6 STAR AND SOLAR SYSTEM

6.1 INTRODUCTION

The sky is the vast, limitless, huge void (emptiness) above the earth's surface. Man has always been interested in and impressed by, the large number of celestial objects present in the sky.

We all know that when we look at the sky, on a clear cloudless night, we see a grand view of a very large number of shining stars spread all over it. We then feel, as if, we are at the centre of a huge spherical dome, surrounding our earth, that has stars, and other heavenly objects, studded in it. This imaginary sphere has been known as the celestial or the heavenly sphere.

Developments in science and technology have enabled our astronomers and scientists to explore and understand the universe as never before. In this unit, we will learn something about our present knowledge of the universe.

We, the human beings, live on the surface of the earth. When we look up, what do we see? Obviously, we see the sky. The sky appears blue on a clear day, but is dark at night. Why is it so? This is because during the day, it is the sunlight which makes it appear blue. But what really is the sky? Well, the vast empty space can be called Sky.

During the daytime, we see a bright ball of fire in the sky which appears to move from the east to the west. We call it the Sun. At night, we see thousands of stars in the sky. If we watch the sky through a telescope we may see millions of stars, some of which are brightly coloured. We see certain groups of stars which appear to be in clusters. They are called constellations. All stars appear twinkling at night. Our Sun is a kind of medium star. It appears bigger to us, because it is too close to earth as compared to other stars.

Then there are star-like objects in the sky which do not twinkle. These are actually planets which revolve around the Sun at different distances. There were initially nine planets including our Earth. However, with the consent of astronomers the "Pluto" has been deleted from the list of planets. Why? You will learn about it in the section related to planets.

Then there is Moon in the sky whose size appear to change everyday. The Moon is the natural satellite of Earth. It completes one revolution around the earth in $27\frac{1}{3}$ days.

Furthermore, we see an occasional comet. It appears as a ball of fire, having a tail. Then, there are shooting stars or meteors. They appear to fall from the sky. In addition to it, there are like the morning star.planets

Bodies such as the earth, moon, planets, sun, stars, meteors, comets, etc., are called heavenly bodies or celestial bodies.

6.2 WHAT IS UNIVERSE?

The vast unimaginable space which encompasses most distant stars, planets or anything else, which exists is called universe.

6.3 WHAT IS ASTRONOMY?

The branch of science which deals with the study of universe is called astronomy. The study of astronomy involves the methods and instruments used for the study of the universe. We know a lot about the universe from the information already gathered by the astronomers.

- **Knowledge Based Questions**

Q.1 The planet having ring around it is
(A) Mercury (B) Uranus (C) Pluto (D) Saturn

Q.2 Which of the plant is of Red colour
(A) Mars (B) Venus (C) Pluto (D) Saturn

Q.3 The celestial bodies revolving around a planet are called.
(A) Star (B) Comets (C) Satellite (D) None

Q.4 The number of stars in universe are
(A) Infinite (B) Nine (C) 10^{23} (D)can't say

Q.5 Brightest planet in the solar system
(A) Venus (B) Mercury (C) Mars (D) Jupiter

Q.6 Farthest planet in the solar system is
(A) Earth (B) Saturn (C) Jupiter (D) Neptune

Q.7 Biggest planet in the solar system is
(A) Sun (B) Jupiter (C) Moon (D) Mars

Q.8 Which of the following is a satellite ?
(A) Moon (B) Earth (C) Mars (D) Jupiter

Q.9 Which of the following is a star?
(A) Sun (B) Moon (C) Earth (D) Jupiter

6.4 THE NIGHT SKY

We all know that the most familiar heavenly (or celestial) objects are the sun and the moon. During daytime, we see only the very bright and shining sun in the sky. We can not see any other celestial object because the sun is very much brighter than all of them. However, as soon as the sun sets in, we get a very different view of the sky.

In night sky, we all can easily observe a large number of shining (fixed) stars, arranged in well-known patterns. The number and details of the objects observed in the night sky, become much more and much better, on a clear cloudless night. Our ancestors also noted five other celestial objects besides the sun, moon and the stars. These objects could be seen by the naked eye. They were observed to move along fairly complicated paths with respect to the (fixed) stars. **The five planets, known to our ancestors were Mercury, Venus, Mars, Jupiter and Saturn**.

We now know that there are eight rather than just five planets. Our earth itself is one of these eight planets.

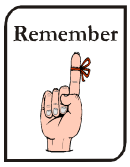
After sunset, the night sky is dotted with bright stars. On a clear night [when there is no dust or clouds in the sky] one can see about 3000 stars with the unaided eye. However, if the sky is viewed through a good telescope, many more stars are visible. Most of the stars are yellow in colour, but some stars are white or red in colour. Another property of the stars is that they appear twinkling. The twinkling takes place due to the atmosphere of the earth. However, if the stars are viewed above the atmosphere, as in the case of a spaceship, they do not twinkle, but appear to shine more brightly.
Another prominent object visible at night is moon, whose size appears to change every night. Besides, there are star-like objects which do not appear to twinkle. These are planets. They revolve around the sun in the same way as our earth. Then there are shooting stars (meteors). They appear to fall from the sky with a long, bright streak of light.

6.4.1 How do the Stars Emit Light ?

All stars are giant balls of hydrogen gas and this includes our sun which is a medium-sized star. At the core (centre) of this giant hydrogen cloud, the temperature is from 2 million to 5 million degree celsius. At such a high temperature, the hydrogen gas fuses (joins or melts) to form a heavier gas called helium, with the liberation of a huge amount of heat and light energy. Thus, it is the fusion of hydrogen gas within the core of the star which emits light energy.

6.5 GALAXY

(i) An enormous cluster of billions of star held together by gravitational force is called galaxy.
(ii) Usually galaxy consists of 10^6 to 10^{12} stars, which also contain a large number of gas clouds (mainly of hydrogen gas) and dust.
(iii) There are about 10^{11} galaxies in the universe and each galaxy has on average 10^{11} stars. So the total number of stars in the universe is about 10^{22} stars.
(iv) The two important galaxies are (i) Milky way galaxy and (ii) Andromeda galaxy
(v) Galaxies have different shapes and sizes. Usually, they are of three types:
(a) Spiral galaxies (b) Elliptical galaxies (c) Irregular galaxies



There are trillions of stars in the universe. They occur in groups called **galaxies**. The gravitational force between stars keeps the stars of a galaxy together. Apart from stars, a galaxy may have other celestial bodies like planets and moons. So you can say **that a galaxy is a group of stars and other celestial bodies bound together by gravitational force.**

The distribution of the stars in a galaxy can give it a shape such as spiral, ring or elliptical. Our sun is a part of a spiral galaxy called the **Milky Way Galaxy**. This galaxy is named after the Milky Way. The **Milky Way** is a band of stars that we can see in a clear night. These stars are a part of our galaxy. The ancient Romans called this band of stars Via Galactica, or 'road of milk'. That is how our galaxy got its name.

(a) A ring galaxy (b) A spiral galaxy. The Milky Way Galaxy is a spiral galaxy.

6.6 STARS

(i) A star is an extremely hot heavenly body that emits heat and light of its own. It also appears to be twinkling and has a regular motion of its own.

(ii) The star which is nearest to earth is sun. The other stars appear very small to us due to their large distance from us. Many of them are much bigger and massive compared to the sun.

(iii) Astronomers, use a special (very large) unit for measuring stellar distances. This unit is known as Light year. A light year equals the distance covered by light, in vacuum, in a time equal to one year.
Light travels in vacuum, with a speed of 3×10^8 ms^{-1}.
Hence, 1 light year = $(3 \times 10^8) \times (365 \times 24 \times 60 \times 60$ metre)
or 1 light year = 9.46×10^{15} metre
or 94,60,00,00,00,000 km

(iv) The light of the sun reaches the earth in 8.3 minutes. Hence we can say that the sun is 8.3 light minute far from the earth.

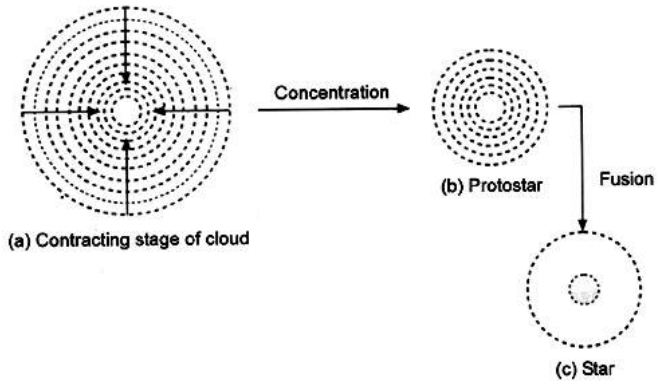
(v) The next nearest star after the sun is Alpha Centuari. Its distance from the earth is 4.3 light years. Our distance from Sirus, the brightest (other than the sun) star is about 8.7 light years.

The Pole Star

We know that the earth rotates about its axis from the west to east. Because of this rotation of the earth, we feel that the stars are moving from east to west.

There is however, one very special star in the northern hemisphere that does not appear to show this (apparent) motion from east to west. It appears to us to be always stationary and at the same position. It is known as Polaris or Pole star or the Dhruv Tara. It is situated in the direction of Earth's axis.
Pole star is located at the north pole of the celestial sphere. The pole star has served as a direction indicator guide to navigators at night time.

(a) Life cycle of stars : In galaxies, mainly the gases are hydrogen and helium which are present at very low density. These gases are at very low temperature of about –173°C. Over millions of years, these gases and dust particles collect in the form of clouds. The process of star birth starts with the formation of such clouds. When the randomly drifting particles come close to form a cloud, the gravitational attraction between them becomes effective and pull them towards the centre of the cloud. The cloud, thus contracts to a smaller volume. The kinetic energy of the particle rushing towards the centre, is converted into random thermal energy. This increases the temperature in the central region of cloud. As the temperature rises, radiation is emitted from the central region. This radiation tries to push the gaseous matter outwards, thus reducing the speed of contraction. The cloud at this state is called protostar.

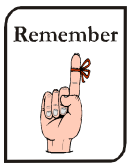


It may take about 1,00,000 years for a cloud to turn into a protostar. The process of contraction continues and the temperature in the core keeps on rising. Finally the temperature reaches about 10^7°C and nuclear fusion starts to convert hydrogen into helium. A star is thus born.

(b) **Cause of Death of stars :** In a star two types of forces are acting continuously. These are gravitational attraction and internal pressures. These act in opposite direction and the star is now in abdicate equilibrium under these two opposing forces. In this stage, the star continues to liberate energy due to fusion reactions taking place inside it. Our sun has been in this state since 4,600 million years. It is likely to remain in a more or less similar state for another four billion years or so.

Final stages of star's life: There are two stages in star's life

(1) Red Giant (2) White Dwarf



Why are Stars not Visible during Daytime?

During daytime, the light from the sun is so strong that it suppresses the light coming from the stars, and hence, they are not visible to us.

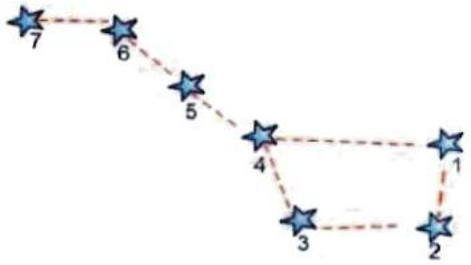
6.7 CONSTELLATION

There are many groups of stars which do not change their position relative to one another. Such groups are known as star constellations.

Thus, a constellation is a group of stars forming recognisable shape or pattern.

6.7.1 Ursa Major or Big Dipper or Vrihat Saptarishi

This constellation consists of seven bright stars, arranged in a pattern somewhat resembling the shape of a big bear. The stars marked 1, 2, 3 and 4 represent the body and the stars marked 5, 6 and 7 represent the tail of the big bear. The head and paws of the big bear are formed by some faint stars, not shown in diagram.



Ursa Major

The Ursa Major constellation can be likened to the following objects :

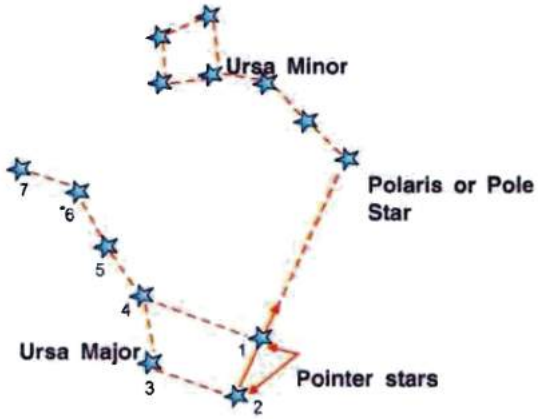
(i) It looks like an **oversized ladle** in which stars marked 1, 2, 3 and 4 form the cup of the ladle and stars marked 5, 6 and 7 form the handle.
The stars 1 and 2 at the end of the cup of the ladle are called pointer stars, as they point in the direction of the pole star.

(ii) It looks like a question mark suspended across the sky, where the stars 1, 2, 3 and 4 form the curved path and the stars 5, 6 and 7 straight line part of the question mark.

(iii) It resembles a kite having a long tail. The Ursa Major is visible clearly in the northern part of the sky in the summer months, between April and September.

6.7.2 Ursa Minor or Laghu Saptarishi or Dhruva Matsaya

Ursa Minor constellation is also a group of seven stars, similar to that of Ursa Major. However, the stars in Ursa Minor are closer and dimmer as compared to the stars of Ursa Major. They form an outline of a ladle or a kite. At the tail of Ursa Minor is a star of average brightness. It is called Pole Star or Polaris. In Indian astronomy, the pole star is called Dhruva Tara. Ursa Minor is clearly seen in northern sky in July summer.



Relative positions of Ursa Major and Ursa Minor

How to locate the Pole Star ?

Look straight in the direction of the stars situated at the far end of the ladle in Ursa Major (stars 1 and 2). The star of medium brightness in the direction of the above stars is the Pole Star (figure). The stars 1 and 2 in Ursa Major which point in the direction of the Pole Star are called pointer stars.

6.7.3 Orion or Hunter or Mriga or Vyadha

Orion is another constellation of seven stars and is one of the most magnificent constellations seen in the winter sky. Its name in Indian astronomy is Vyadha or Mriga. It Looks like a hunter with his shield and club upraised Fig (a). The seven major stars in it form the body of the hunter. The head and limbs are formed by faint stars, not shown in Fig.(a).

In the Orion, four stars form a kind of rectangle. In the one corner of this rectangle is situated the largest star called Betelgeuse. whereas another bright star called Rigel, is situated on the opposite corner. There are three prominent, stars which are situated in the middle of the constellation forming a straight Line.

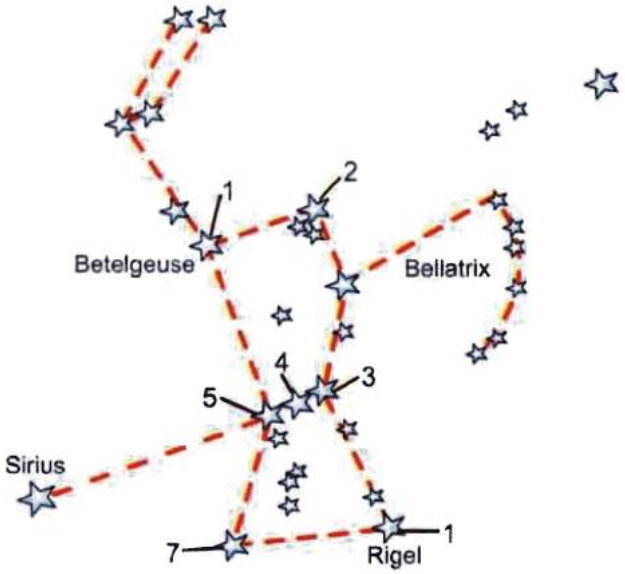
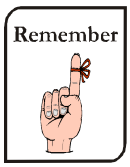


Fig. (a) Orion or Mriga



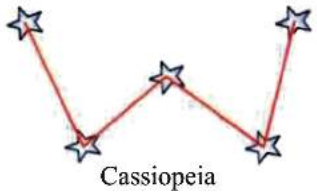
A constellation does not have a few stars. It has a large number of stars as shown in Fig. (b).

Fig.(b) Other stars present in the constellation Orion

The brightest star, Sirius is situated in the constellation of Orion. In order to locate Sirius, imagine a straight line passing through the three middle stars of orion. Looking along this line towards east, you will find a very bright star. It is Sirius.

6.7.4 Cassiopeia

It is another prominent constellation in the northern sky. It looks like a distorted M or W formed by five stars. It is visible in winter in the early part of the night.



Cassiopeia

(i) It contains five stars.
(ii) It appears to resemble the shape of a queen sitting on her thorne.
(iii) It is usually observed during the autumn season.

6.7.5 Scorpio

(i) This constellation is also a summer constellation.
(ii) It contains seven stars in it.
(iii) These seven stars are so arranged that they appear to resemble a scorpion.

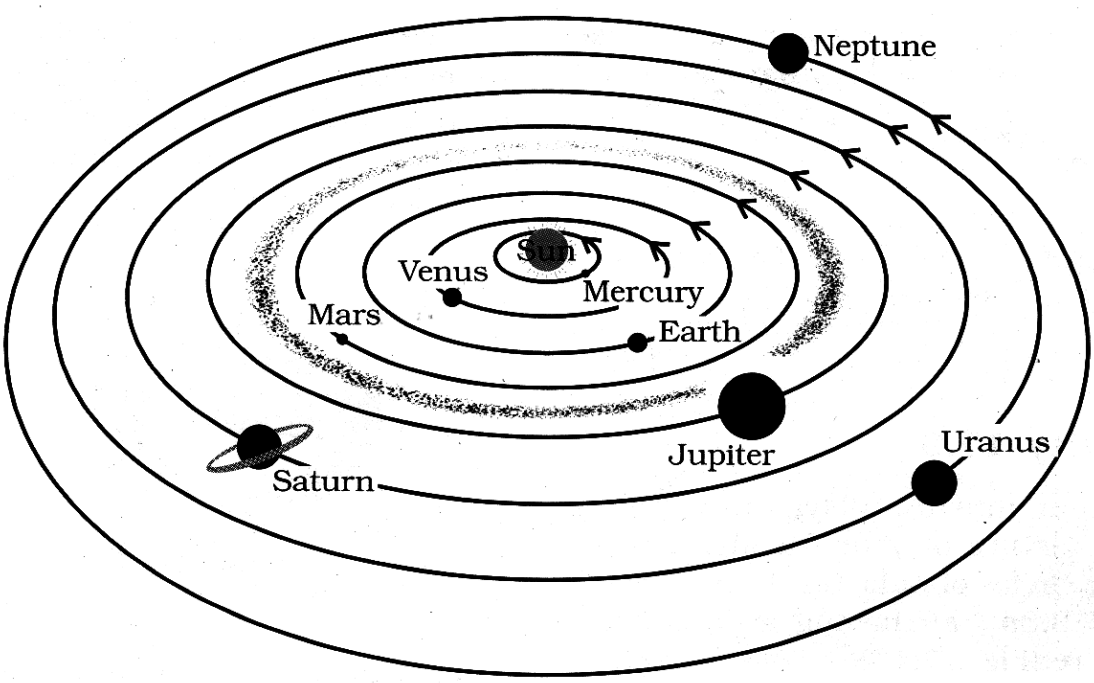
6.7.6 Differences between a galaxy and a constellation :

Galaxy	Constellation
1. It is a group of billions of stars.	1. It is a group of only a few stars.
2. It does not form a definite pattern.	2. The stars are arranged in definite, recognizable patterns.
3. There are billions centre of galaxies in the universe.	3. At present we know of only about 88 constellations.
4. Very few galaxies are visible to the naked eye.	4. Many constellations are visible to the naked eye.

6.8 SOLAR SYSTEM

The solar system consists of the sun, the eight planets, and their satellities (or moons) and thousands of other small heavenly bodies such as asteroids, comets and meteros. The planets revolve around the sun in somewhat elongated oval-shaped or elliptical orbits. The orbits, however, have different sizes. Orbit of mercury being the smallest and that of Neptune being the largest. According to their distance from the sun, the eight planets are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune.

Based on their distances from the sun, planets have been divided into two groups. The planets Mercury, Venus, Earth and Mars all receive substantial amount of solar energy and are known as the inner planets. The other four planets, Jupiter, Saturn, Uranus, Neptune are comparatively too far away from the sun and are known as the outer planets.



The Solar System (not to scale)

6.8.1 The Sun

The sun is clearly the largest and the heaivest member of the solar system. The outer surface of the sun is at a temperature of nearly 6,000 K. Its inner core is very much hotter. The temperature there is about 74,000 million kelvin. The hydrogen nuclei, present in the sun, fuse together to form helium nuclei (nuclear fusion). It is this reaction that generates all the heat and light energy radiated by the sun.The sun is both very large and very massive, compared to the earth.

The sun is the star closest to the earth at a distance of **150 million km** from the earth. Light from the sun takes **8¼ minutes** to reach the earth. The diameter of the sun is over **109 times** the diameter of the earth and it is **333,000 times** as heavy as the earth. The sun is made up of hydrogen gas that is continuously being converted into helium at extremely high temperature. The centre of the sun is thus extremely hot at about 14 million degrees Celsius, while its surface temperature is about **6000 degrees** Celsius. Compared to the other stars the sun looks enormous to us as it is so close to the earth. The next nearest star, Alpha Centauri, is several times bigger than the sun, but it appears tiny as it is much away from us. Sometimes, from some areas on the surface of the sun, hot gases shoot outward.

These are called prominences. There are also some darker, relatively cooler patches (of about **4000ºC**) on the surface of the sun. These spots are called sunspots and are of interest to scientists as they are found to interfere with radio and wireless transmission from the earth. They also produce change in weather on the earth.

6.8.2 Planets

The 'planet' are those (bright) heavenly bodies that revolve round the sun. They look like stars but they do not twinkle. Their observed brightness is only due to the light of the sun reflected by them. There are eight planets now in our solar system. They move in elliptical shaped paths called orbits around the sun. The eight planets of our solar system, in increasing order of their distances from the sun are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune . The planets, relatively nearer to the sun have features that are quite different from those which are 'far off'. We can divide the planets into two categories :

(i) The terrestrial planets, and (ii) The Jovian planets.

Mercury, Venus, Earth and Mars are the terrestrial planets. They have solid and rocky surfaces.

The Jovian planets are Jupiter, Saturn, Uranus and Neptune. These planets are very large in size and are made up largely of gases.

(a) Mercury (Budha) *:* This planet is nearest to the sun and also the fastest of all the planets. That is why it is visible in the sky only very close the horizon for a short period just before sunrise or just after sunset. It always presents the same side to the sun so tht is one part always has day and is the hottest. The other part always has night and is the coldest. It is yellowish orange in colour. Though mercury is not a star, it is known as morning or evening star due to its brightness. Mercury have close resemblance with those of the moon. Both are nearly similar in size and mass. Mercury too has no atmosphere and its surface is rocky and has mountains too.

(b) Venus (Shukra) : It is a planet which our elder often called an evening or morning star. It is one of the most familiar celestial bodies that our elders could identify easily. Venus occasionally appears as an evening star just above the western horizon and it also appears in the eastern sky as morning star. However, it is not visible throughout the year as it is closer to the sun than the earth. Venus appears the brightest of all celestial bodies, including all planets, the moon and stars. This is so, in spite of the fact that Venus is farther away from the sun than Mercury. The bright appearence of Venus is due to its cloudy atmosphere, which reflects almost three fourth of the sunlight that falls on it. The mass of Venus is nearly 4/5 times that of the earth while both are nearly same in size. Venus has no moon or satellite of its own. Its rotation is from East to West.

(c) Earth (Prithvi)

Earth, our home planet, is perhaps the only unique planet in the universe that contains oxygen and water i.e. the two things necessary to sustain life.It has two main motions associated with it.

(i) Its revolution around the sun for which is takes a time of nearly 365.25 days (1 year)

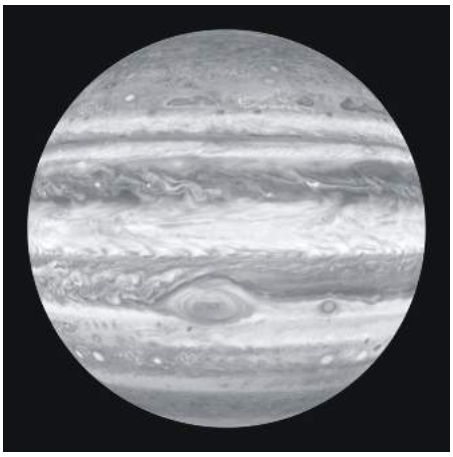
(ii) Its rotation about an axis of its own which takes a time of nearly 24 hours (1 day). It is the combined effect of these two motions that brings about the observed changes in seasons on the earth.

The axis of rotation of earth remains tilted in the same direction throughout its revolution around the sun. When the northern hemisphere is tilted towards the sun, there is summer season on it and winter in the southern hemisphere. The reverse happens when the southern hemisphere is tilted towards the sun.

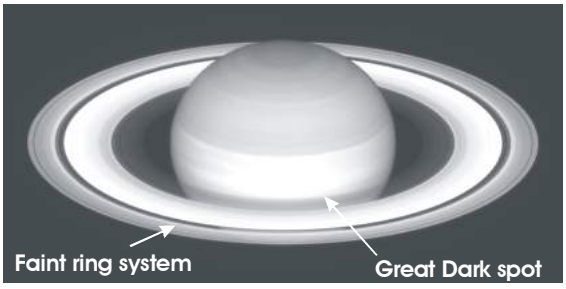
Note that on June 21, the earth is farther away from the sun than on December 22. On this day, we have the longest day in the northern hemisphere while it is the shortest in the soutern hemisphere. On december 22, the length of the day is the shortest in the northern hemisphere and the longest in the souther hemisphere. On september 23 and March 21, the duration of day and night is equal in both the hemisphere.

(d) **Mars (Mangal) :** Mars, an orange red planet is nearest to the earth.Mars is visible from the earth for most part of the year. However, it is best situated for observation when it opposite the sun's position in the sky with respect to the earth. On these days it is closer to the earth as well. The diameter of Mars is slightly more than half of that of the earth but its mass is only one tenth of that of the earth. It has a thin atmosphere that makes it easier to view its surface from the earth. Mars has two natural satellites or moons named Phobos and Deimos. It is also known as Red Planet.

(e) **Jupiter (Brihaspati) :** Jupiter is the largest of all the planets. Its mass is more than the combined mass of all other planets. The distance of Jupiter from the sun is more than the sum of distances of each of the four planets that are closer to the sun. So, it receives much less light and heat of the sun compared to earth and Mars. Yet, it appears the brightest of all the planets in the sky except Venus and occasionally Mars Jupiters bright appearance is due to its thick atmosphere that reflects most of the sunlight falling on it. It is believed that Jupiter mainly consists of hydrogen and helium in gaseous form. Its cloud like outer regions consist of methane in gaseous form while ammonia is present in crystalline form. Until 2002, Jupiter was known to have as many as 28 satellites or moons. It also has faint rings around it.



(f) **Saturn (Shani) :** Saturn is the most distant planet known to the early astronomers. Its distance from the sun is almost two times that of Jupiter. It is similar in size, mass and composition to Jupiter. It is however, cooler than Jupiter. The most distinguishing feature of Saturn is its beautiful rings that encircle the planet. There are three distinct rings that surround the planet. These rings are not visible with the naked eyes and can be observed only with the help of a telescope.
Saturn is known to have 30 satellites or moons, largest amongst all the planets. Its density is less than that of water.



(g) **Uranus :** Uranus was the first planet to be discovered with the help of a telescope. Uranus appears as a small disc although its diameter is almost four times that of the earth. Hydrogen and methane have been detected in the atmosphere of Uranus, Its distance from the sun is almost two times that of Saturn. So far 21 satellites or moons of Uranus have been discovered. Its rotation is from East to West. Its axis is highly tilted so in its orbital motion it appears rolling.

(h) **Neptune :** Neptune is eighth planet in the terms of its distance from the sun. Neptune has the same size as that of uranus. Neptune also has some rings around it. The temperature on the surface of Neptune remain below –200°C. So, it is an extremely cold planet.

6.8.3 Asteroids

The asteroids or planetoids are very minor planets that are present throughout the solar system. They are however, found in great numbers in a belt between the orbits of Mars and Jupiter. All the asteroids follow their own orbits around the sun.

6.8.4 Comets

Comets are seen rarely. They present a fascinating sight and appear as having a bright head with a long tail. Comets move around the sun like the planets but have very large periods of revolution. They develop very long tails when their orbits bring them close to the sun.

The orbits of most of the comets are such that they move around the sun once and then vanish away, never to be seen again. A few like Halley's comet are, however, exceptions to this. They reappear at regular intervals in around 76 years and are bright enough to be seen by the naked eye.

6.8.5 Meteors and Meteorites

These are very small objects whose ecentric orbits bring them into collision with the earth. When they enter the earth's atmosphere at very high speeds, the heat produced by the friction, against the atmospheric air, causes them to get vaporized and produce a brilliant trail. For this reason, meteors are also known as shooting stars.

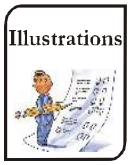


Illustration 1

All the stars, except the pole star, appear to move from east to west. Give reason?

Solution

The apparent motion of stars in the sky is due to the rotation of earth on its axis. The earth rotates on its axis from west to east direction due to which the starts appear to move in the opposite direction, from east to west. The ploe star, appears to be stationary and does not move because it lies on the axis of rotation of earth which is fixed and does not change with time.

6.9 DIFFERENCES BETWEEN A STAR AND A PLANET

	Star		Planet
1	Stars have their own light.	1	Planets do not have their own light.
2	Stars produce their own energy due to the fusion of hydrogen.	2	Planets do not produce their own energy. They have to depend upon the Sun for energy.
3	Stars appear to twinkle at night.	3	Planets do not twinkle at night.
4	Stars have enormous mass.	4	Planets have inSignificant mass, compared to the stars.
5	Stars do not change their relative position in the sky everyday.	5	Planets change their position in the sky on a daily basis.
6	Stars appear to move from east to west in the sky.	6	Planets appear to rotate from the west to east except Venus in the sky.

6.10 SATELLITE

A satellite is a small body revolving around a planet.

Satellites are of two types :

(a) Natural satellite (b) Artificial satellite

(A) NATURAL SATELLITE (THE MOON)

(i) The moon, our nearest neightbour in space, is a natural satellite to earth. A satellite is a heavenly body that revolves around a planet.

(ii) The moon has no air or water on it. Its diameter is about (1/4 th) of the diameter of the earth and its mass is about (1/8th) that of the earth. It has no light of its own. Its observed silvery glow is only due to the light of sun reflected by its surface.

(iii) The moon is very much smaller than stars but it appears bigger to us because of its nearness.

(iv) The moon has a very interesting feature associated with it. It takes the same time (27 days and 7 hours) to revolve around the earth as well as to spin, or rotate, once about its own axis. We on the earth therefore, always see only one side (the front side) of the moon. Its other, or 'back' side is not seen from the earth.

The moon is the only natural satellite of the earth and is our nearest neighbour in the space. It is the brightest object in the sky, next to the Sun.

However, with unaided eye we can see only a few bright stars.

Furthermore, all the stars which constitute a constellation are not at the same distance from the earth. They are just in the same line of sight In the sky.

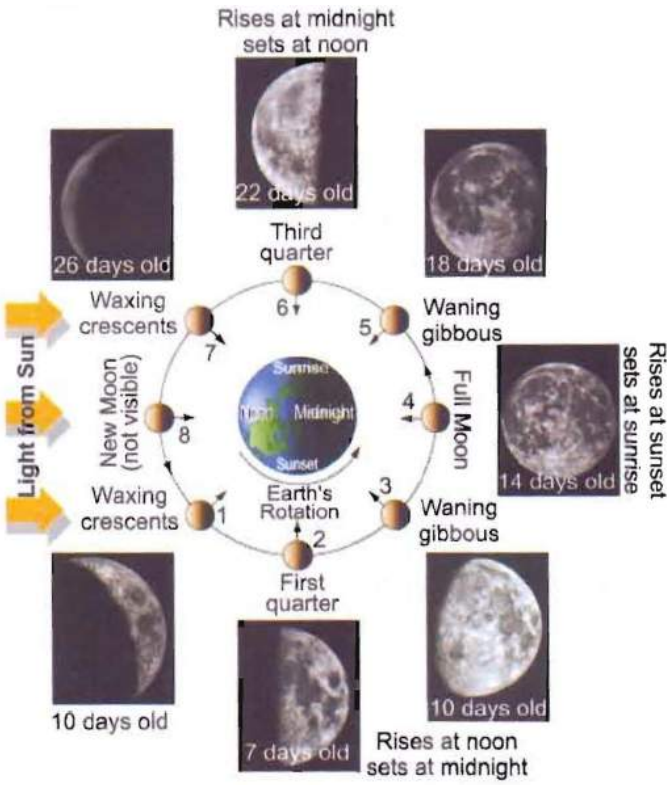
The surface of the moon is rugged. It is made of very large craters (deep depressions or holes) and very high mountains. It has no atmosphere, and hence, no life exists on it. Its gravitational pull is one-sixth that of the earth.

Surface of the Moon

The moon always presents its same face towards the earth. On the day side of the moon, the temperatures could be as high as 110°C. On the contrary, the temperature on the night side of the moon could be as low as –150°C.

PHASES OF THE MOON

The moon is a non-luminous body. It has no light of its own. It only reflects the light of the sun falling on its surface. When this reflected light reaches the earth, we see the moon. Only that part of the moon is visible, which reflects the sunlight towards the earth.



Phases of the Moon

On the New Moon Day. the moon is between the sun and the earth. Thus, the reflected light from the moon does not reach the earth, and hence, it is not visible.

The night just after the New Moon Day, we see the Crescent Moon. It is because only the reflected light from the crescent part reaches the earth. The rest of the moon is only faintly visible, because the sunlight reflected from the earth also falls on the moon's disc.

The crescent goes on increasing every day, till on the fifteenth day (from the New Moon Day). the full bright face of the moon is visible. On this day the earth is between the sun and the moon, such that the night side of the earth is facing the day side of the moon. This is called Full Moon Day. This gradual increase in the bright disc of the moon is called waxing of the moon.

After the Full Moon, the bright face of the moon goes on decreasing every night. This decrease in the bright disc of the moon is called waning of the moon. By another fifteen days, the New Moon is formed.

This waxing and waning of the disc of the moon, as the moon revolves around the earth is called phases of the moon.

The moon revolves around the earth. As the earth revolves around the sun, exactly the way the moon revolves around the earth. The moon completes one revolution around the earth in 27⅓ days. It takes exactly the same time to spin once about its axis. Due to the same time for rotation on its axis and revolution around the earth, it always presents the same face towards the earth.

However as the moon revolves anound the earth, the earth moves ahead in its own orbit around the sun. Thus, from the earth the moon appears to complete one revolution between one New Moon to the next New Moon in 29½ days.

Lunar calendars commonly used by astrologers are based on the idea that the Moon completes one revolution around the Earth in 29½ days.

Different Phases of Moon

The changes in the shape of the moon, or the various phases of the moon, are due to the (daily) change in its position relative to the sun. The transition from the new moon position (when its other or 'back' side is getting illuminated by the sun) to the full moon position (when its 'front' side is getting illuminated by the sun) takes place in nearly 15 days. The full cycle of going back to the new moon position gets completed in 29 days and 12 hours.

The Moon's Surface

The moon's surface is dusty and barren. There are many craters of different sizes. It also has a large number of steep and high mountains. Some of these are as high as the highest mountains on the Earth.

Did You Know ?

On 21 July, 1969 [Indian time], an American civilian astronaut Neil Armstrong landed on the moon for the first time. He was followed by Edwin Aldrin, the astronaut from the American defence services.

An astronaut on the moon

Illustration 2

What is the source of moons light

Solution

Moon is a satellite of earth. It does not emit light of its own but partially reflects the incident light from the sun which appears as a moon's light.

(B) ARTIFICIAL SATELLITE

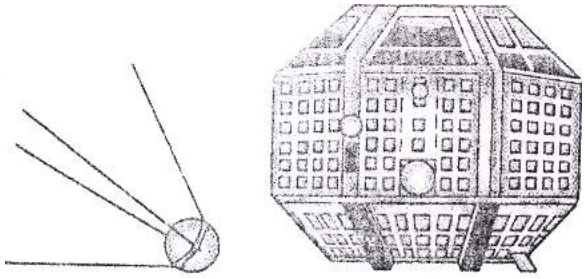
A man-made space-craft placed in orbit around the earth is called an **artificial satellite**. The night sky has now got an additional quota of objects put there by man. These are called artificial satellites. Several countries, including India, have put number of such satellities in space. These are being put to a variety of uses like communication, meterological research and so on. These artificial satellites last for a certain period before burning out like meteors.

We can often see some of these artificial satellities (travelling quite fast across the sky) just before sunrise or just after sunset.

The speed of artificial satellites to be used for long distance communication is so adjusted that they complete one revolution around the earth in 24 hours. As a result, the satellite appears to be stationary with respect to the transmitting station on the ground.

The artificial satellites are also known as man-made satellites. An artificial satellite is placed in orbit around the earth with the help of a launch vehicle called rocket.

India has built and launched several artificial satellites. Aryabhatta was the first Indian satellite. Some other Indian satellites are INSAT, IRS, Kalpana-1, EDUSAT, etc.



Sputnik-I Aryabhata

Artificial satellites have many practical applications. They are used for forecasting weather, transmitting television and radio signals. They are also used for telecommunication and remote sensing.

6.10.1 Difference between natural and artificial satellite

S. No.	Natural Satellite	Artificial Satellite
1.	Natural satellite is the heavenly natural bodies revolving around the planets.	Artificial satellites are man made objects which are made to revolve around the earth.
2.	These satellites are at larger distance from the planet.	These satellites are comparatively closer to the planet than natural satellites.
3.	Moon is the natural satellite of earth	Apple, Rohini are the artificial satellite

6.10.2 Geostationary (Geo-synchronous) and Polar (Sun-Synchronous) Satellites

Geostationary Satellites : A geostationary satellite is a satellite that remains fixed with respect to a particular point on the earth. For such satellites, the time period of their revolution around the earth is the same as the time period of rotation of the earth about its own axis, i.e. nearly 24 hours.

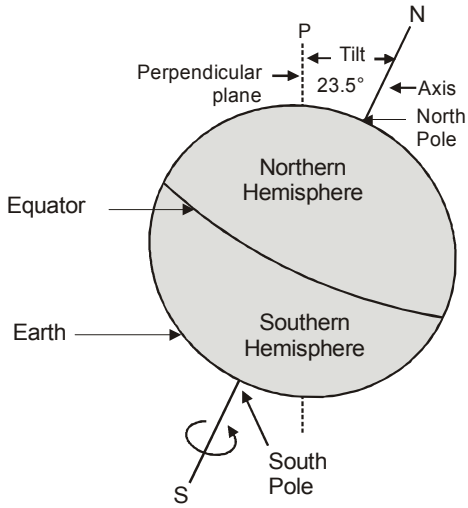
Sun-Synchronous Orbit Satellites: A satellite is said to be in a sun-synchronous orbit if its position, with respect to a particular location on the earth, which always remains in tune with the position of the sun over that location.

6.10.3 Motion of Earth

The earth has two types of motion :

(i) The earth rotates on its axis **(ii)** The earth revolves around the sun

(i) **The earth rotates on its axis :** The earth rotates (or spins) on an imaginary axis which passes through its north and south poles. The earth completes one rotation on its axis in **24 hours** which we call one day. The earth rotates (or spins) on its axis from west to east. The axis of rotation of earth is not perpendicular to the plane of the earth's orbit.

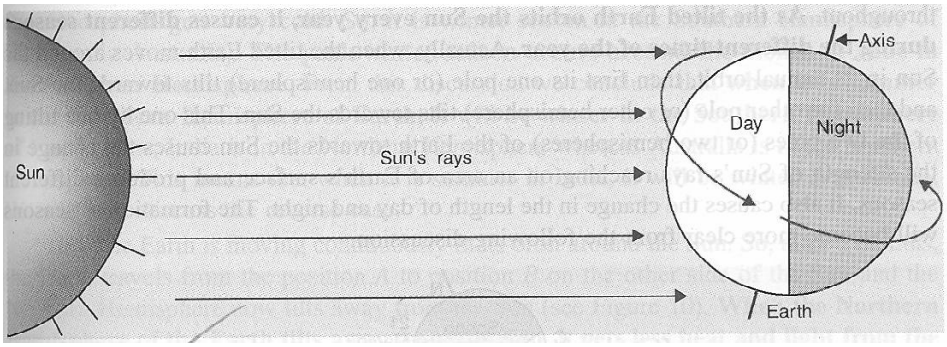


The axis of rotation of earth is slightly tilted with respect to the plane of its orbit (or path) around the sun. In fact, the axis of earth is tilted at an angle of **23.5 degrees** to the perpendicular plane. The earth rotates on its axis in the tilted position and it also revolves around the sun in the same tilted position throughout. The earth is spherical in shape. We can divide the earth into two half spheres called two hemispheres. The two hemispheres of earth meet at the equator (which is an imaginary line running around the middle part of the earth between the north pole and south pole). The upper half part of the earth below the north pole and above the equator is called Northern Hemisphere. The lower half part of the earth below the equator and above the south pole is called Southern Hemisphere. We (in India) live in the Northern Hemisphere of the earth. On the other hand, Australia is in the Southern Hemisphere of the earth.

(A) The rotation of earth on its axis causes day and night.

An important consequence of the rotation of earth on its axis is that it causes day and night on the earth. The formation of day and night can be explained as follows :

The earth receives its light from the sun. The light of sun always falls on that half part of earth which is facing the sun.



In the figure, the left side of earth is facing the sun, so it is day in this part of the earth. That part of the earth which is turned away from the sun does not receive any sunlight, it remains in the dark and has night. In figure, the right side of earth is away from the sun, so it is night in this part of the earth.

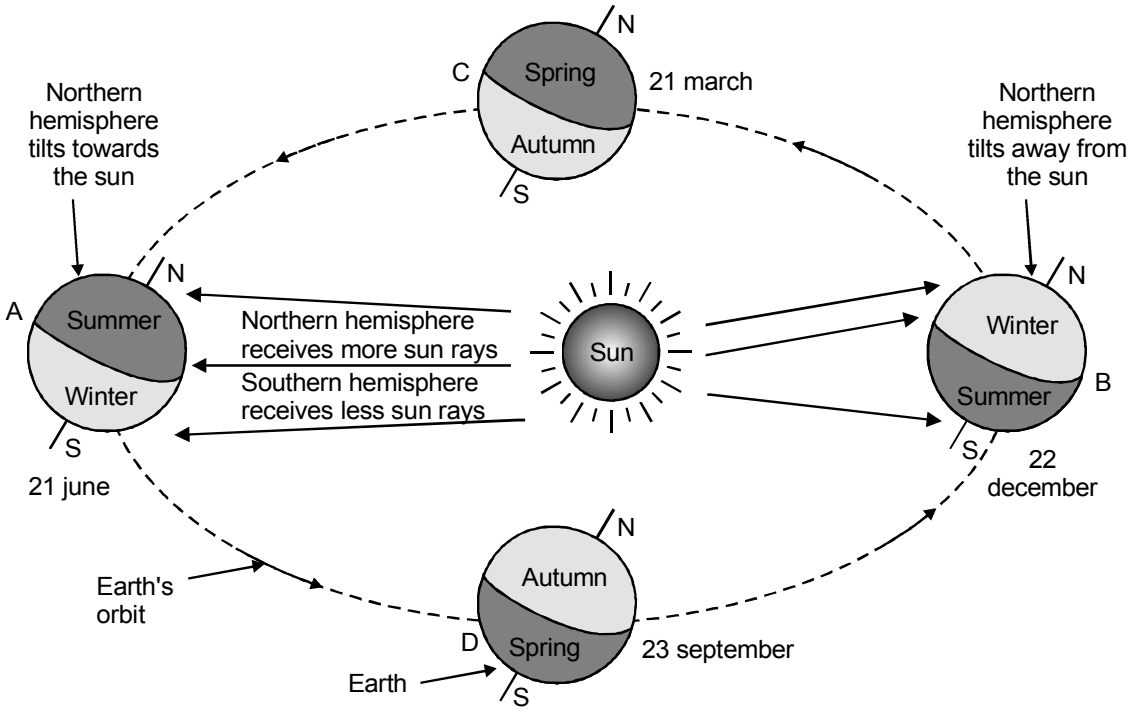
As the earth continues to rotate (or turn) on its axis, almost every **12 hours**, a day changes into a night and a night changes into a day. Since the earth's axis is tilted at an angle, therefore, the length of day and night actually changes throughout the year. From the above discussion we conclude that : The day and night are caused by the daily rotation of earth on its axis. The change in the length of day and night is, however, caused by the tilt of earth's axis.

There are four seasons in a year : summer, winter, spring and autumn. The hot season of the year is called summer. The coldest season of the year is called winter. The season after winter and before summer is called spring. And the season after summer and before winter is called autumn. The spring and autumn seasons are neither very hot nor very cold, they have a moderate weather. We will now describe how the different seasons on the earth are formed.

(ii) **The earth revolves around the sun :** The motion of tilted earth around the sun causes seasons. An important consequence of the revolution of the earth around the sun is that it causes seasons on the earth such as summer, winter, spring and autumn. Two factors are responsible for causing different seasons on the earth are :

- ❖ Motion of the earth around the sun once every year.
- ❖ Tilting of the earth's axis to the plane of its orbit around the sun.

The earth rotates (or spins) on its axis and also revolves (or moves) around the sun. The earth takes 1 year (or **365 ¼ days**) to complete one revolution around the sun. The north-south axis on which the earth spins is not at right angles to the earth's orbit around the sun. The earth's axis is tilted at an angle of **23.5^0** to its orbit around the sun. When the earth moves around the sun in its orbit, it remains tilted to its orbit throughout. As the tilted earth orbits the sun every year, it causes different seasons during the different times of the year. Actually, when the tilted earth moves around the sun in its annual orbit, then first its one pole (or other hemisphere) tilts towards the sun. This one by one tilting of the two poles (or two hemispheres) of the earth towards the sun causes the change in the strength of sun's rays reaching on an area of earth's surface and produces different seasons. It also causes the change in the length of day and night. The formation of seasons will become more clear from the following discussion.



(A) When the earth is at position A in its orbit around the sun, then the Northern Hemisphere of the earth tilts towards the sun. When the Northern Hemisphere of the earth tilts towards the sun, it gets more heat and light from the sun and has summer season. During this period, at noon, the sun's rays fall almost perpendicularly in the Northern Hemisphere, they have more heating effect and hence the atmosphere becomes very hot. So, it is summer season in the Northern Hemisphere of earth (as in India). The peak summer season occurs around the month of June in the Northern Hemisphere. When the Northern Hemisphere of earth tilts towards the sun, then at the same time, the Southern. Hemisphere tilts away from the sun. When the Southern Hemisphere of the earth tilts away from the sun, it gets less heat and light from the sun and has winter season. During this period, even at noon, the sun's rays fall obliquely in the Southern Hemisphere, they have less heating effect and hence the atmosphere gets very cold. So, it is winter season in the Southern Hemisphere of earth (as in Australia). The peakwinter season occurs around the month of June in the Southern Hemisphere. From the discussion we conclude that when it is summer in the Northern Hemisphere of earth, it will be winter in the Southern Hemisphere of earth. Now, India is in the Northern Hemisphere whereas Australia is in the Southern Hemisphere. This means that when it is summer in India, it will be winter in Australia.

(B) The earth is moving continuously in its orbit around the sun. So, after 6 months, the earth travels from the position A to position B on the other side of the sun and the Northern Hemisphere now tilts away from the sun. When the Northern Hemisphere of the earth tilts away from the sun, it gets less heat and light from the sun and has winter season. The peak winter season occurs around the month of December in the Northern Hemisphere of earth.

When the Northern Hemisphere of earth tilts away from the sun, then at the same time, the Southern Hemisphere tilts towards the sun. When the Southern Hemisphere tilts towards the sun, it gets more heat and light from the sun and has summer season. The peak summer season in the Southern Hemisphere occurs around the month of December. From the above discussion we conclude that when it is winter in the Northern Hemisphere of earth, it will be summer in the Southern Hemisphere of earth. This means that when it is winter in India, it will be summer in Australia.

There are two times in a year when the Northern Hemisphere and the Southern Hemisphere of the earth are neither tilted towards the sun nor tilted away from the sun (see positions C and D). This gives us two other seasons : spring and autumn. When the earth is at position C in its orbit around the sun, then it is spring season in the Northern Hemisphere but autumn season in the Southern Hemisphere. This happens around the month of March. On the other hand, when the earth is at position D in its orbit around the sun, then it is autumn in the Northern Hemisphere but spring in the Southern hemisphere. This happens around the month of September. During spring and autumn seasons, both the hemispheres of the earth get almost equal amounts of heat and light from the sun. At positions C and D, day and night are equal in both the hemispheres.

Please note that the seasons on earth are determined by the angle at which the sun rays fall on its surface and not by the distance of the earth from the sun. During the summer, at noon time, the sun rays fall almost perpendicularly on the earth's surface due to which the sun appears very hot. On the other hand, during winter even at noon time, the sun rays are inclined at a considerable angle to the earth's surface due to which the sun appears less hot. It is a surprising fact that in India the earth is nearer to the sun during our winter and farther from the sun during our summer. In general, we can say that :

- **In the Northern Hemisphere :**
  - **(i)** It is winter when the earth is closer to the sun.
  - **(ii)** It is summer when the earth is farther from the sun.
- **In the Southern Hemisphere :**
  - **(i)** It is summer when the earth is closer to the sun.
  - **(ii)** It is winter when the earth is farther from the sun.

Another point to be noted is that due to the tilted axis to the earth, the sun rays fall on the earth for a longer time during summer and for shorter time during winter. Due to this, the days are longer in summer but shorter in winter. Please note that when the day is long then the night is short and when the day is short then the night is long.

The cases of longest day of the year, shortest day of the year and of equal day and night of the year are described below :

(i) In June it is summer season in the Northern Hemisphere of the earth. On **June 21**, the earth is farthest from the sun. So, on **June 21**, we have the longest day in the Northern Hemisphere but the shortest day in the Southern Hemisphere.

(ii) In December it is winter season in the Northern Hemisphere. On **December 22**, the earth is nearest to the sun. So, on **December 22**, we have the shortest day in the Northern Hemisphere but the longest day in the Southern Hemisphere.

(iii) In March, it is spring season in the Northern Hemisphere but autumn season in the Southern Hemisphere. In September, it is autumn season in the Northern Hemisphere but it is spring season in the Southern Hemisphere. On **March 21 and September 23**, the duration of day and night is equal in both the Hemisphere of the earth.

LET US RECAPITULATE

- The vast empty space in which the stars, the sun, the planets, the moon, and everything else exists, is called universe.
- **Celestial bodies :** Bodies such as the earth, the moon, the planets, the sun, the stars, the comets, etc.
- Stars are the celestial bodies that give out heat energy and light energy of their own. Our sun is a medium order star.
- **Stars :** Giant balls of fusing hydrogen or helium which emit huge amount of heat and light.
- Stars are too far away. It takes millions of years, before the light from some stars actually reaches us.
- Alpha Centauri is the nearest star to our solar system.
- The distances of the stars are expressed in light years.
- **Light year :** The distance travelled by light in one year.
- **Pole star :** A star in line with north pole of the earth, whose position does not change.
- **Shooting stars :** Same as meteor.
- The celestial bodies revolving around the sun are called planets.
- **Orbit :** The path along which celestial bodies revolve around the sun or other celestial bodies.
- The sun and the planets constitute the solar system. In the solar system, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune are the planets in the order of increasing distance from the sun.
- Day and night are formed due to the rotation of the Earth about its own axis in 24 hours.
- Seasons on the Earth are due to the revolution of the Earth around the sun and the tilting of its axis of rotation.
- **Natural satellite :**The heavenly bodies revolving around a planet are called moons. With the exception of Mercury and Venus, all planets have moons. Earth has only one moon.
- **Phases of moon :** The waxing and waning of the disc of the moon as it revolves around the earth.
- The phases of the moon occur due to relative change in the positions of the Earth and moon, while revolving around the sun.
- **Comets :** The bright "star-like" objects with a long tail approaching the sun in a highly elliptical orbit.
- **Asteroids :** The small pieces of rocks or metals which revolve around the sun, in between the orbits of Mars and Jupiter.
- **Meteor :** A bright "star-like" object which suddenly appears in the sky and then for a few moments streaks in the form of a brilliant flash towards the earth.
- **Meteorites :** The unburnt pieces of meteor, which reach the surface of the earth.

CONCEPT APPLICATION LEVEL - I [NCERT Questions]

Q.1 Which of the following is not a member of the solar system?
(A) An asteroid (B) A satellite (C) A constellation (D) A comet
Ans. (C) A constellation

Q.2 Which of the following is not a planet of the sun?
(A) Sirius (B) Mercury (C) Saturn (D) Earth
Ans. (A) Sirius

Q.3 Phases of the moon occur because:
(A) we can see only that part of the moon which reflects light towards us.
(B) our distance from the moon keeps changing.
(C) the shadow of the Earth covers only a part of the moon's surface.
(D) the thickness of the moon's atmosphere is not constant.
Ans. (A) we can see only that part of the moon which reflects light towards us.

Q.4 Fill in the blanks:
(a) The planet which is the farthest from the Sun is ..... .
(b) The planet which appears reddish in colour is ..... .
(c) A group of stars that appear to form a pattern in the sky is known as a ..... .
(d) A celestial body that revolves around a planet is known as ..... .
(e) Shooting stars are actually not ..... .
(f) Asteroids are found between the orbits of ..... and .....
Ans. (a) neptune (b) mars (c) constellation (d) satellite (e) stars
(f) mars, jupiter

Q.5 Mark the following statements as True (T) or False (F):
(a) Pole star is a member of the solar system. [ ]
(b) Mercury is the smallest planet of the solar system. [ ]
(c) Uranus is the farthest planet in the solar system. [ ]
(d) INSAT is an artificial satellite. [ ]
(e) There are nine planets in the solar system. [ ]
(f) Constellation Orion can be seen only with a telescope. [ ]
Ans. (a) False (b) True (c) False (d) True (e) False (f)False.

Q.6 Match items in column A with one or more items in column B.

Column-A		Column-B
(i)	Inner planets	(a) Saturn
(ii)	Outer planet	(b) Pole Star
(iii)	Canstellation	(c) Great Bear
(iv)	Satellite of the Earth	(d) Moon
		(e) Earth
		(f) Orion
		(g) Mars

Ans. (i) g,e (ii) a (iii) c,f (iv) d

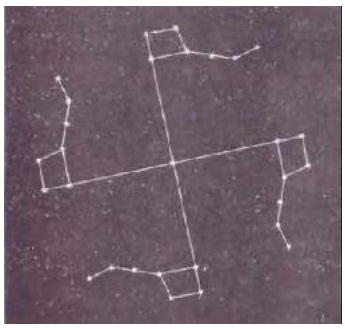
Q.7 In which part of the sky can you see Venus if it is visible as an evening star?
Ans. Western Horizon

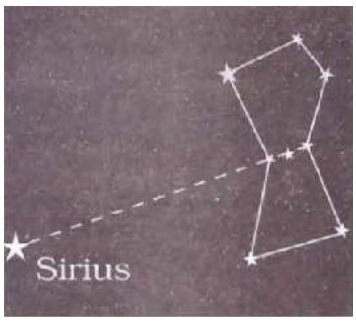
Q.8 Name the largest planet of the solar system.
Ans. Jupiter (Brihaspati).

Q.9 What is a constellation? Name any two constellations.
Ans. Constellations are a group of stars that appear to form some recognizable shape. For examples Ursa Major and Orion.

Q.10 Draw sketches to show the relative positions of prominent stars in:
(a) Ursa Major and (b) Orion.

Ans.





Q.11 Name two objects other than planets which are members of the solar system.
Ans. Comets, asteroids and meteors.

Q.12 Explain how you can locate the Pole Star with the help of Ursa Major.
Ans. Pole star can be located with the help of the two stars at the end of Ursa Major. Imagine a straight line passing through these stars as shown in Fig. Extend this imaginary line towards the north direction. (About five times the distance between the two stars). This line will lead to a star which is not too bright. This is the Pole Star. Pole star does not move at all as all other for the verification, the stars drift from east to west.

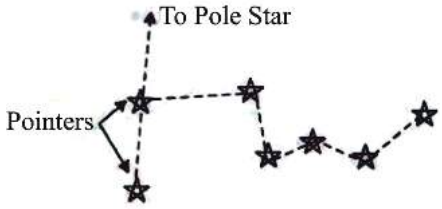


Fig. Pole Star

Q.13 Do all the stars in the sky move? Explain.
Ans. No, stars actually do not move but they only appear to move from east to west, as the earth from where we see them, rotates from west to east. However pole star, which is situated in the direction of the earth's axis. It does not appear to move.

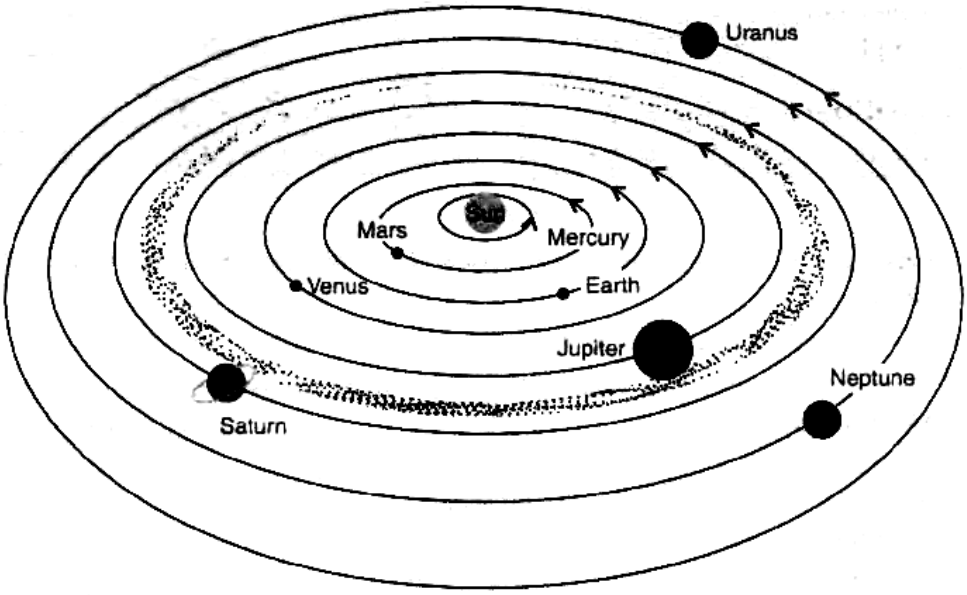
Q.14 Why is the distance between stars expressed in light years? What do you understand by the statement that a star is eight light years away from the Earth?
Ans. The Sun is nearly 150,000,000 kilometres (150 million km) away from the earth. The next nearest star to the earth after the Sun is Alpha Centauri. It is at a distance of about 40,000,000,000,000 km from the earth. Some stars are even farther away. It is not convenient to express such distances in kilometres. Such large distances are expressed in another unit known as light year. One light year is the distance travelled by light in one year. If we say that a star is eight light years away from earth, it means that the light from that star will reach the earth in eight years.

Q.15 The radius of Jupiter is 11 times the radius of the Earth. Calculate the ratio of the volumes of Jupiter and the Earth. How many Earths can Jupiter accommodate'?

Ans. Let the radius of earth be R, so the radius of Jupiter be 11 R.

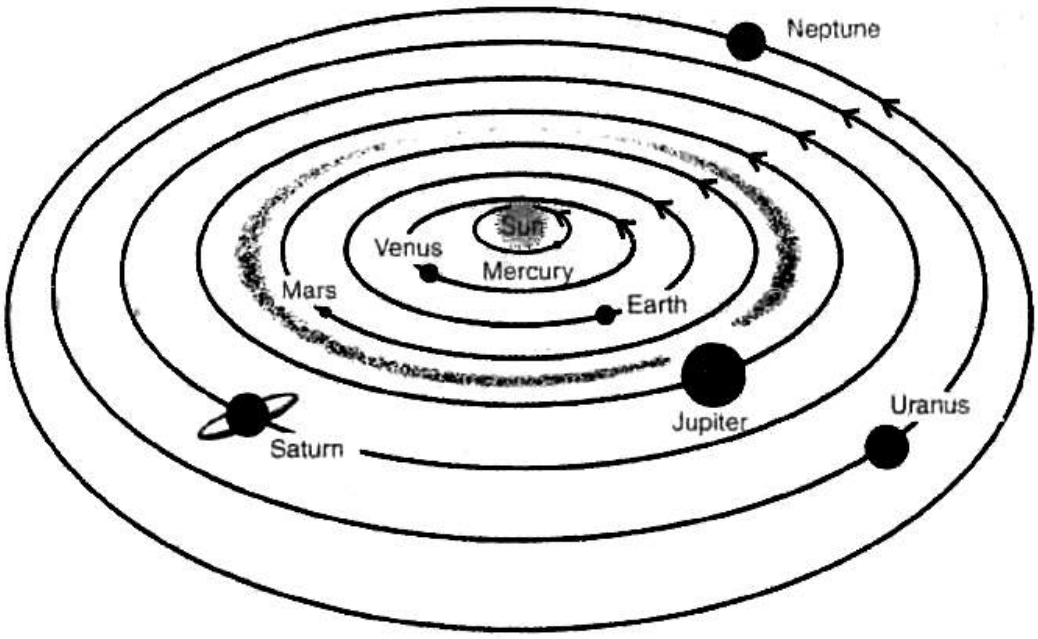
$$\frac{\text{Volume of Jupiter}}{\text{Volume of Earth}} = \frac{\frac{4}{3}\pi(11R)^3}{\frac{4}{3}\pi R^3} = \frac{1331}{1} = 1331 : 1.$$ Jupiter accommodate 1331 Earth.

Q.16 Boojho made the following sketch (Fig.) of the solar system. Is the sketch correct? If not, correct it.



Solar System

Ans. It is not correct. Figure (a) is a correct sketch of solar system.



Solar System