UNIT 3

Universe

Learning Objectives

G9V3UR

After completing this lesson, students will be able to

- understand the evolution of the universe.
- explain the vastness of the universe.
- interpret Kepler's laws of motion and solve related problems.
- calculate the orbital velocity and the time-period of satellites.
- know more about International Space Station.

Introduction

If you look at the sky, you can see the Sun during daytime; moon and numerous stars during night time. In the earlier days, before the invention of astronomical instruments, people were able to see the Sun, moon and stars only. Based on their observation, they thought that Earth is the centre of all the objects in the space. This was known as the geocentric model, held by Greek astronomer Ptolemy (2nd Century), Indian astronomer Aryabhatta (5th Century) and many astronomers around the world. Later Polish astronomer Nicolaus Copernicus observed the space more keenly and proposed the heliocentric model (helios = Sun), with Sun at the centre of the solar system. The invention of the telescope in the Netherlands, in 1608, created a revolution in astronomy. The improvement of telescopes led astronomers to realize that our Sun is one of hundreds of billions of stars in a galaxy, what we call the Milky Way. We have millions of galaxies in space. The collection of all the things that exist in space is known as the universe. In this lesson we will study how the universe came into existence and all the things in it, how satellites are put into orbit and also about international space station.

3.1 Building Block of the Universe

The basic constituent of the universe is luminous matter i.e., galaxies which are really the collection of billions of stars. The universe contains everything that exists including the Earth, planets, stars, space, and galaxies. This includes all matter, energy and even time. No one knows how big the universe is. It could be infinitely large. Scientists, however, measure the size of the universe by what they can see. This is called the 'observable universe'. The observable universe is around 93 billion light years (1 light year = the distance that light travels in one year, which is 9.4607×10^{12} km) across.

One of the interesting things about the universe is that it is currently expanding. It is growing larger and larger all the time. Not only is it growing larger, but the edge of the universe is expanding at a faster and faster rate. However, most of the universe what we think of is empty space. All the atoms together only make up around four percent of the universe. The majority of the universe consists of something scientists call dark matter and dark energy.

Activity 1

Form a team of three to four students. Prepare a poster about the astronomers.

3.1.1 Age of the universe

Scientists think that the universe began with the start of a massive explosion called the Big Bang. According to Big Bang theory, all the matter in the universe was concentrated in a single point of hot dense matter. About 13.7 billion years ago, an explosion occurred and ejected all the matter in all directions in the form of galaxies. Nearly all of the matter in the universe that we understand is made of hydrogen and helium, the simplest elements, created in the Big Bang. The rest, including the oxygen that we breathe, the carbon, calcium, and iron in our bodies, and the silicon in our computer chips are formed in the cores of stars.

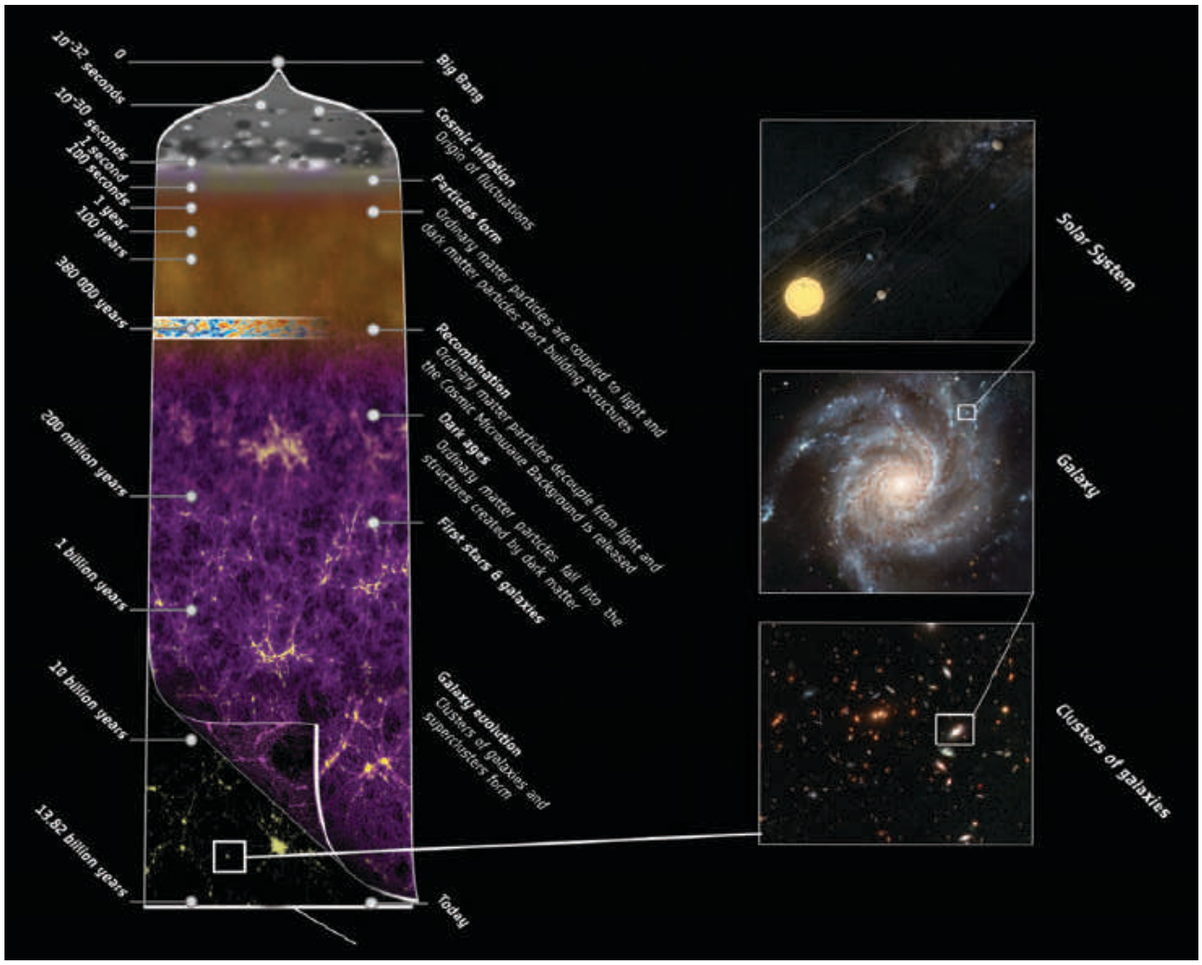


Figure 3.1 Formation of the universe

The gravity that holds these stars together generally keeps these elements deep inside their interiors. When these stars explode, these fundamental building blocks of planetary systems are liberated throughout the universe.

More to Know

DARK MATTER AND DARK ENERGY

Scientists are not sure exactly what dark matter is. Dark matter gets its name because it cannot be seen with any type of instrument that we have today. Around 27% of the universe is made up of dark matter. Dark energy is something that fills all space. The theory of dark energy helps us to explain why the universe is expanding. Around 68% of the universe is dark energy.

3.1.2 Galaxies

According to astronomers galaxies were formed shortly after the Big Bang that happened 10 billion to 13.7 billion years ago. Immediately after the Big Bang, clouds of gases began to compress under gravity to form the building blocks of galaxies. A galaxy is a massive collection of gas, dust, and billions of stars and their solar systems. Scientists believe that there are one hundred billion (10^{11}) galaxies in the observable universe. The size of the galaxies ranges having a few hundred million (10^{8}) stars to one hundred trillion (10^{14}) stars. Galaxies are also in different shapes. Depending on their appearance galaxies are classified as spiral, elliptical, or irregular. Galaxies occur alone or in pairs, but they are more often parts of groups, clusters, and super clusters. Galaxies in such groups often interact and even merge together.

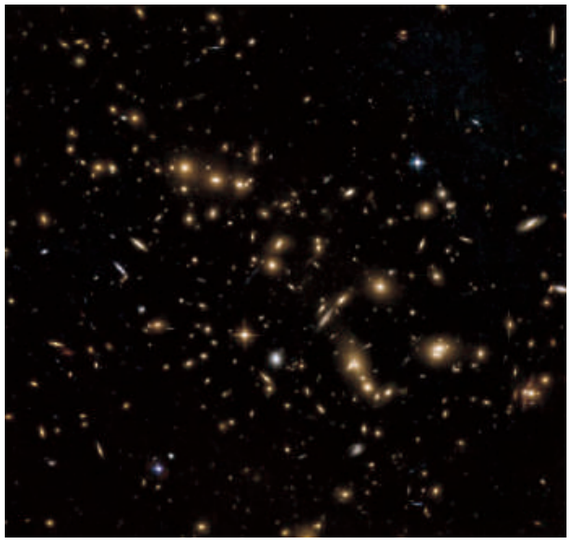


Figure 3.2 Galaxies
(Image from Hubble Space Telescope)

Our Sun and all the planets in the solar system are in the Milky Way galaxy. There are many galaxies besides our Milky Way. Andromeda galaxy is our closest neighboring galaxy. The Milky Way galaxy is spiral in shape. It is called Milky Way because it appears as a milky band of light in the sky. It is made up of approximately 100 billion stars and its diameter is 1,00,000 light years. Our solar system is 25,000 light years away from the centre of our galaxy. Just as the Earth goes around the Sun, the Sun goes around the centre of the galaxy and it takes 250 million years to do that.

Figure 3.3 Milky Way Galaxy

DO YOU KNOW?

The distance of Andromeda, our nearest galaxy is ≈ 2.5 million light-years. If we move at the speed of the Earth (30 km/s), it would take us 25 billion years to reach it!

3.1.3 Stars

Stars are the fundamental building blocks of galaxies. Stars were formed when the galaxies were formed during the Big Bang. Stars produce heat, light, ultraviolet rays, x-rays, and other forms of radiation. They are largely composed of gas and plasma (a superheated state of matter). Stars are built by hydrogen gases. Hydrogen atoms fuse together to form helium atoms and in the process they produce large amount of heat. In a dark night we can see nearly 3,000 stars with the naked eye. We don't know how many stars exist. Our universe contains more than 100 billion galaxies, and each of those galaxies may have more than 100 billion stars.

Figure 3.4 Stars

Though the stars appear to be alone, most of the stars exist as pairs. The brightness of a star depends on their intensity and the distance from the Earth. Stars also appear to be in different colours depending on their temperature. Hot stars are white or blue, whereas cooler stars are orange or red in colour. They also occur in many sizes. Some stars have radii a thousand times larger than that of our own Sun.

A group of stars forms an imaginary outline or meaningful pattern on the space. They represent an animal, mythological person or creature, a god, or an object. This group of stars is called constellations. People in different cultures and countries adopted their own sets of constellations outlines. There are 88 formally accepted constellations. Aries, Gemini, Leo, Orion, Scorpius and Cassiopeia are some of the constellations.

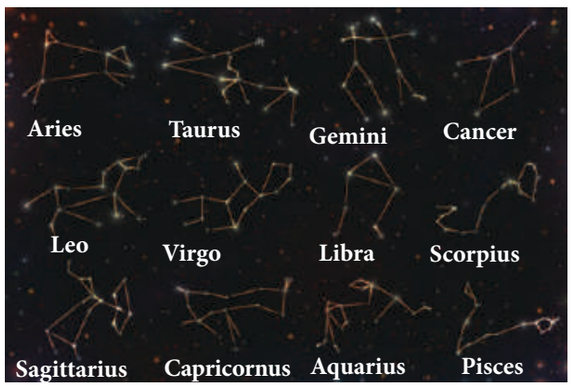


Figure 3.5 Constellations

Activity 2

Observe the sky keenly during night. Can you see a group of stars? Can you figure out any shape? Discuss with your teachers and find out their name.

3.2 The Solar System

The Sun and celestial bodies which revolve around it form the solar system. It consists of large number of bodies such as planets, comets, asteroids and meteors. The gravitational force of attraction between the Sun and these objects keep them revolving around it.

3.2.1 The Sun

The Sun is sometimes referred to by its Latin name Sol or by its Greek name Helios. The ancient Greeks grouped the Sun together with the other celestial bodies which moved across the sky, calling them all planets. But the Sun is a medium sized star, a very fiery spinning ball of hot gases. Three quarters of the Sun has hydrogen gas and one quarter has helium gas. It is over a million times as big as the Earth. Hydrogen atoms combine or fuse together to form helium under enormous pressure. This process, called nuclear fusion releases enormous amount of energy as light and heat. It is this energy which makes Sun shine and provide heat. The Sun is situated at the centre of the solar system. The strong gravitational fields cause other solar matter, mainly planets, asteroids, comets, meteoroids and other debris, to orbit around it. The Sun is believed to be more than 4.6 billion years old.

More to Know

Sun	
Diameter (across equator):	about 1,392,000 km (1 million 392 thousand km)
Volume:	1.3 million times that of Earth
Distance from the Earth:	About 150 million (15 crore) km
Sun's gravity:	28 times that of the Earth
Surface temperature:	From 5500˚C to 6000˚C
Core temperature:	1.5 million˚C
Composition:	75% Hydrogen + 25% helium + 70 elements

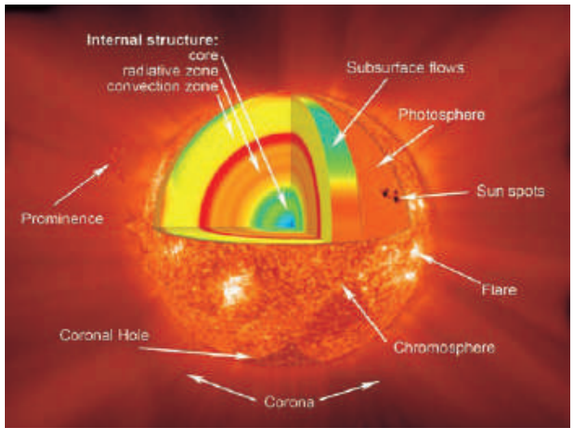


Figure 3.6 Internal view of the Sun

Formation of the Sun

At the time of the Big Bang, hydrogen gas condensed to form huge clouds, which later concentrated and formed the numerous galaxies. Some of the hydrogen gas was left free and started floating around in our galaxy. With time, due to some changes, this free-floating hydrogen gas concentrated and paved way for the formation of the Sun and solar system. Gradually, the Sun and the solar system turned into a slowly spinning molecular cloud, composed of hydrogen and helium molecules, along with dust. The cloud started to undergo the process of compression, as a result of its own gravity. Its excessive and high-speed spinning ultimately resulted in its flattening into a giant disc.

Rotation

The Sun rotates on its axis. Since the Sun is primarily made of very hot gas, the surface at the equator rotates once every 25.4 days. The rotation near the poles takes around 36 days.

Energy output

Most of the energy emitted by the Sun is visible light and a form of radiation known as infrared rays, which we feel as heat.

DO YOU KNOW?

- The Sun travels around the galaxy once every 200 million years – a journey of 100,000 light years.
- The Sun provides our plant with 126,000,000,000,000 horsepower of energy every day!
- For 186 days one cannot see the Sun in the North Pole.
- The amount of energy reaching the Earth's surface from the Sun is 6,000 times the amount of energy used by all human beings worldwide.
- The Sun is one among the 6000 stars which is visible to the naked eye from the Earth.

Colour

It is a common misconception that Sun emits yellow color radiation and it is not true. The radiation coming from the Sun contains all the colors. But the yellow is most intense among all the colors. Sunlight is scattered by the molecules when it passes through the Earth's atmosphere. The scattering of light depends on the color. Blue and violet are scattered more and red is scattered less.

3.2.2 Planets

A planet revolves around the Sun along a definite curved path which is called an orbit. It is elliptical. The time taken by a planet to complete one revolution is called its period of revolution. The period of revolution increases as the distance of the planet from the Sun increases. Thus the period of revolution of the Earth is 365.30 days whereas that of Neptune is 164.80 years.

Besides revolving around the Sun, a planet also rotates on its own axis like a top. The time taken by a planet to complete one rotation is called its period of rotation. The period of rotation of the Earth is 23 hours and 56 minutes and so the length of a day on Earth is taken as 24 hours. Table 3.1 tells about the length of a day on each planet. A day on the planet mercury is 59 Earth days, i.e., $59 \times 24 = 1416$ hours. Jupiter rotates so fast that a day lasts only less than 10 hours.

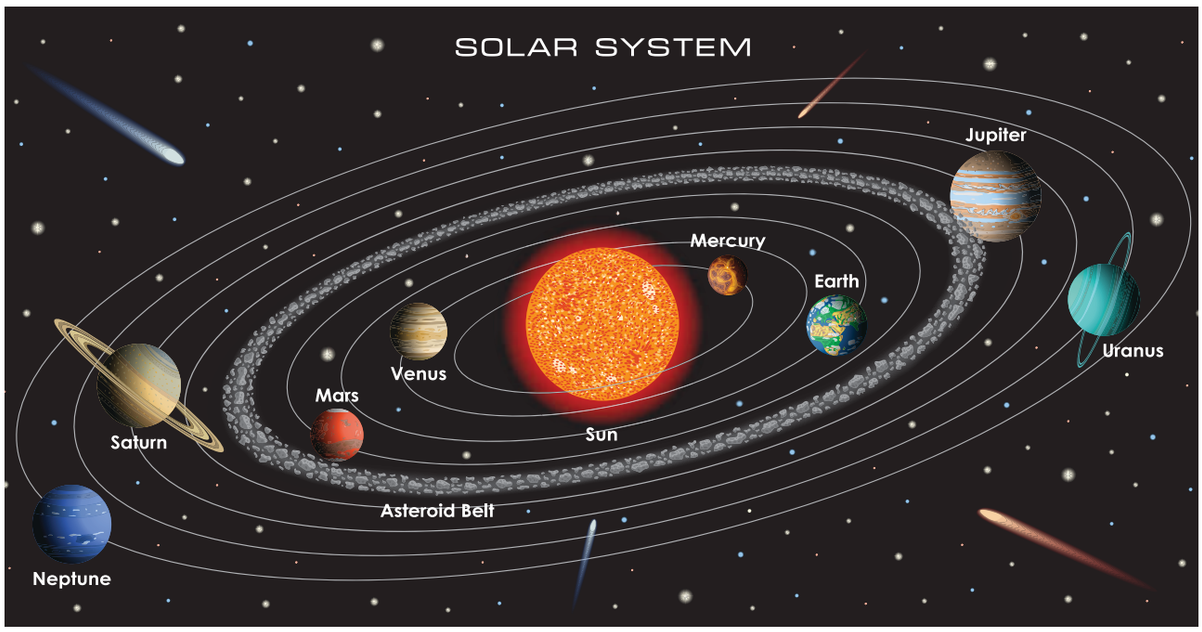


Figure 3.7 Planets in Orbit

Table 3.1 Length of a day on each planet

Planets	Length of a day
Mercury	58.65 days
Venus	243 days
Earth	23.93 hours
Mars	24.62 hours
Jupiter	9.92 hours
Saturn	10.23 hours
Uranus	17 hours
Neptune	18 hours

The planets are spaced unevenly. The first four planets are relatively close together and close to the Sun. They form the inner solar system. Farther from the Sun is the outer solar system, where the planets are much more spread out. Thus the distance between Saturn and Uranus is much greater (about 20 times) than between the Earth and the Mars.

The four planets grouped together in the inner solar system are Mercury, Venus, Earth and Mars. They are called inner planets. They have a surface of solid rock crust and so are called terrestrial or rocky planets. Their insides, surfaces and atmospheres are formed in a similar way and form similar pattern. Our planet, Earth can be taken as a model of the other three planets.

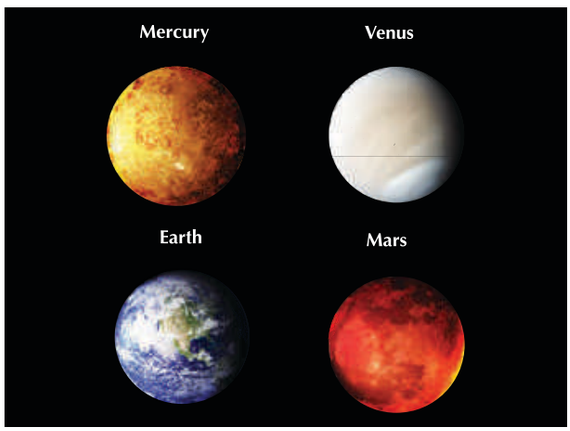


Figure 3.8 Inner Planets

The four large planets Jupiter, Saturn, Uranus and Neptune spread out in the outer solar system that slowly orbit the Sun are called outer planets. They are made of hydrogen, helium and other gases in huge amounts and have very dense atmosphere. They are known as gas giants and are called gaseous planets. The four outer planets Jupiter, Saturn, Uranus and Neptune have rings whereas the four inner planets do not have any rings. The rings are actually tiny pieces of rock covered with ice. Now let us learn about each planet in the solar system.

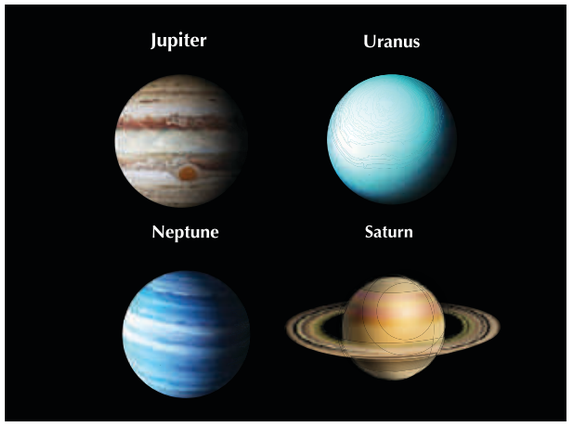


Figure 3.9 Outer Planets

Mercury

Mercury is a rocky planet nearest to the Sun. It is very hot during day but very cold at night. It moves around the Sun faster than any other planet – one year being only 87.97 Earth days and rotates very slowly. One day is equal to 58.65 days. Mercury can be easily observed thorough telescope than naked eye since it is very faint and small. It always appears in the eastern horizon or western horizon of the sky.

Venus

Venus is a special planet from the Sun, almost the same size as the Earth. It is the hottest planet in our solar system. After our moon, it is the brightest heavenly body in our night sky. A day on this planet is longer than its year. A day on this planet

is 243 Earth days, and a year is only 224.7 Earth days. This planet spins in the opposite direction to all other planet and so unlike Earth, the Sun rises in the west and sets in the east here. Venus can be seen clearly through naked eye. It always appears in the horizon of eastern or western sky.

Activity 3

Watch the sky in the early morning. Do you see any planet? What is its name? Find out with the help of your teachers.

The Earth

The Earth where we live is the only planet in the solar system which supports life. Due to its right distance from the Sun it has the right temperature, the presence of water and suitable atmosphere and a blanket of ozone. All these have made continuation of life possible on the Earth. It moves around the Sun in 365.25 days and rotation period is 23.93 hours. The axis of rotation of the Earth is not perpendicular to the plane of its orbit. The tilt is responsible for the change of seasons on the Earth. From space, the Earth appears bluish green due to the reflection of light from water and land mass on its surface.

The Earth rotates on its axis from west to east (Fig. 3.10), so the Sun appears to move in its opposite direction that is from east to west. Life on Earth as we know would not be possible without the Sun. The solar energy from the Sun has supported and sustained terrestrial existence on Earth since the beginning of time.

DO YOU KNOW?

More than 1 million Earth would fit inside the Sun! A man weighing 60 kg in the Earth will weigh 1680 kg in the Sun.

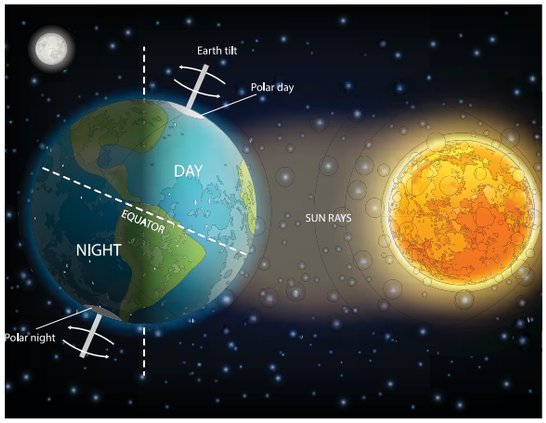


Figure 3.10 The rotation of the Earth on its axis

DO YOU KNOW?

All stars appear to us as moving from east to west, whereas there is one star which appears to us stationary in its position. It has been named as Pole star. The pole star appears to us as fixed in space at the same place in the sky in the north direction because it lies on the axis of rotation of the Earth which itself is fixed and does not change its position in space. It may be noted that the pole star is not visible from the southern hemisphere.

Mars

The first planet outside the orbit of the Earth is Mars. It appears slightly reddish and therefore it is also called the red planet. It has two small natural satellites (Deimos and Phobos). A natural satellite of any planet is called moon. One day on this planet is of 24 hours 37 minutes 22 seconds, and one year is 686.98 days, i.e., 687 Earth days.

Jupiter

Jupiter is called as Giant planet. It is the largest of all planets (about 11 times larger and 318 times heavier than Earth). It has 3 rings and 65 moons. Its moon Ganymede is the largest moon of our solar system. Rotating faster than any other planet, Jupiter has the shortest days - one day lasting only 9 hours 55 minutes 30 seconds. One year in Jupiter equals our 11.862 years.

Saturn

Known for its bright shiny rings, Saturn appears yellowish in colour. It is the second biggest and a giant gas planet in the outer solar system. It rotates very fast - the rotation period being 10.7 hours but revolves slowly around the Sun - the revolution period being 29.46 Earth years. At least 60 moons are present - the largest being Titan. Titan is the only moon in the solar system with clouds. Having least density of all (30 times less than Earth), this planet is so light.

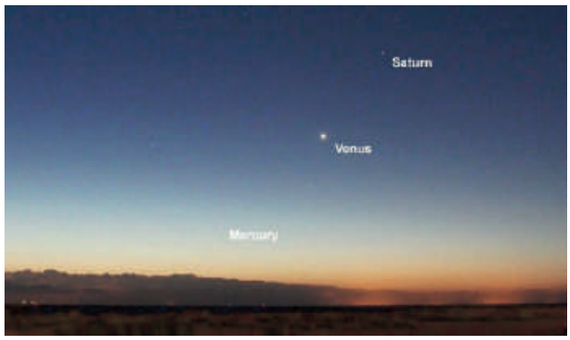


Figure 3.11 Planets seen from Earth

Uranus

Uranus is a cold gas giant and it is the seventh planet from the Sun in the solar system. It can be seen only with the help of large telescope. It has a greatly tilted axis of rotation. As a result, in its orbital motion it appears to roll on its side. Its revolution period is 84 Earth years and the rotation period is 17.2 hours. Due to its peculiar tilt, it has the longest summers and winters each lasting 42 years.

Neptune

It appears as Greenish star. It is the eighth planet from the Sun and is the windiest planet. Every 248 years, Pluto crosses its orbit. This situation continues for 20 years. It has 13 moons – Triton being the largest. Triton is the only moon in the solar system that moves in the opposite direction to the direction in which its planet spins.

3.2.3 Other bodies of the solar system

Besides the eight planets, there are some other bodies which revolve around the Sun. They are also members of the solar system.

Asteroids

There is a large gap in between the orbits of Mars and Jupiter. This gap is occupied by a broad belt containing about half a million pieces of rocks that were left over when the planets were formed and now revolve around the Sun. These are called asteroids. The biggest asteroid is Ceres – 946 km across. Every 50 million years, the Earth is hit by an asteroid nearing 10 km across. Asteroids can only be seen through large telescope.

Figure 3.12 Asteroids

Comets

Comets are lumps of dust and ice that revolve around the Sun in highly elliptical orbits. Their period of revolution is very long.

When approaching the Sun, a comet vaporizes and forms a head and tail. Some of the biggest comets even seen had tails 160 million (16 crores) km long. This is more than the distance between the Earth and the Sun. Many comets are known to appear periodically. One such comet is Halley's Comet, which appears after nearly every 76 years. It was last seen in 1986. It will next be seen in 2062.

Figure 3.13 Comet

Cosmic year

The Sun travelling at a speed of 250 km per second (9 lakh km/h) takes about 225 million years to complete one revolution around the Milky Way. This period is called a cosmic year.

Meteors and Meteorites

Meteors are small piece of rocks scattered throughout the solar system. Traveling with high speed, these small pieces come closer to the Earth's atmosphere and are attracted by the gravitational force of Earth. Most of them are burnt up by the heat generated due to friction in the Earth's atmosphere. They are called meteors. Some of the bigger meteors may not be burnt completely and they fall on the surface of Earth. These are called meteorites.

Figure 3.14 Meteors and Meteorites

Satellites

A body moving in an orbit around a planet is called satellite. In order to distinguish them from the man made satellites (called as artificial satellites), they are called as natural satellites or moons. Satellite of the Earth is called Moon (other satellites are written as moon). It moves around the Earth once in 27.3 days in an approximate circular orbit of radius 3.85×10^5 km. Natural satellites do not make their own light. We can see the Earth's satellite Moon, because it reflects the light of the Sun. Satellite moves around the planets due to gravity, and the centripetal force. Among the planets in the solar system all the planets have moons except Mercury and Venus.

Figure 3.15 Moon revolving around Earth

3.3 Orbital Velocity

We saw that there are natural satellites moving around the planets. There will be gravitational force between the planet and satellites. Nowadays many artificial satellites are launched into the Earth's orbit. The first artificial satellite Sputnik was launched in 1956. India launched its first satellite Aryabhatta on April 19, 1975. Artificial satellites are made to revolve in an orbit at a height of few hundred kilometres. At this altitude, the friction due to air is negligible. The satellite is carried by a rocket to the desired height and released horizontally with a high velocity, so that it remains moving in a nearly circular orbit.

The horizontal velocity that has to be imparted to a satellite at the determined height so that it makes a circular orbit around the planet is called orbital velocity.

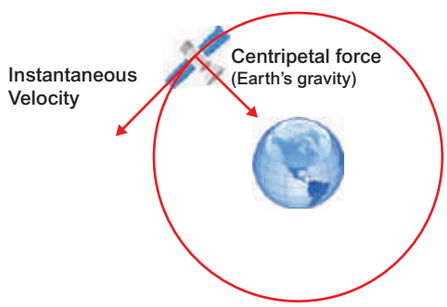


Figure 3.16 Orbital velocity

The orbital velocity of the satellite depends on its altitude above Earth. Nearer the object to the Earth, the faster is the required orbital velocity. At an altitude of 200 kilometres, the required orbital velocity is little more than 27,400 kph. That orbital speed and distance permit the satellite to make one revolution in 24 hours. Since Earth also rotates once in 24 hours, a satellite stays in a fixed position relative to a point on Earth's surface. Because the satellite stays over the same spot all the time, this kind of orbit is called 'geostationary'. Orbital velocity can be calculated using the following formula.

$v = \sqrt{\frac{GM}{(R+h)}}$ where

G = Gravitational constant ($6.673 \times 10^{-11} Nm^2kg^{-2}$)

M = Mass of the Earth (5.972×10^{24} kg)

R = Radius of the Earth (6371 km)

h = Height of the satellite from the surface of the Earth.

Example 1

Can you calculate the orbital velocity of a satellite orbiting at an altitude of 500 km?

Data: $G = 6.673 \times 10^{-11}$ SI units;

$M = 5.972 \times 10^{24}$ kg; R = 6371000 m;

h = 500000 m.

Solution:

$$v = \sqrt{\frac{6.67 \times 10^{-11} \times 5.972 \times 10^{24}}{(6371000 + 500000)}}$$

Ans: $v = 7613\ ms^{-1}$ or $7.613\ kms^{-1}$

Microgravity is the condition in which people or objects appear to be weightless. The effects of microgravity can be seen when astronauts and objects float in space. Micro- means very small, so microgravity refers to the condition where gravity 'seems' to be very small. Many things seem to act differently in microgravity. Fire burns differently. Without the pull of gravity, flames are mere round. NASA performs science experiments in microgravity. These experiments help NASA to learn things that would be hard or perhaps impossible to learn on Earth.

3.4 Time period of a Satellite

Time taken by the satellite to complete one revolution round the Earth is called time period.

$$\text{Time period, } T = \frac{\text{Distance covered}}{\text{Orbital velocity}}.$$

$$T = \frac{2\pi r}{v}$$

Substituting the value of v, we get

$$T = \frac{2\pi(R+h)}{\sqrt{\frac{GM}{(R+h)}}}.$$

Example 2

At an orbital height of 500 km, find the orbital period of the satellite.

Solution

$h = 500\text{x}10^3\text{m}$, $R = 6371\text{x}10^3\text{m}$,

$v = 7616\text{x}10^3\ \text{kms}^{-1}$.

Substituting the values,

$$T = \frac{2\pi(R+h)}{v} = 2 \times \frac{22}{7} \times \frac{(6371+500)}{7616}$$

$= 5.6677\text{x}10^3\text{s} = 5667$ s.

This is $T \approx 95$ min

Activity 2

Prepare a list of Indian satellites from Aryabhatta to the latest along with their purposes.

3.5 Kepler's Laws

In the early 1600s, Johannes Kepler proposed three laws of planetary motion. Kepler was able to summarize the carefully collected data of his mentor - Tycho Brahe - with three statements that described the motion of planets in a Sun-centered solar system. Kepler's efforts to explain the underlying reasons for such motions are no longer accepted; nonetheless, the actual laws themselves are still considered an accurate description of the motion of any planet and any satellite. Kepler's three laws of planetary motion can be described as below.

First Law – The Law of Ellipses

The path of the planets about the Sun is elliptical in shape, with the center of the Sun being located at one of the foci.

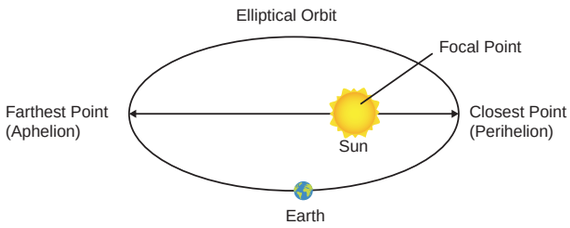


Figure 3.17 The Law of Ellipses

Second Law – The Law of Equal Areas

An imaginary line drawn from the center of the Sun to the center of the planet will sweep out equal areas in equal intervals of time.

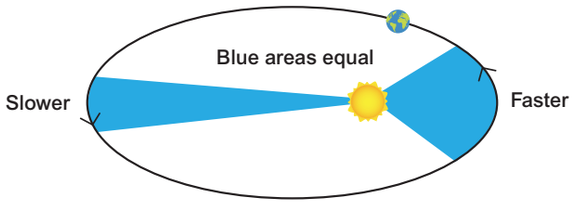


Figure 3.18 The Law of Equal area

Third Law – The Law of Harmonies

The ratio of the squares of the periods of any two planets is equal to the ratio of the cubes of their semi major axis from the Sun.

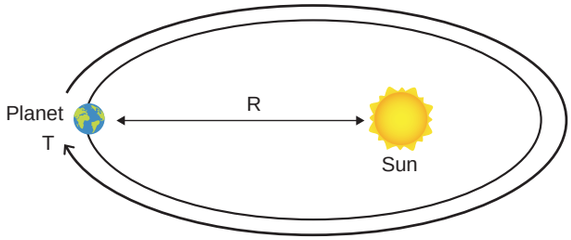


Figure 3.19 The Law of Harmonics

3.6 International Space Station

ISS is a large spacecraft which can house astronauts. It goes around in low Earth orbit at approximately 400 km distance. It is also a science laboratory. Its very first part was placed in orbit in 1998 and its core construction was completed by 2011. It is the largest man-made object in space which can also be seen from the Earth through the naked eye. The first human crew went to the ISS in 2000. Ever since that, it has never been unoccupied by humans. At any given instant, at least six humans will be present in the ISS. According to the current plan ISS will be operated until 2024, with a possible extension until 2028. After that, it could be deorbited, or recycled for future space stations.

Figure 3.20 International Space Station

3.6.1 Purpose of International Space Station

The ISS is intended to act as a scientific laboratory and observatory. Its main purpose is to provide an international lab for conducting experiments in space, as the space environment is nearly impossible to reproduce here on Earth. The microgravity environment present in the ISS provides ideal conditions for doing many scientific researches especially in biology, human biology, physics, astronomy and meteorology.

More to Know

Some facts about ISS

Mass/Power	420 000 kg / 75 kW to 90 kW
Length/Width/ Height	73 m / 108 m / 31 m
Operating Altitude	407 km
Orbital velocity/ Period	7.67 km s^{-1} (27 600 km hr^{-1}) / 93 min
Humans visited	227 (as of July 2018)
Food needed to support three for six months	3,630 kg
Total length of wire for electrical connections	13 km
Most no. of days spent in ISS	665 days by astronaut Peggy Wilson

3.6.2 Benefits of ISS

According to NASA, the following are some of the ways in which the ISS is already benefitting us or will benefit us in the future.

Supporting water-purification efforts

Using the technology developed for the ISS, areas having water scarcity can gain access to advanced water filtration and purification systems. This could very well be a life-saving difference for the people in such hazardous locations. The water recovery system (WRS) and the oxygen generation system (OGS) developed for the ISS have already saved a village in Iraq from being deserted due to lack of clean water.

Eye tracking technology

The Eye Tracking Device, built for a microgravity experiment, has proved ideal to be used in many laser surgeries. This device tracks the eye's position very accurately without interfering with the surgeon's work. Also, eye tracking technology is helping disabled people with limited movement and speech. For example, a kid who has severe disability in body movements can use his eye-movements alone and do routine tasks and lead an independent life.

Robotic arms and surgeries

Robotic arms developed for research in the ISS are providing significant help to the surgeons in removing inoperable tumours (e.g., brain tumours) and taking biopsies with great accuracies. The same technology designed for huge robotic arms that help astronauts in space is being brought back to Earth to do some heavy lifting in cancer treatment - in the form of a surgical robot. Its inventors say that the robot could take biopsies with remarkable precision and consistency.

Figure 3.21 Robotic arm

Apart from the above-mentioned applications there are many other ways in which the researches that take place in the ISS are helpful. They are: development of improved vaccines, breast cancer detection and treatment, ultrasound machines for remote regions etc,.

3.6.3 ISS and international cooperation

As great as the ISS' scientific achievements are, no less in accomplishment is the international co-operation which resulted in the construction of the ISS. An international collaboration of five different space agencies of 16 countries provides, maintains and operates the ISS. They are: NASA (USA), Roskosmos (Russia), ESA (Europe), JAXA (Japan) and CSA (Cananda). Belgium, Brazil, Denmark, France, Germany, Italy, Holland, Norway, Spain, Sweden, Switzerland and the UK are also part of the consortium. In fact, in the late 1950s, the idea of international space missions was unthinkable. The first part of the ISS was launched by the Russian Zarya module, which was funded by America. The first crew sailed on board was Russian Soyuz spaceship. Even as the ISS has sections split into US Orbital Segment, Russian Orbital Segment etc., on the whole it is jointly-owned by all the participating agencies and their nations. Cooperative international agreements between the world powers have made the largest international scientific undertaking a possibility. The many significant researches and functions of the ISS could only have been possible with the full co-operation of these nations.

The Indian Space Research Organisation (ISRO) had proposed its Indian Human Spaceflight Programme to be done by 2021/2022 according to ISRO Chairman, K. Sivan. The first crew is to consist of three astronauts to be taken to space with a spacecraft called *Gaganyaan* on a GSLV-III rocket. V.R. Lalithambika, a specialist in advanced launcher technologies, will help the project as Director of the Human Space Flight Project.

Points to Remember

- The basic constituent of universe is galaxies which are really the collection of billions of stars.
- Scientists think that the universe began with the start of a massive explosion called the Big Bang.
- The universe contains everything that exists including the Earth, planets, stars, space, and galaxies.
- Depending on their appearance, galaxies are classified as spiral, elliptical, or irregular.
- Our Sun and all the planets in the solar system are in the Milky Way galaxy.
- Stars are the fundamental building blocks of galaxies.
- A group of stars forms an imaginary outline or meaningful pattern on the space, called constellations.
- The Sun and celestial bodies which revolve around it form the solar system.
- The first four planets are relatively close together and close to the Sun. They form the inner solar system. Farther from the Sun is the outer solar system, where the planets are much more spread out.
- Due to its right distance from the Sun, Earth has the right temperature, the presence of water and suitable atmosphere and a blanket of ozone.
- Million pieces of rocks that were left over when the planets were formed and now revolve around the Sun are called asteroids.
- Comets are lumps of dust and ice that revolve around the Sun in a highly elliptical orbits.
- A body moving in an orbit around a planet is called satellite.
- The ISS is intended to act as a scientific laboratory and observatory. Its main purpose is to provide an international lab for conducting experiments in space.

A-Z GLOSSARY

Asteroid	Small, rocky object orbiting the Sun.
Astronomy	The scientific study of the universe and the objects in it.
Big Bang Theory	A theory which states that the universe began in an enormous explosion.
Comet	A chunk of dirty, dark ice, mixed with dust and grit which revolves around the Sun in an oval orbit.
Constellation	A group of stars that can be seen as a pattern from Earth. There are 88 constellations.
Galaxy	A group of stars, nebulae, star clusters, globular clusters and other matter. There are millions of galaxies in the universe.
Meteor	A meteoroid that travels through the Earth's atmosphere. As it falls toward Earth, it burns up, making a streak of light. Also known as a shooting star.
Meteorite	A meteor that hits the Earth's surface.
Milky Way	A broad band of light that looks like a trail of spilled milk in the night sky. Created by the millions of faint stars that form part of our galaxy.
Moon	Any natural object which orbits a planet.

Orbit	The path of one object as it revolves around another
Planet	A relatively large object that revolves around a star, but which is not itself a star.
Satellite	Any object in outer space that orbits another object. Manmade satellites are launched into space to orbit a planet or moon.
Solar System	The Sun and all the objects that orbit it.
Space station	A large, manned satellite in space used as a base for space exploration over a long period of time.
Star	A ball of constantly exploding gases, giving off light and heat. The Sun is a star.
Universe	The word used to describe everything that exists in space, including the galaxies and stars, the Milky Way and the Solar System.

GADUY2

TEXTBOOK EVALUATION

I. Choose the correct answer.

1. Which of the following statements is correct?

   A. There are eight planets in our Solar System.

   B. Except Mars, all other planets revolve around the Sun in elliptical orbits

   (a) A only (b) B only
   (c) Both A and B (d) None

2. Who proposed the heliocentric model of the universe?
   (a) Tycho Brahe (b) Nicolaus Copernicus
   (c) Ptolemy (d) Archimedes

3. Which of the following is not a part of outer solar system?
   (a) Mercury (b) Saturn
   (c) Uranus (d) Neptune

4. Ceres is a _____.
   (a) Meteor (b) Star
   (c) Planet (d) Astroid

5. The period of revolution of planet A around the Sun is 8 times that of planet B. How many times is the distance of planet A as great as that of planet B?
   (a) 4 (b) 5
   (c) 2 (d) 3

6. The Big Bang occurred _____ years ago.
   (a) 13.7 billion (b) 15 million
   (c) 15 billion (d) 20 million

II. Fill in the blanks.

1. The speed of Sun in km/s is _____.
2. The rotational period of the Sun near its poles is _____.
3. India's first satellite is _____.
4. The third law of Kepler is also known as the Law of _____.
5. _____ is the only moon in the solar system that moves in the opposite direction to the direction in which its planet spins.
6. The number of planets in our Solar System is _____.

III. True or false.

1. The distance between Saturn and Uranus is about 10 times as that between Earth and Mars.
2. ISS is a proof for international cooperation.

3. Halley's comet appears after nearly 67 hours.
4. Satellites nearer to the Earth should have lesser orbital velocity.
5. Mars is called the red planet.

IV. Match the following.

1. Jupiter	a. 17.2 hours
2. Mercury	b. 10.7 hours
3. Venus	c. 87.97 days
4. Saturn	d. 9 hours 55 min
5. Mars	e. 243 days
	f. 87.97 days
	g. 24 hours 37 min

V. Answer very briefly.

1. What is solar system?
2. What is a cosmic year?
3. Define orbital velocity.
4. Define time period of a satellite.
5. What is a satellite? What are the two types of satellites?

VI. Answer in brief.

1. Write a note on the inner planets.
2. Write about comets in brief.
3. State Kepler's laws.
4. Write short notes on Gaganyaan.
5. What factors have made life on Earth possible?

VII. Answer in detail.

1. Give an account of all the planets in the solar system.
2. Discuss the benefits of ISS.
3. Write a note on orbital velocity.

VIII. Conceptual questions

1. Why do some stars appear blue and some red?
2. Why are we able to see the Moon even though it is not a luminous body?
3. How is a satellite maintained in nearly circular orbit?
4. Why are some satellites called geostationary?
5. A man weighing 60 kg in the Earth will weigh 1680 kg in the Sun. Why?

IX. Numerical problems

1. Calculate the speed with which a satellite moves if it is at a height of 36,000 km from the Earth's surface and has an orbital period of 24 hr (Take R = 6370 km)
   [Hint: Convert hr into seconds before doing calculation]
2. At an orbital height of 400 km, find the orbital period of the satellite.

REFERENCE BOOKS

1. Big Bang - By Simon Singh.
2. What are the stars - By G. Srinivas.
3. An introduction to Astronomy - By Baidyanath Basu.

INTERNET RESOURCES

https://en.wikipedia.org/wiki/Eye_tracking_on_the_ISS#/media/File:Eye_Tracking_Device_003.jpg
https://www.space.com/52-the-expanding-universe-from-the-big-bang-to-today.html
https://phys.org/news/2016-06-star-black-hole.html

Concept Map

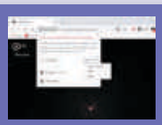
ICT CORNER

Building Blocks of Universe

Explore the universe in an interactive nutshell

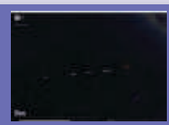
Steps

- Type the given URL to reach interactive universe and allow the browser to play "JAVA Script", if asked.
- Click and drag the "Scale Pointer" present in the right side of the page or scroll the mouse to zoom into the universe.
- Click and drag the mouse pointer to North-South (up-down) axis to observe the fabricating structure of the galaxy.
- Zoom in on to extreme close up to view the solar system and to view the name of the objects present in the galaxy.


Step1


Step2


Step3


Step4

Interactive Universe's

URL: http://stars.chromeexperiments.com/ or Scan the QR Code.

*Pictures are indicative only

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