

JSR IAS ACADEMY

GENERAL SCIENCE
PHYSICS

Nature of Universe - II

Satellites

An object that **revolves around a planet in a stable and consistent orbit** is called a satellite.

Satellites can be classified into two categories – **natural and artificial**.

Natural satellites

- ❖ All natural objects revolving around a planet are natural satellites. They are also called moons.
- ❖ Most moons are spherical, were captured by the strong gravity of a planet.
- ❖ All planets **except mercury and Venus in our solar system have moons**.
- ❖ Jupiter and Saturn have more than 60 moons.

Artificial satellites

- ❖ Artificial satellites are **man-made objects** placed in an orbit to rotate around a planet – usually the Earth.
- ❖ The world's first artificial satellite launched was **Sputnik-1 by Russia**
- ❖ **Aryabhata** was the first satellite launched by India.

ISRO The Indian Space Research Organisation (ISRO)

- ❖ headquartered in the city of Bangalore.
- ❖ Its **vision** is to “**harness space technology for national development while pursuing space science research and planetary exploration.**”
- ❖ **Formed in 1969**, ISRO superseded the erstwhile Indian National Committee for Space Research (INCOSPAR) established in 1962 by the Scientist **Vikram Sarabhai**.
- ❖ It is **managed by the Department of Space**, which reports to the **Prime Minister of India**.
- ❖ ISRO built India's first satellite, **Aryabhata**, which was launched by the Soviet Union on 19 April 1975.
- ❖ In 1980, **Rohini** became the first satellite to be placed in orbit by an Indian-made launch vehicle, **SLV-3**.
- ❖ ISRO subsequently developed two other rockets: the **Polar Satellite Launch Vehicle (PSLV)** for launching satellites into polar orbits and the **Geosynchronous Satellite Launch Vehicle (GSLV)** for placing satellites into geostationary orbits.
- ❖ Satellite navigation systems like **GAGAN** and **IRNSS** have been deployed.

Achievements

- ❖ In January 2014, ISRO used an indigenous cryogenic engine in a **GSLV-D5** launch of the **GSAT-14**.
- ❖ ISRO sent a lunar orbiter, **Chandrayan -1**, on 22 October 2008
- ❖ a Mars orbiter, **Mars Orbiter Mission**, on 5 November 2013, which entered Mars orbit on 24 September 2014, making India the **first nation to succeed on its first attempt to Mars**, and **ISRO the fourth space agency in the world** as well as the **first space agency in Asia to reach Mars orbit**.
- ❖ On 18 June 2016 ISRO set a record with a launch of 20 satellites in a single payload.
- ❖ On 15 February 2017, ISRO launched 104 satellites in a single rocket (PSLV-C37) and created a world record.
- ❖ ISRO launched its heaviest rocket, **Geosynchronous Satellite Launch Vehicle Mark III (GSLV-Mk III)**, on 5 June 2017 and placed a communications satellite **GSAT-19** in orbit.
- ❖ With this launch, ISRO became capable of launching 4 ton heavy satellites.
- ❖ ISRO launched **Chandran 2** on July 22, 2019, Geosynchronous Satellite Launch Vehicle (GSLV-Mk III). It entered the Moon's orbit on August 20, 2019 and its lander landed on the Moon on September 7 (FAILED).



India became the first Asian country to reach Mars and the first nation in the world to achieve this in the first attempt. Soviet Space Program, NASA, and European Space Agency are the three other agencies that reached Mars before ISRO.



Kalpna Chawla travelled over 10.4 million miles in 252 orbits of the earth, logging more than 372 hours in space.

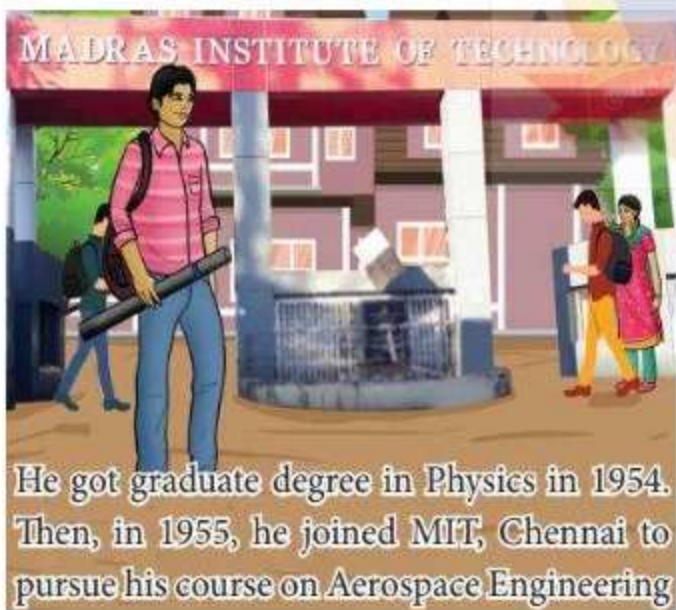


The Missile Man Of India

A.P.J. Abdul Kalam (1931-2015)

Abdul Kalam started his school education in Government school at Rameswaram. He was very much interested in science and mathematics during his school days

He assisted his relative, a news paper agent during his childhood to meet his educational expenditure



After completing his studies at MIT, he designed an aircraft named 'Nandhi' using indigenous materials with the help of indigenous technologists. He operated that flight himself

He took charge as the Director of Indian Defence Research Development Organisation and the scientific advisor to the Defence Ministry of India in 1983

Kalam successfully launched the 'Rohini-1' satellite using the India's first satellite launch vehicle SLV-3 in 1980. He acted as the Project Director when the missiles Thrishul, Agni, Prithvi, Nag and Akash were designed in the Indian Defence

Abdul Kalam played a vital role in the nuclear explosion test project in Pokran named "Operation Sakthi" in 1999. The credit that the India has become a nuclear power goes to him

India for the first time experimented nuclear explosion test named 'Smiling Buddha' in 1974. Kalam was one among the sixty Aeronautical Engineers in this project

Kalam worked in five missile projects of India. He was the most important behind the designing defence rocket of India



The Government of India awarded him the Bharatha Ratna. He was the President of India during the period from 2002-2007

Subrahmanyan Chandrasekhar (19 October 1910 – 21 August 1995) was an Indian American astrophysicist who spent his professional life in the United States. He was awarded the 1983 Nobel Prize for Physics with William A. Fowler. His mathematical treatment of stellar evolution yielded many of the best current theoretical models of the later evolutionary stages of massive stars and black holes. The Chandrasekhar limit is named after him. Chandrasekhar worked on a wide variety of physical problems in his lifetime.



The distance of Andromeda, our nearest galaxy is approximately 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!

Stars

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.

Our universe contains more than 100 billion galaxies, and each of those galaxies may have more than 100 billion stars.

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.

A group of stars represent an animal, mythological person or creature, a god, or an object.

This group of stars is called constellations.

There are 88 formally accepted constellations.

Aries, Gemini, Leo, Orion, Scorpius and Cassiopeia are some of the constellations.



Observable universe

- ❖ 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.
- ❖ 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.

Age of the Universe

- ❖ About 13.7 billion years ago, an explosion occurred
- ❖ Nearly all of the matter in the universe that we understand is made of hydrogen and helium,
- ❖ Scientists believe that there are one hundred billion (1011) galaxies in the observable universe.
- ❖ Depending on their appearance, galaxies are classified as spiral, elliptical, or irregular.
- ❖ 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.

The Solar System

Sun and the celestial bodies which revolve around it form the solar system.

The Sun

- ❖ 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.
- ❖ Sun is believed to be more than **4.6 billion years old.**

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 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

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 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 the distance between the Earth and the Mars.**

Inner solar system

The four planets grouped together in the inner solar system are **Mercury, Venus, Earth and Mars.** They are called **inner planets**.

Terrestrial or Rocky planets

They have a surface of solid rock crust and so are called **terrestrial or rocky planets**.

Outer solar system

The four large planets **Jupiter, Saturn, Uranus and Neptune** spread out in the outer solar system and slowly orbit the Sun are called outer planets.

Gaseous 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.

Mercury:

- ❖ Mercury is a **rocky planet nearest to the Sun.**
- ❖ It is **very hot during day but very cold at night.**
- ❖ 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.**
- ❖ This planet **spins in the opposite direction** to all other planets.
- ❖ 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.**

The Earth:

- ❖ 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.**
- ❖ Earth appears **bluish green** due to the **reflection of light from water and land mass on its surface.**

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**).

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.

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.**
- ❖ 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.

Uranus:

- ❖ Uranus is a **cold gas giant** and 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.**
- ❖ 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.

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.**

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 ever 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.

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.**



Satellites

- ❖ A body **moving in an orbit around a planet** is called satellite.
- ❖ **Satellite of the Earth is called Moon** (other satellites are written as moon).
- ❖ Among the planets in the solar system all the planets have moons **except Mercury and Venus**.

DO YOU KNOW? 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.

- ❖ The **first artificial satellite Sputnik** was launched in 1956.
- ❖ India **launched its first satellite Aryabhata** on April 19, 1975.

DO YOU KNOW? All stars appear to us as moving from east to west, where as 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.

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.

First Law – The Law of Ellipses

All planets revolve around the Sun in elliptical orbits with Sun at one of their foci.

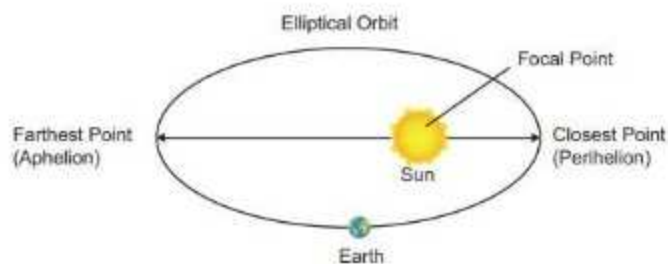


Figure 9.6 The Law of Ellipses

Second Law – The Law of Equal Areas

The line connecting the planet and the Sun covers equal areas in equal intervals of time.

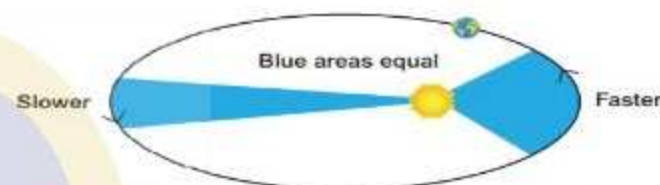


Figure 9.7 The Law of Equal Area

Third Law – The Law of Harmonies

The square of time period of revolution of a planet around the Sun is directly proportional to the cube of the distance between sun and the planets.

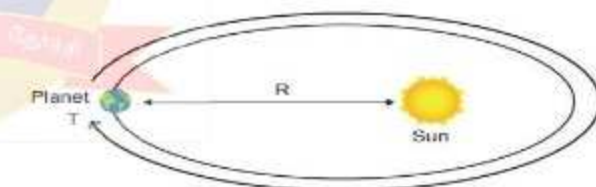


Figure 9.8 The Law of Harmonics

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**.
- ❖ 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 9.9 International Space Station

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.

The water recovery system (WRS)

- ❖ Areas having water scarcity can gain access to advanced water filtration and purification systems.
- ❖ 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**.
- ❖ 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**.
- ❖ Its inventors say that the **robot could take biopsies with remarkable precision and consistency**.

Development of **improved vaccines, breast cancer detection and treatment, ultrasound machines for remote regions** etc.,

ISS and International Cooperation

An international collaboration of **five different space agencies of 16 countries** provides, maintains and operates the ISS.

They are:

1. NASA (USA),
2. Roskosmos (Russia),
3. ESA (Europe),
4. JAXA (Japan) and
5. CSA (Canada).

Belgium, Brazil, Denmark, France, Germany, Italy, Holland, Norway, Spain, Sweden, Switzerland and the UK are also part of the consortium.



Rockets were invented in China, more than 800 years ago. The first rockets were a cardboard tube packed with gunpowder. They were called fire arrows. In 1232 AD, the Chinese used these 'fire arrows' to defeat the invading Mongol army. The knowledge of making rockets soon spread to the Middle East and Europe, where they were used as weapons.

The Moon is the only natural satellite of the Earth. It is at a mean distance of about 3,84,400 km from the Earth. Its diameter is 3,474 km. It has no atmosphere of its own. It doesn't have its own light, but it reflects the sunlight. The time period of rotation of the Moon about its own axis is equal to the time period of revolution around the Earth. That's why we are always seeing its one side alone.



Kalam Sat is the world's smallest satellite weighing only 64 gram. It was built by a team of high school students, led by Rifath Sharook, an 18 year old school student from 'Pallapatti' near Karur, Tamil Nadu. It was launched into the space on 22nd June 2017 by NASA.



Dr. Mysamy Annadurai

was born on 2nd July 1958, at Kodhavadi, a small village near Pollachi in Coimbatore district. He pursued his B.E. degree course at Government College of Technology, Coimbatore. In 1982, he pursued his higher education and acquired an M.E. degree at PSG College of Technology, Coimbatore. In the same year he joined the ISRO as a scientist. And later, he got his doctorate degree from Anna University of Technology, Coimbatore. Annadurai is a leading technologist in the field of satellite system. He has served as the Project Director of Chandrayaan-1, Chandrayaan-2 and Mangalyaan. He has also made significant contributions to the cost effective design of Chandrayaan.

**Dr. Kailasa vadivoo**

Sivan is the chairperson of the Indian Space Research Organization (ISRO). He was born in Sarakkalvilai, in Kanyakumari district of Tamil Nadu. Sivan graduated with a bachelor's degree in Aeronautical Engineering from Madras Institute of Technology in 1980. Then he got his master's degree in Aerospace Engineering from Indian Institute of Science, Bangalore in 1982, and started working in ISRO. He completed his doctoral degree in Aerospace Engineering from Indian Institute of Technology, Bombay in 2006. He was appointed as Chairman of ISRO from 10th January 2018. Sivan is popularly known as the 'Rocket Man' for his significant contribution to the development of cryogenic engines for India's space programs. The ability of 'ISRO' to send 104 satellites in a single mission is a great example of his expertise.

DO
YOU
KNOW?

Rakesh Sharma, an Indian pilot from Punjab was selected as a 'Cosmonaut' in a joint space program between India and Soviet Russia and become the first Indian to enter into the space on 2nd April, 1984.

DO
YOU
KNOW?

The members present in the crew during the Man Landing Mission were Neil Armstrong, Buzz Aldrin and Michael Collins.

DO
YOU
KNOW?

In 1989, Galileo Galilei was memorialized with the launch of a Jupiter-bound space probe bearing his name. During its 14-year voyage, the Galileo space probe and its detachable mini-probe, visited Venus, the asteroid Gaspra, observed the impact of Comet Shoemaker-Levy 9 on Jupiter, Europa, Callisto, IO, and Amalthea.

In order to avoid the possible contamination of one of Jupiter's moons, the Galileo space probe was purposely crashed into Jupiter at the end of its mission in September 2003.