CHAPTER 3 SOLAR SYSTEM

Objectives

After studying this chapter, students should be able to:

(i) identify the components of the solar system.

(ii) describe the position of the Earth in relation to the Sun and other planets.

(iii) Prove the shape of the Earth.

Components of the Solar System

The solar system consists of the following:

1. Sun: This is at the center of the solar system and is **the largest object in our solar system, containing 99.8 percent of the solar system's mass. It is the source of heat and light that supports life on Earth. Planets orbit the sun in oval-shaped paths called ellipses. The orbits of the planets are in the same plane called the ecliptic which is defined by the plane of the Earth's orbit. The ecliptic is inclined 7^0 from the plane of the equator. The planets orbit in counter-clockwise direction. All the planets except Venus and Uranus rotate in a similar direction.**
2. **Eight official planets namely Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune . Planets are big bodies orbiting the sun. In 2006, the International Astronomical Union classified Pluto as a "dwarf planet". Planets clear smaller objects out of their orbits by sucking the small bodies into themselves or flinging them out of orbit. Dwarf planets, with their weaker gravities, are** unable **to clear out their orbits and they are smaller in size than regular planets.**
3. **Large number of small bodies called comets, asteroids and meteors. Comets are often known as dirty snowballs, and consist mainly of ice and rock. When a comet's orbit takes it close to the sun, some of the ice in its central nucleus turns into gas that shoots out of the comet's sunlit side, which the solar wind carries outward to form into a long tail. Asteroids are minor planets, most of which circle the sun in a region known as the asteroid belt, between the orbits of Mars and Jupiter.**
4. **More than 130 satellites and interplanetary meduim**. Satellites which are also called moons are objects that revolves around a planet. The earth has one satellite.

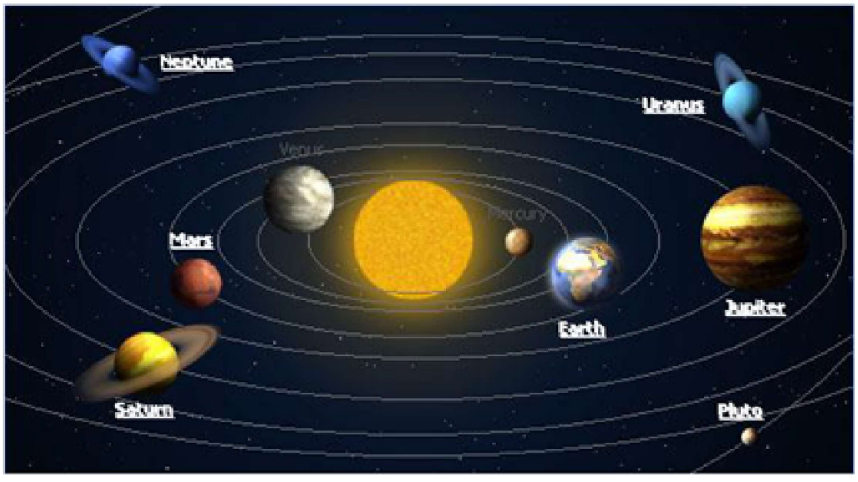

Figure 3.1: Sun and the planets.

Characteristics of each Planet

1. **Mercury:** It is the smallest and closest planet to the sun. It orbits the sun very fast once in 88 days at 48km/second. It rotates slowly once in every 59 days. It is about 4878 km in diameter with surface temperature ranging between -183^{0}C to 427^{0}C. The surface is gray to orange in colour and is covered with craters.
2. **Venus:** This is the second planet away from the sun. It has almost same size with the Earth, with a diameter of 12104km. Venus has a very thick atmosphere, composed largely of carbon dioxide. There is liquid water and oxygen. This atmosphere gives Venus a brownish-yellow color. It also traps heat (the greenhouse effect) making the surface of Venus the hottest in the Solar System, about 480^{0}C. Venus rotates very slowly, taking 224 days to complete one turn.
3. **Earth:** It is the only planet known to have living things. Its atmosphere is composed mostly of oxygen and nitrogen. The earth's atmosphere protects it from the sun's harmful rays. The atmosphere also keeps heat as well as water from escaping into space. Earth is a rocky planet. Beneath its surface lie solid iron and nickel surrounded by rocks. It differs from the other planets because it has liquid water on its surface, maintains life, and has active plate movement. It rotates on its axis every 24 hours (a day) and revolves around the Sun every 365 days (a year). The Earth has one moon and a diameter of 12,756km.
4. **Mars:** This is a little more than half the size of the Earth, having a diameter of 6,794 kilometers. It takes Mars 687 days to revolve once around the Sun. It rotates at about the same speed as the Earth, taking 24 hours 37 minutes. Mars has a very thin atmosphere which is composed largely of carbon dioxide and small amount of oxygen. Its surface is very cold, and is covered with craters, volcanoes, and large canyons. Mars is reddish in color. Mars has two small moons-Deimos and Phobos.
5. **Jupiter:** This is the largest planet in the Solar System, with a diameter of 142,984 kilometers. Jupiter orbits the Sun once every 12 years. It rotates very fast, in only 10 hours. Its surface is made up of gas (mostly hydrogen) and helium. The outer gaseous part of Jupiter is broken into bands of white, yellow, red, and brown clouds. Jupiter has 63 known satellites including the four large Galilean moons (Io, Europa, Callisto, and Ganymede) and smaller ones. A thin ring of fine dust particles surrounds Jupiter.
6. **Saturn:** It has three rings. It is a large planet with a diameter of 120,536 kilometers it is only a little smaller than Jupiter. It revolves around the Sun in 29 years, and rotates a little more than 10 hours. Like Jupiter, Saturn is composed of mostly gas, and has a core composed of rock and metallic hydrogen. The surface of Saturn looks banded, and has a brown-yellow, butterscotch color. Saturn's rings are probably composed of small particles of ice and rock. Saturn has 61 moons.
7. **Uranus:** It has a diameter of 51,118 kilometers. It revolves around the Sun slowly, taking 84 years to complete one orbit. It rotates in about 17 hours. It is covered by a thick layer of gas, and has a fairly uniform blue-green colour. Uranus has 27 named moons and six unnamed ones and is surrounded by a system of nine rings. The rings consist of chunks of unknown black material.
8. **Neptune :** It is slightly smaller than Uranus, with a diameter of 49,532 kilometers. It circles the Sun once every 165 years, and rotates in 16 hours. Its atmosphere appears blue, and is marked by large dark blue storm systems. It is surrounded by a system of five rings and at least 13 moons.

Uniqueness of the Earth

Earth, with average distance of 149,597,890 km from the sun, is the third planet and one of the most unique planets in the solar system. It is unique because it is the only planet known to sustain life because of its atmospheric composition of nitrogen and oxygen and physical properties such as the presence of water covering over 70.8%.Earth is also unique however because it is the largest of the terrestrial planets (one that is composed

of a thin layer of rocks as opposed to those that are mostly made up of gases like Jupiter or Saturn) based on its mass, density, and diameter. Earth is also the fifth largest planet in the entire solar system.

Table 2.1 : Features of regular planets and dwarf planets

NAME OF PLANET	AVERAGE DISTANCE FROM SUN	DIAMETER	TIME TO SPIN ON AXIS (a day)	TIME TO ORBIT SUN(a year)	GRAVITY (Earth= 1)	AVERAGE TEMPERATURE	CONTENTS OF ATMOSPHERE	YEAR OF DISCOVERY	KNOWN MOONS
Mercury	57,900,000 km (36,000,000 miles)	4,878 km (3,031 miles)	59 days	88 days	0.38	-183 °C to 427 °C (-297 °F to 800 °F)	Sodium, helium	n/a	None
Venus	108,160,000 km (67,000,000 miles)	12,104 km (7,521 miles)	243 days	224 days	0.9	480 °C (896 °F)	Carbon Dioxide (96%), Nitrogen (3.5%)	n/a	None
Earth	149,600,000 km (92,960,000 miles)	12,756 km (7,926 miles)	23 hours, 56 mins	365.25 days	1	14 °C (57 °F)	Nitrogen (77%), Oxygen (21%)	n/a	1
Mars	227,936,640 km (141,700,000 miles)	6,794 km (4,222 miles)	24 hours, 37 mins	687 days	0.38	-63 °C (-81 °F)	Carbon Dioxide(95.3%), Argon	n/a	2
Jupiter	778,369,000 km (483,500,000 miles)	142,984 km (88,846 miles)	9 hours, 55 mins	11.86 years	2.64	-130 °C (-202 °F)	Hydrogen, Helium	n/a	63
Saturn	1,427,034,000 km (888,750,000 miles)	120,536 km (74,900 miles)	10 hours, 39 mins	29 years	1.16	-130 °C (-202 °F)	Hydrogen, Helium	n/a	61
Uranus	2,870,658,186 km (1,783,744,300 miles)	51,118 km (31,763 miles)	17 hours, 14 mins	84 years	1.11	-200 °C (-328 °F)	Hydrogen, Helium, Methane	1781	27
Neptune	4,496,976,000 km (2,797,770,000 miles)	49,532 km (30,779 miles)	16 hours, 7 mins	164.8 years	1.21	-200 °C (-328 °F)	Hydrogen, Helium, Methane	1846	13

DWARF PLANETS

NAME OF DWARF PLANET	DISTANCE FROM SUN	DIAMETER	TIME TO SPIN ON AXIS (a day)	TIME TO ORBIT SUN(a year)	AVERAGE TEMPERATURE	YEAR OF DISCOVERY	KNOWN MOONS
Ceres	413,900,000 km (257,031,000 miles)	950 km (590 miles)	9 hours, 5 minutes	4 years, 220 days	-106 °C (-159 °F)	1801	None
Pluto	4,436,820,000 to 7,375,930,000 km (2,756,902,000 to 4,583,190,000 miles)	2,390 km (1430 miles)	6 days, 9 hours	248 years	-228 °C (-378 °F)	1930	3
Haumea	5,260,000,000 to 7,708,000,000 km (3,268,000,000 to 4,789,000,000 miles)	1960 x 1518 x996 km (1218 x 943 x 619 miles)	4 hours	285 years	-240 °C (-400 °F)	2004	2
Makemake	5,760,800,000 to 7.939,700,000 km (3,579,000,000 to 4,933,000,000 miles)	Between 1300 and 1900 km (808 to 1180 miles)	Unknown	309 years	-243 °C (-405 °F)	2005	None
Eris	5,665,500,000 to 14,634,000,000 km 3,518,000,000 to 9,088,000,000 miles	3,000 km (1,850 miles)	8 hours	557 years	-248 to -232 °C -414 to -386 °F	2005	1

Earth's Size

The Earth has an estimated mass of 5.9736×10^{24} kg. Its volume is also the largest of these planets at $108.321 \times 10^{10} km^3$. Earth is the densest of the terrestrial planets as it is made up of a crust, mantle and core. Earth's average density is 5515×10 kg/m^3.

Earth is classified as the largest of the terrestrial planets based on its circumference and diameter. At the equator, earth's circumference is 40,075.16 km(24,901.55 miles). It is slightly smaller between the North and South poles at 40,008 km (24,859.82 miles). Earth's diameter at the poles is 12,713.5 km (7,899.80 miles) while it is 12,756.1 km (7,926.28 miles) at the equator. The surface area of the earth is about 443 million square kilometer.

Earth's Shape

Earth's circumference and diameter differ because its shape is classified as an oblate spheroid or ellipsoid, instead of a true sphere. This means that instead of being of equal circumference in all areas, the poles are squeezed, resulting in a bulge at the equator, and thus a larger circumference and diameter there.

The equatorial bulge at Earth's equator is measured at 42.72 km (26.5 miles) and is caused by the planet's rotation and gravity. Gravity itself causes planets and other celestial bodies to contract and form a sphere. This is because it pulls all the mass of an object as close to the center of gravity (the Earth's core in this case) as possible.

Proof of Earth's Sphericity

1. **Circumnavigation of the earth: The first voyage around the world by Ferdinand Magellan and his crew proved that the Earth is spherical as they did not encounter an abrupt edge over which they will fall. If the Earth were flat, they would have fallen off its edge.**

Fig 3.2: Circumnavigation of the earth

2. Earth's Circular Horizon: The distant horizon viewed from the deck of a ship at sea or from a cliff on land is always circular in shape. This circular horizon widens with increasing altitude and could only be seen on a spherical body.

Fig 3.3: Circular Horizon

3. Ship's visibility: When a ship appears over the distant horizon, the top of the mast is seen first before the hull. Also, when a ship leaves the harbor, the hull disappears over the mast. If the earth were flat, the entire ship would be seen all at once.

Fig 3.4: Ship's visibility

4. Sunrise and Sunset: The sun rises and sets at different times in different places. As the earth rotates from West to East, the sun rises in the east and sets in the West. If the earth were flat, the whole world would experience sunrise and sunset at the same time.

Fig 3.5: Sunrise and Sunset

5. Lunar eclipse: The shadow cast by the earth on the moon during an eclipse of the moon (when the Earth comes between the moon and the sun) is always circular. This indicates that the Earth is spherical in shape as only a sphere can cast such a circular shadow.

6. Aerial photographs: Pictures taken by spacecraft indicates that the Earth is spherical in shape.

Summary

- The solar system consists of the sun, eight planets (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune), dwarf planets, comets and asteroids. Pluto is now regarded as a dwarf planet because of its small size and inability to clear out its orbits · Each planet has its own distinct characteristics.
- The Earth is unique because it is the only planet known to sustain life because of its atmospheric composition of nitrogen and oxygen and physical properties such as the presence of water which covers over 70.8%.
- The Earth is the largest of the terrestrial planets based on its circumference and diameter.
- The shape of the Earth is classified as an oblate spheroid or ellipsoid, instead of a true sphere.

Revision Questions

Objective Questions

1. Which of the following statements is not true about the solar system?

A. The rays of the sun give energy to the system B. All the planets rotate around the sun.

C. All the planets have their orbits round the sun.

D. The planets revolve around the sun.

2. Which of the following is not a proof that the earth is spherical?

A. The earth's horizon as seen from a ship B. Planetary observed as observed from a telescope C. The earth's shadow on the moon during an eclipse D. The four seasons 3. Which of these planets has the largest size?

A. Earth B. Neptune C. Jupiter D. Mars 4. The earth is unique because it A. has a large circumference and diameter.

B. contains large amount of gases.

C. contains gases and water which can support life.

D. contains plants and animals.

5. Which of the planets has the highest number of satellites?

A. Mercury B. Venus C. Saturn D. Jupiter 6. Which of these is a dwarf planet?

A. Neptune B. Pluto C. Earth D. Saturn 7. The ecliptic is defined by the plane of the _____ orbit.

A. Earth's B. Pluto's C. Jupiter's D. Uranus's 8. Satellites are also called _____

A. Moons B. Planets C. Comet D. Meteors 9. The closest planet to the sun is called _____

A. Mars B. Earth C. Neptune D. Mercury 10. The planet with the largest number of satellites is called _____

A. Jupiter

B. Mercury

C. Saturn

D. Jupiter

Answers

1. B 2. D 3. C 4. C 5. D. 6. B 7. A 8. A 9. D 10. D

Essay Questions

1. State three reasons to show that the Earth is spherical. (SSCE, 1990) 2. Describe the size of the Earth.
3. List all the components of the solar system.
4. Explain the characteristics of the planets.
5. State four reasons why the earth is unique.