complete a single revolution.

Venus is the only planet in the solar system whose period of rotation (243 days) is greater that its period of revolution (224 days).

The different phases of Venus can be observed through a telescope. These phases resemble the phases of the moon.

Earth

Earth

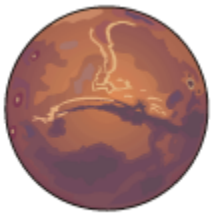
It is also called *Prithvi.* It is the third planet from the sun in the solar system. The Earth is the only planet in the solar system that supports life.

This is possible because of its optimal distance from the Sun that helps to maintain a normal temperature range. The presence of water and atmosphere are other factors that help to support life on Earth. In addition to these, the presence of an ozone layer in the Earth's atmosphere protects the Earth from the harmful radiation from Sun.

The Earth appears bluish-green from outer space. This is because of the land surface and the presence of water (70%) on Earth.

The Earth rotates on its axis, which is tilted at an angle of $23\frac{1}{2}^{\circ}$. The axis is inclined to its orbital plane at an angle of 66.5º. The Earth completes a single rotation in twenty four hours. This tilt is responsible for the change of seasons on Earth. Earth revolves about its own axis from west to east.

Earth has only one satellite, known as the Moon.



Mars

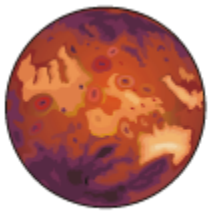
Mars

It is also called *Mangal*. It is the fourth planet in the solar system.

It is also known as the red planet because of its reddish appearance.

Mars has two natural satellites, named ***phobos*** and ***deimos*** meaning fear and terror respectively. It is believed that the Romans worshipped this planet as the God of war.

Jupiter



Jupiter

It is also called *Brihaspathi*. It is the largest planet in the solar system. This planet is made up mostly of gases such as hydrogen and helium. Jupiter's mass is 318 times more than that of the Earth. You should also know that in size Jupiter is 1300 times larger than the Earth. Jupiter rotates on its axis at a high speed. It has faint rings around it.

If we look at Jupiter through a telescope, we will be able to clearly see four of its satellites.

Jupiter has 63 natural satellites; this is the highest number of satellites of a single planet in the solar system.

Saturn

Saturn

It is also called *Shani*. Saturn is the second largest planet in the solar system. Like Jupiter, this too is composed of gases. Its size is 765 times the size of the Earth.

Saturn looks yellowish in colour when we look through a powerful telescope. The rings of Saturn are made of ice particles. These rings make Saturn unique among all the planets in the solar system. It has 47 natural satellites.

The density of Saturn is lesser as compared to that of the other planets. Its density is even less than that of water. In other words, if it were possible for us to drop Saturn in water, it would float on the surface of water because of its lower density.

Uranus

Uranus

Uranus is the penultimate planet in the solar system and can be observed only with the help of a telescope. Uranus has 27 natural satellites.

Like the planet Venus, it also rotates on its axis form East to West.

Uranus' axis of rotation is tilted up to 90° such that its axis is nearly level with its path of orbit.

Neptune

It is the outermost planet in the solar system. It is also made up of gases. Neptune has 13 natural satellites.

Do you know:

Pluto from its discovery in 1930 till 2006, it was considered as the ninth planet in the solar system. However, Pluto was taken out from the list of planets by the International Astronomical Union. In 2006, a new definition of planets was adopted by the International Astronomical Union (IAU). According to this definition, Pluto does not qualify to be a planet. It is now considered as a **Dwarf Planet**.

Facts and figures

Name of the Planet	Number of Known Satellites	Period of Revolution	Period of Rotation	Presence of Atmosphere	Presence of Rings
Mercury	0	88 days	58.65 days	No	No
Venus	0	225 days	243.0 days	Yes	No
Earth	1	1 year (365 days)	24 hours	Yes	No
Mars	2	1.88 years	24 hrs 37 min	Yes	No
Jupiter	64	11.84 years	9 hrs 56 min	Yes	Yes
Saturn	33	29 years	10 hrs 40 min	Yes	Yes
Uranus	27	84 years	17 hrs 24 min	Yes	Yes

Neptune	13	164 years	16 hrs 11 min	Yes	Yes

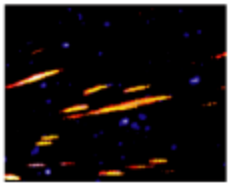
Asteroids, Comets, Meteors

Apart from Sun, the planets, and their satellites, there are other members of the solar system such as asteroids, comets, meteors, and meteorites.

Did you know that Halley's Comet returns after every 76 years? It was last seen in 1986 and is scheduled to return in 2061.

Comets have been associated with bad luck because their appearances have coincided with floods, droughts, and other natural disasters. You should know now that they are natural celestial objects.

Meteors and meteorites



Meteors are small objects that enter the Earth's atmosphere as a result of its gravitational pull. On entering the Earth's atmosphere, they acquire very high speeds.

Do meteors strike the Earth's surface?

No, meteors do not strike the Earth's surface. The high speed of a meteor causes friction with the Earth's atmosphere. This causes the meteor to heat up. As a result, it evaporates completely!

Meteors are also known as shooting stars.

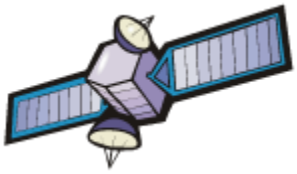
Meteorites are the small parts of meteors that are left behind in the atmosphere after burning out. These meteorites help scientists to study the solar system.

Comets are the solar system bodies that are usually spherical in shape and develop tail when comes near the sun. Comets become visible when they are close to the sun and the earth.

Comets can be categorized into two groups:

- **Long Period Comets**: These comets complete one revolution around the Sun in 200 and more years. Great Comet of 1843 is one of the examples of this type.
- **Short Period Comets**: These comets complete one revolution around the Sun in years less than 200. One of the examples is Halley's comet that takes 76 years to complete the revolution. It last appeared in 1985.

Artificial Satellites



Artificial satellites, as the name suggests, are satellites made by humans and placed into an orbit to revolve specially around the Earth and other planets.

These satellites help in telecommunication, weather forecasting, military purposes, remote sensing, etc.

Aryabhatta was the first Indian satellite to be launched into space.

Some of the satellites launched by India are INSAT, IRS, EDUSAT, Kalpana-1, CARTOSAT-1, etc.

Remote sensing satellites are placed in the Earth orbit at a height of 600 to 900 km with the help of cameras. They send pictures of the various parts of the earth.

Geostationary satellite

A geostationary satellite revolves around the Earth in a special orbit known as the geosynchronous orbit situated at a height of about 36000 km from the Earth.

The orbital period of a geostationary satellite equals the period of rotation of the Earth. It is used in communication and remote imaging.

The orbits of geostationary satellites lie over the equator and follow a circular path.