6th term 1 (Geography)

Physics part - 1		
Natuer of Univerce		
6th term - 1Geography	Unit - 1	The Universe and Solar System
7th Std term - 3	Unit - 2	Universe and Space
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Unit - 1 The Universe and Solar System

1. Universe

- The Universe is a vast expanse of space. Most astronomers believe that the Universe came into existence after the Big Bang explosion that tookplace about 15 billion years ago. The universe consists of billions of galaxies, stars, planets, comets, asteroids, meteoroids and natural satellites. These are collectively called as celestial bodies, which are located far away from each other. A Light year is the unit used to measure the distance between the celestial bodies.

A light-year is the distance traversed by light in a year at a velocity of 300,000 km per second. Sound travels at a speed of 330 m per second.

Galaxy

- It is a huge cluster of stars which are held together by gravitational force. Most of the galaxies are scattered in space, but some remain in groups.The Milky Way Galaxy was formed about 5 billion years after the Big Bang explosion. Our solar system is a part of the Milky Way galaxy. Andromeda galaxy is the nearest to the Earth apart from the 'Magellanic Clouds' galaxy

2. The Solar System

- The word 'solar' is derived from the Roman word 'sol', which means 'Sun God'. The solar system is believed to have formed about 4.5 billion years ago. The solar system is a gravitationally bound system which comprises of the Sun, the eight planets, dwarf planets, satellites, comets, asteroids and meteoroids.

The Sun

- The Sun is at the centre of the solar system. Each member of the solar system revolves around the Sun. The Sun is sohuge that it accounts for 99.8 percent of the entire mass of the solar system. The Sun is made up of extremely hot gases like Hydrogen and Helium. The Sun is a star. It is self-luminous so it gives light on its own. The surface temperature of the Sun is about 6,000° C. It is the source of light and heat energy to the entire solar system. Sunlight takes about 8.3 minutes to reach the Earth.

1.3 million Earths fit inside the Sun. Imagine how big the Sun is.

GEO CONNECT: The ancient Tamils knew that the planets went around the Sun. For example, in Tamil literature Sirupanatruppadai, the line வாள் நிறவிசும்பின் கோள் மீன் சூழ்ந்த இளங்கதிர்ஞாயிறு mentions that the Sun is surrounded by planets.

Planets

- The word planet means wanderer. There are eight planets in the solar system. They are Mercury, Venus, Earth, Mars, Jupiter, Saturn,Uranus and Neptune. All the planets rotate anti-clockwise (from west to east) on their own axes except Venus and Uranus. The elliptical path in which the planets move around the Sun is known as orbit. The eight planets revolve in their respective orbits because of the gravitational pull of the Sun. They do not move out of their paths or away from the solar system.

- The four planets nearer to the Sun are called Inner or Terrestrial Planets (Mercury, Venus, Earth and Mars). The inner planets are comparatively smaller in size and are composed of rocks. The surface of inner planets has mountains, volcanoes and craters. The last four planets are called as Outer Planets or Jovian Planets (Jupiter, Saturn, Uranus, and Neptune). They are also called Gaseous Giants. An asteroid belt is found between Mars and Jupiter.

Mnemonic to remember the order of planets: My Very Educated Mother Just Showed Us Neptune.

Mercury (The Nearest Planet)

- Mercury is the smallest and closest planet to the Sun. It is named after the Roman deity 'Mercury', themessenger to the Gods. It is an airless and waterless planet.It does not have an atmosphere and so experiences extremes of temperature. It has no natural satellites. Mercury can be viewed in the morning and evening with naked eye.

Venus (The Hottest Planet)

- Venus is the second planet from the Sun. It is called Earth's twin, as it is almost the same size as the Earth. It has the longest rotation Venus period(243 days) among the planets in the Solar system. It rotates in the opposite direction to all other planets except Uranus. It has no natural satellites like Mercury. It is named after the Roman goddess of love and beauty. It is often visible in the mornings and the evenings and so it is frequently called as the Morning Star and the Evening Star. After the Moon, it is the brightest natural object in the night sky.

Earth (The Living Planet)

- The Earth is the third planet from the Sun and the fifth largest planet in the solar system. It is called 'blue planet' or 'watery planet' becausethree-fourth of the Earth is covered by water. The Earth is the only planet in the solar system which is not named after any Greek or Roman deity. It is the only planet known to support life. The polar diameter of the Earth is 12, 714 km and the equatorial diameter is 12, 756 km. The Earth revolves around the Sun at a speed of about 30 km per second. Life is possible on Earth because of the presence of land, air and water. The only natural satellite of the Earth is the Moon.

The distance between the Sun and the Earth is about 150 million kilometre. A flight flying at a speed of 800 km per hour from the Earth would take 21 years to reach the Sun.

Mars (The Red Planet)

- Mars is the fourth planet from the Sun and the second smallest planet in the solar system, after Mercury. It is named after the Roman Godof war. It appears red in colour due to the presence of iron oxide on its surface. So, it is often described as The Red Planet. It has a thin atmosphere. It also has polar icecaps like the Earth. Mars has two natural satellites namely Phobos and Deimos. Many orbiters and rovers have been launched to explore this planet.

On 24th September, 2014 Mangalyan (Mars Orbiter Mission - MOM), launched by the Indian Space Research Organization (ISRO), reached the orbit of Mars to analyze its atmosphere and topography. ISRO has now become the fourth space agency to reach Mars after the Soviet Space programme, NASA and the European Space Agency.

Jupiter (the Largest Planet)

- Jupiter is the f fth planet from the Sun and the largest planet in the solar system. It is named after the king of the Roman gods. It is the third brightest objectin the night sky, after moon and Venus. It is the fastest spinning planet in the solar system. It is called a gas giant planet. Its atmosphere is made up of mostly Hydrogen and Helium like the Sun. It has the largest number of natural satellites. Io, Europa, Ganymede and Callisto are a few large satellites of Jupiter.

Saturn (The Ringed planet)

- Saturn is the sixth planet from the Sun and the second largest planet in the solar system, after Jupiter. It is named after the Roman god of agriculture. Saturn has many rings around it. These rings are huge and are mostly made up of ice, rocks and dust particles.

- Saturn has 62 natural satellites around it. Titan, Saturn's largest moon, is theonly satellite in the solar system that has clouds and dense atmosphere composed of nitrogen and methane. The specific gravity of Saturn is less than that of water.

Uranus (The Somersaulting planet)

- Uranus is the seventh planet from the Sun. It was the first to be discovered with a telescope by the astronomer William Herschel in 1781. It appears green due to the presence of ethane. It is named after the Greek god of the sky. It rotates on its axis from east to west like Venus. Its axis is tilted so much that, it appears to orbit the Sun on its sides like a rolling ball. Uranus has 27 natural satellites, of which Titania is the largest.

Neptune (The coldest Planet)

- Neptune is the eighth and the farthest planet from the Sun. There are strongwinds in this planet. It is named after the Roman god of sea. Neptune has 14 natural satellites, the largest being Triton. Because of its distance from the Sun, Neptune is oneof the coldest planets in the solar system. The striking blue and white features of Neptune help to distinguish it from Uranus.

The Dwarf Planets

- Dwarf planets are small celestial bodies found beyond the planet Neptune. They are extremely cold and dark. They are almost spherical in shape, but unlike planets they can share their orbit with other dwarf planets. The five dwarf planets of the solar system are Pluto, Ceres, Eris, Makemake and Haumea.

The Moon - Earth's Satellite

- Satellites are celestial objects, which revolve around the planets. The moon is the Earth's only satellite. It revolves around the Earth once in every 27 days and 8 hours. It takes about the same time for it to complete one rotation around its axis. It has no atmosphere. The surface of the moon is characterized by craters created by the impact of meteors. The distance between the moon and the Earth is about 3, 84,400 km. The size of the moon is one-quarter of the Earth. The Moon is the only celestial body where humans have landed.

Asteroids

- Asteroids are small solid objects that move ISRO launched India's first ever Moon mission, Chandrayaan - 1 in 2008. Around the Sun. They are found as a belt between Mars and Jupiter. They are too small to be called as planets. They are also known as Planetoids or Minor Planets.

Comets

- A comet is a celestial object made up of a head and a tail. The head of a comet consists of solid particles held together by ice andthe tail is made of gases. Halley's Comet is the most famous comet which comes close to the Earth every 76 years. It last appeared in 1986 and will next appear in 2061.

Meteors and Meteorites

- A meteor is a stone like or metallic body. When entering into the Earth's atmosphere, most of them burn. As they often appear as streaks of light in the sky, they are also known as Shooting Stars. Meteors which strike the Earth's surface are called meteorites.

3. Motions of the Earth

- Have you noticed the Sun in the morning, afternoon or evening? Is it in the same place throughout the day? No. It is seen in the east in the morning, overhead in the afternoon and in the west in the evening. Have you ever thought of the reason behind it? This is because of the constant moving of the Earth around the Sun. It seems that the Sun is moving, but it is not so. This is similar to what you experience when you are travelling in a bus or train. When you look out of the window, the trees, lamp posts and other objects seem to be moving, but actually it is you who are moving. To understand the motions of the Earth better, you need to be familiar with the shape and inclination of the Earth.

Shape and Inclination of the Earth

- The Earth is spherical in shape. It rotates on its axis, which is an imaginary line that runs from the North Pole to the South Pole passing through the centre of the Earth. The Earth's axis is always tilted or inclined from the vertical by an angle of 23½°. It makes an angle of 66½° with the plane of the Earth's orbit.

- The velocity of the Earth's rotation varies from 1670 km per hour at the equator to 845 km per hour at 60° N and S latitudes and zero at the poles.

Rotation

- It is the spinning movement of the Earth on its axis. The Earth rotates from west to east (anticlockwise) and takes 23 hours 56 minutes and 4.09 seconds tocomplete one rotation. The time taken by the Earth to complete one rotation is called a day. The rotation of the Earth causes day and night. As the Earth is spherical inshape, only one half of it is illuminated by the Sun at a time. The other half remains dark. The illuminated portion of the Earth experiences day, whereas the darkened part of the Earth experiences night. The line which divides the surface of the Earth into a lighted half and a dark half is called the Terminator Line.

The Midnight Sun is a natural phenomenon that occurs in the summer months in places north of the Arctic Circle or south of the Antarctic Circle, when the Sun remains overhead 24 hours a day.

Revolution

- It is the movement of the Earth around the Sun on its elliptical path. The Earth takes 365 ¼ days for it to complete one revolution. It revolves around the Sun at aspeed of 30 km per second. For the sake of convenience, we take it as 365 days and call it a year. The remaining quarter day is added once in every four years in the month of February. That is why February has 29 days once in four years. It is called a Leap Year. The inclination of the Earth on its axis and its revolution around the Sun cause different seasons.

- The Northern Hemisphere is inclined towards the Sun for six months from 21st March to 23rd September while the Southern Hemisphere is tilted away from the Sun.

- From Sep 23rd to March 21st the southern hemisphere is inclined towards the Sun and the northern hemisphere faces away from the Sun. The changing position of the Earth in its orbit during revolution gives the impression that the Sun is continuouslymoving north and south of the equator. The equator faces the Sun directly on 21 March and 23 September. These two days are called Equinoxes, during which the day and night are equal throughout the Earth.

Perihelionis the Earth's closest position to the Sun. Aphelion is the farthest position of the Earth from the Sun.

- On 21st June, the Tropic of Cancer faces the Sun. This is known as Summer Solstice. It is the longest day in the Northern Hemisphere and longest night (shortest day) in the Southern Hemisphere. On 22nd December, the Tropic of Capricorn faces the Sun. It is called as Winter Solstice. It is the longest day in the Southern Hemisphere and longest night (shortest day) in the Northern Hemisphere.

4. Spheres of the Earth

- The Earth is the most suitable planet to support life. It has three major components that we call as the realms of the Earth-lithosphere, hydrosphere and atmosphere. The three components along with suitable climate make life possible on Earth. All living things exist in a narrow zone called the biosphere. Now let us have a close look at each of the spheres.

Lithosphere

- The word lithosphere is derived from the Greek word Lithos, which means rocky. The Lithosphere is the land on which we live. It is the solid outer layer of the Earth consisting of rocks and soils.

Hydrosphere

- The word Hydro means water in Greek. The hydrosphere consists of water bodies such as oceans, seas, rivers, lakes, ice caps on mountains and water vapour in the atmosphere.

Atmosphere

- The word Atmo means air in Greek. Atmosphere is the envelope of air that surrounds the Earth. Different types of gases make up the atmosphere. The major gases are Nitrogen (78%) and Oxygen (21%). The other gases like Carbon dioxide, Hydrogen, Helium, Argon, and Ozone are present in meageramounts.

Biosphere

- The narrow belt of interaction among the lithosphere, the hydrosphere and the atmosphere, where life exists is known as Biosphere. Bio means life in Greek. It consists of distinct zones. Each zone has its own climate, plant and animal life. These zones are known as ecosystems.

The Gulf of Mannar Biosphere Reserve in the Indian Ocean covers an area of 10,500 sq.km in the ocean.

7th term 3

Unit.2 Universe and Space

GEO Centric Theory

Sky is a wonder. Sun, Moon, stars all appear to rise in the East and move towards the west,giving us an impression that all these objects aregoing around the Earth. Just as in a moving bus the distant mountains and trees appear to move backwards, perhaps really Earth is spinning and that is why Sun, Moon and stars appear to go around the Earth. Does the Earth revolve around the Sun, or the Sun revolves around the Earth? How do you know about it?

When you look at the night sky you can see lot of twinkling objects. But a few of them differ from the others. They don't twinkle and while the other stars hold a fixed pattern from night to night, these drift. They wander across the sky, moving against the backdrop of stars. These are called planets. Our ancestors observed this and they imagined a universe with the Earth at the center, the stars in the distant background, and Sun, Moon and the planets orbiting around us.

Two observations supported the idea that Earth was thecenter of the Universe. First, from anywhere on the Earth, the Sun appears to revolve around the Earth once in a day. While the Moon and the planets have their own motions, they also appear to revolve around the Earth about once per day. Even the celestial sphere studded with stars appears to rise and set in the evening, and make one complete rotation in a year. Second, the Earth seems to be unmoving from the perspective of an earthbound observer; it feels stationary.

As civilization progressed the early astronomers found two types of motion of celestial objects. Let us take the case of Moon. On a daily basis Moon appears to rise in the east and set in the west. Thus, one can say that Moon is going around the Earth with a period of one day. But for a careful observer, it was clear that the Moon was also exhibiting another motion. Suppose, the Moon is appearing in the sky today near the star Asvini, tomorrow we will observe that the Moon is near the star Bharani, a star east of Asvini. And the next day it will be near the star Kartikai, east of Bharani. After 27 days, moving little by little eastwards, the Moon again stations itself near asvini. Thus, everyday Moon appears to move from east to west in one day where as it appears to go in a circle from west to east in the background of stars in about 27 days.

These two motions were puzzling. Very soon astronomers like Aryabhata said thatEarth is spinning in its axis, that is the cause of apparent daily motion from East to West. Whereas the eastward motion of Moon in the celestial sphere with a period of about 27 days, was seen as the 'actual' motion of the celestial objects.

Thus, the geocentric model (also known as geocentrism), that is a description of the Universe with spherical and spinning Earth at the center and the Sun, Moon, stars, andplanets all orbits the Earth emerged in various cultures. In Greece, this model was put forth by the Greek philosopher Plato and his disciple Aristotle in 6th century B.C. It was standardized by a Greeco Roman mathematician Ptolemy in the 2nd Century A.D. A similar model is seen in the Siddhanthic astronomy in India like Aryabhateeyam of Aryabhata.

How moon exhibit phases

Astronomers in ancient times also observed certain facts. The Purananuru (65) of Sangam literature, the poet PoetKalathalaiyar singing in appreciation of CheramanPeruncheralathansays“

On the day when the full moon appears,the sunand moon look at each other with their bright light. In the evening time, one sphere hides behind the mountains.”

On the full moon day, when the Sun is setting in the west, precisely at the same time, Moon rises at the East. That is both Sun and Moon are in the opposite side. Likewise when it is waning half moon, the Moon is rises when it is midnight and the waxing half moon rises during noon. From such observations and modelling ancient astronomers could explain why we have waxing and waning of moon.

It is probably easier to understand the waxing and waning of Moon in the order of new moon & full moon and then how the first and third quarter moon (half moon) appear and then the phases in between.

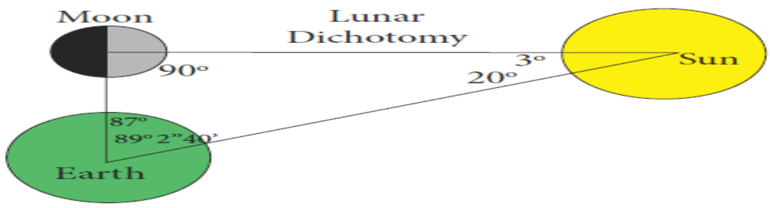
Sun is the source of light. Sun light falls on the spherical earth, but only on the side facing Sun. The opposite side of Earth is without sunlight. As the Earth spins day and night follows as different parts of Earth appear before the Sun. That is at all times one half of Earth is illuminated by Sun and one half is in darkness.

Likewise at all times one half of Moon is illuminated by Sun and the opposite side is shroud in darkness.

As shown in the above diagram, when the moon is positioned between the earth and sun, notice all the illuminated part of Moon is away from Earth. Hence we cannot see any part of the illuminated side of the Moon. Only the dark side of Moon is towards Earth. When the moon is in this position, we have new moon. Now look at the moon when it is behind the Earth. Now the portion of the moon illuminated by sun is totally towardsEarth. The dark side isaway from the Earth. This means the moon willappear to be round in the sky. This is full moon.

When the Sun, Earth and Moon are in 90 degree angle how will the moon appear to a person on the surface of the Earth? Now if you look at the portion of moon facing Earth, we will see half if it illuminated and half is dark side.

Thus, the moon will appear as half moon. The half moon during the waxing period is called as first quarter and the half moon during the waning period is called as third quarter. (figure sun moon and earth are at right angles)



Once we understand those four key moonphases, the phases between them should be fairly easy to visualize.

The word crescent refers to the phases where the moon is less than half illuminated. The word gibbous refers to phases where the moon is more than half illuminated. Waxing essentially means "growing" or expanding in illumination, and waning means "shrinking" or decreasing in illumination. Note all so that these discoveries could be made with naked eye. You do not need telescope or any modern equipment.

Epicycles

Moon going around Earth with 27 day period nicely explained its motion. However astronomers in ancient times faced problem in explaining the motion of the then known five planets- Mercury, Venus, Mars, Jupiter and Saturn

Moon in the background of stars moved everyday eastwards nicely. However for example, if we were observing the motion of Mars from January, it would appear to move eastward in the background stars. That is the position of mars today will be near a star which is east of the star near which it was yesterday. However on June 28, we will see a change. From that datethe Mars would appear to move west rather than its normal eastward motion. This reversal of direction of planets is called as 'retrograde motion'. If we continue to observe, on August28 once again the Mars would appear to reversethe direction and again on its usual eastward motion in the celestial sphere. Usually Jupiter is brighter than Mars, however, around the period of retrograde motion the Mars was much bright than other times; even brighter than Jupiter.

Other planets also exhibited number of puzzling behaviours. Venus and Mercury always appeared very close to Sun, and hence never appeared in the midnight sky. The brightness of Jupiter also varied again when it exhibited retrograde motion. For example in 2018, Jupiter reversed its direction of motion on March 9, 2018 and again resumed its normal eastward motion on July 11, 2018.

The simple geocentric model, where planets go around the Earth could not explain why the brightness of the planets changed, and why they reversed their directions. Change in brightness and retrograde motion would be impossible if we assumed that the planets were at the same distance at all times from Earth.

To explain the puzzling phenomena astronomers in early times proposed a change in the simple geocentric model. This is called as epicycle model.

Ptolemy (2nd cent) in Greece, Aryabhattain India and others used the epicycle model to explain the motion of the celestial objects. Their models were improved by generation of astronomers like Tycho Brahe and NeelakantaSomayaji.

Although, the model explained many phenomena there were number of mismatches. The model was becoming messy.

Arrival of telescope

Telescope was invented by Hans Lippersheybut Galilio used it for studying the sky for the first time. The telescope showed more universe was than visible to naked eye. With his simple telescope matching toy telescopes of today, Galilio was able to see mountains on the Moon, small dim stars invisible to naked eye, sunspots on the face of Sun. He was able to demonstrate that the milky way, an hazy bright patch in the sky is nothing but thousands of stars huddled together, Jupiter had moons going around it and Saturn had mysterious appendage which we now know as rings.

One of the most startling observations he made was related to telescopic observation of Venus. This convinced him to accept the theory of the Polish Astronomer Nicolus Copernicus, that it is not Sun, planets and Stars that go around Earth, but it is Earth and other planets that go around the Sun- heliocentric theory.

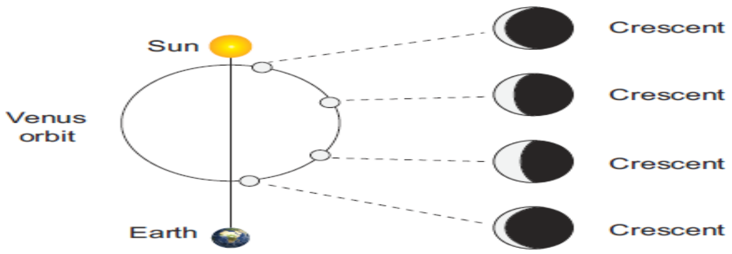
Heliocentric model

Dissatisfied with the messy epicycle model Nicolus Copernicus, radically proposed that the model will become simple if we assume Sun is at the center and all planets, including Earth, go around it.

Suppose, Earth and Mars are on the two sides of the Sun, then Mars would be far and appear dim, compared to when they are on the same side. Earth orbit around Sun in 365 days, whereas Mars takes 687 days. This implies at times Earth will overtake Mars. When the Earth is approaching and overtaking Mars, the Mars would appear to exhibit retrograde motion. In short all the observed phenomena could be explained in a simple way.

However how do we know that actually Sun is at the center or not?

Galileo found that his observation of Venus gave the observational evidence to support the heliocentric theory. Galileo observed Venus in 1610-1611 with a telescope. To naked eye, Venus is just a gleaming bright spot. However, through a telescope, the shape of the planet can be seen. Galilio was startled to find like Moon Venus too exhibited phases. The shape varied from crescent to gibbous. Also, the size of the planet varied. When the planet was in gibbous phase the size was small, and when it was thin crescent the size was many folds higher.



As the Venus went around the epicycle, as shown in the diagram Venus would exhibit phases. Also at times the planet would be nearer, making the apparent size grow bigger and at times far making the apparent size smaller. Thus, the variation in the brightness can also be explained.

It became clear to Galilio that the geocentric epicycle model will not help in accounting for the observed phases of the Venus.

Look at the above diagram. If the Venus was going around the Sun, and its orbit is inside that of Earth, Venus would appear always near the Sun in the sky. It can never be seen in the midnight sky. Two when it is near the Earth, it would be brighter and bigger compared to when it is on the other side of the Sun. Thirdly only if the Venus is revolving around the Sun, it can exhibit gibbous phase, and the size of the gibbous phase smaller than the crescent phase. If the Venus was revolving around the Earth, we can never see the gibbous phase of the Venus and it would be seen only if it is orbiting the he Sun. This clinching observational evidence proved that at the least Venus orbited around the Sun. Further evidences collected by astronomers using telescope and other advanced modern instruments gave enough evidence that all planets revolve around the Sun.

If Galileo were around today, he would surely be amazed at exploration of our solar system and beyond by ISRO, NASA, Russian space agency and others.

Now we can observe planets orbiting around other stars (called exoplanets), proving that not only planets orbit around the Sun in solar system, but all around the universe suchplanetary systems exist. Who knows, in some ofthere could be life and in rare cases intelligentlife, like humans wondering and exploringuniverse. Imagine a future time when such lifemeet us; how exciting and momentous it wouldbe!

Origin of the Universe

You are a student who belong to a particular class studying in VII std. In your school, there might me many section for VII std. Likewise, there are VI std class, VIII std class and so on. All of them together make the school. Likewise, our Sun is a star with a planetary system. Billions of such stars consitute a system called as galaxy. The name of our galaxy is, Milky Way. Like MilkyWay, there are at least hundreds of billions of galaxies in the Universe. How did all these come about? Where they in existence always or was there a beginning?

When we observed other galaxies we found a strange behavior. All the galaxies were appearing to move away from us. Further, farther they are faster they appear to move. Cosmologists , scientists who study the structure and evolution of universe that is cosmos, reason that this imply at one point of time in the past all matter was confined in a single point and since then it has started to expand.

The event when the matter confined in a single point and began to expand is called 'big bang'. This is considered as the origin of our universe as we know it.

The Big Bang Theory is the prevailing model of the evolution of the Universe. Under this theory, space and time emerged together about 14 billions of years ago. At that time, the entire Universe was inside a bubble that was thousands of times smaller than a pinhead. It was hotter and denser than anything we can imagine. Then it suddenly expanded. The present Universe emerged .Time, space andmatter all began with the Big Bang.

In a fraction of a second, the Universe grew from smaller than a single atom to bigger than a galaxy. And it kept on growing at a fantastic rate. It is still expanding today. Over the next three minutes, the temperature dropped below 1 billion degrees Celsius. After 300 000 years, the Universe had cooled to about 3000 degrees. Atomic nuclei could finally capture electrons to form atoms. At that stage of the evolution of the Universe, it was filled with clouds of hydrogen and helium gas. Giant clouds of hydrogen and helium were gradually drawn to the places where dark matter was most dense, forming the first galaxies, stars, and everything else seen today.

We cannot see anything that happened during the first 300000 years of the Universe. Scientists try to work it out from their knowledge of atomic particles and from computer models. The only direct evidence of the Big Bang itself is a faint glow in space, called cosmic microwave background.

As millions of years passed, the dense areas pulled in material because they had more gravity. Finally, about 100 million years after the Big Bang, the gas became hot and dense enough for the first stars to form. New stars were being born at a rate 10 times higher than in the present-day Universe. Large clusters of stars soon became the first galaxies.

Building Blocks of Universe.

As stated above universe is constituted of galaxies, just as lot of houses in our locality constitute a village or a city. We have lot of things such as rooms, furniture etc. in our homes. Likewise lot of stellar objects such as stars, planets, asteroids and meteors are the building blocks of our universe.

Galaxies.

A galaxy is a large collection of stars or cluster of stars and celestial bodies held together by gravitational attraction. There are about billions of galaxies in the universe. Most galaxies range from thousand to ten thousand parsec in diameter. As we have different types of houses in a locality, the galaxies are also of different types.

Types of galaxies

There are various types of galaxies such as spiral, elliptical, barred spiral and irregular

Spiral Galaxy

Spiral galaxies consist of a flat, rotating disk containing stars, gas and dust, and a centralconcentration of stars known as the bulge. These are often surrounded by a much fainter halo of stars. Spiral galaxies are named by their spiral structures that extend from the centerinto the galactic disc. The spiral arms are sites of ongoing star formation and are brighter than the surrounding disc because of the young, hot stars that inhabit them.

Elliptical Galaxy

An elliptical galaxy is a type of galaxy having an approximately ellipsoidal shape and a smooth image. Unlike flat spiral galaxies with organization and structure, elliptical galaxies are three-dimensional, without much structure, and their stars are in somewhat random orbits around the center. Interestingly Stars found inside of elliptical galaxies are on an average much older than stars found in spiral galaxies. Elliptical galaxies tend to be surrounded by large numbers of globular clusters.

Irregular Galaxy

An irregular galaxy is a galaxy that does not have a distinct regular shape, unlike a spiral or an elliptical galaxy, they are often chaotic in appearance, with neither a nuclear bulge nor any trace of spiral arm structure. About one forth of the galaxies found so far are of this type.

Cosmologists say that some irregular galaxies were once spiral or elliptical galaxies but were deformed by an uneven external gravitational force. Irregular galaxies may contain abundant amounts of gas and dust.

Barred Spiral

A barred spiral galaxy is a spiral galaxy with a central bar-shaped structure composed of Stars. Bars are found in approximately in two-thirds to one third of all spiral galaxies. The Milky Way Galaxy, where our own Solar System is located, is classified as a barred spiral galaxy.

Milky Way

The Milky Way is the galaxy in which our solar system is located. Thediameter of Milky Way is over100,000 light years. The MilkyWay includes stars smaller than our Sun as wellas many other stars that are thousands of timesbigger than the Sun. It includes many othercelestial bodies of gases, clouds of dust, deadstars, newly born stars, etc. It is also thoughtto contain at least 100 billion stars. The galaxythat is closest to our Milky Way is Andromeda.The descriptive "milky" is derived from theappearance from Earth of the galaxy – a bandof light seen in the night sky formed from starsthat cannot be individually distinguished by thenaked eye. In Indian mythology, this patch calledas Akasha Ganga. From the Earth, the MilkyWay appears as a band because its disk-shaped structure is viewed from within. Galileo Galilifirst resolved the band of light into individual stars with his telescope in 1610. Until the early 1920s, most astronomers thought that the Milky Way contained all the stars in the Universe. Observations by Edwin Hubble showed that the Milky Way is just one of many galaxies.

The Milky Way does not sit still, but is constantly rotating. Our solar system is located within the disk of the galaxy, about 27,000 light years away from the centre of the galaxy. The solar system travels at an average speed of 828,000 km/h. Even at this rapid speed, the solar system would take about 230 million years to travel all the way around the Milky Way. When the solar system was in the same spot as it is now, there were no humans, no Himalayan mountain on Earth and the dinosaurs were roaming around the Earth.

Tucked inside the very center of the galaxy is a monstrous black hole, billions of times as massive as the sun. Although, black holes cannot be directly viewed, scientists can see their gravitational effects as they change and distort the paths of the material around it, most galaxies, like our milkyway, are thought to have a black hole in their heart.

Constellation

A constellation is a recognizable pattern of stars in the night sky when viewed from the Earth. International Astronomical Union has classified 88 constellations to cover the entire celestial sphere. Many of the old constellations have Greek or Latin names and are often named after mythological characters.

Ursa Major (Saptha Rishi Mandalam) is a large constellation and it covers a large part of the sky. The most striking feature of this constellation is a group of seven bright stars known as big dipper (seven Sages in Indian astronomy).

Ursa Minor in Lattin means 'the little bear' it lies in the northern sky. The Pole star – Polaris (Dhrua) lies within this constellation. The main group, 'little dipper', consists of seven stars and is quite similar to that found in Ursa Major.

Orion was a hunter in Greek mythology. The constellation comprises around 81 stars out of which all but 10 are too faint to be seen with naked eye.

Different constellations become visible in the sky at different times in the year. This happens due to the revolution of the Earth around the Sun.

Unlike galaxy, constellations are mereoptical appearance and not real objects. In galaxy stars are bound by gravity and constitute a system. In a constellation, one star may be near and another very very far, but because they are in the same direction appear to be near to each other in the sky.

Name of Constellations	
Indian Name	**English Name**
Mesham	Aeries
Rishabham	Taurus
Midhunam	Gemini
Kadakam	Cancer
Simmam	Leo
Kanni	Virgo
Thulam	Libra
Vrischikam	Scorpio
Dhanusu	Sagittarius
Makaram	Capricorn
Kumbam	Aquarius
Meenam	Pisces

Stars

A Star is a luminous heavenly body that radiate energy. With naked eyes, we can see nearly 3000 stars in the night sky and many more with the help of a telescope. The stars are remotely located and appear as tiny dots of light. Their light travels long distances to reach us. The atmosphere disturbances do not allow light to reach us in a straight line path. Because of this the stars appear to twinkle. The Sun is the nearest star to the Earth. The next nearest star is Alpha Centauri

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, the ones that are not usually asteroids or meteors that were captured by the strong gravity of a planet. All planets except mercury and Venus in our solar system have moons. Earth has only one moon-whereas planets like Jupiter and Saturn have more than 60 moons.

Artificial satellites

Artificial satellites are man-made objects placed in an obit to rotate around a planet – usually the Earth. The world's first artificialsatellite launched was Sputnik-1 by Russia,
Aryabhatta was the first satellite launched by India. These satellites are used in television and radio transmission, studying agriculture yield, locating mineral resources, weather forecasting, locate different places on earth.

ISRO

The Indian Space Research Organisation (ISRO) is the space agency of the Government of India 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. The establishment of ISRO thus institutionalized space activities in India. It is managed by the Department of Space, which reports to the Prime Minister of India.

ISRO built India's first satellite, Aryabhatta, which was launched by the Soviet Union on 19 April 1975. It was named after the Indian astronomer Aryabhata. 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. These rockets have launched numerous communication satellites and earth observation satellites. Satellite navigation systems like GAGAN and IRNSS have been deployed. 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 and 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.

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.

Unit -3 UNIVERSE AND SPACE SCIENCE

Rockets

The universe is a great mystery to all of us. Our minds always try to know about the space around us. Understanding the space will be helpful to us in many ways. Space research provides information to understand the environment of the Earth and the changing climate and weather on Earth. Exploring the space will help us to answer many of the challenges we are facing these days

Discovery of rockets has opened a small portion of the universe to us. Rockets help us to launch space probes to explore the planets in the solar system. They also help us to launch space-based telescopes to explore the universe.

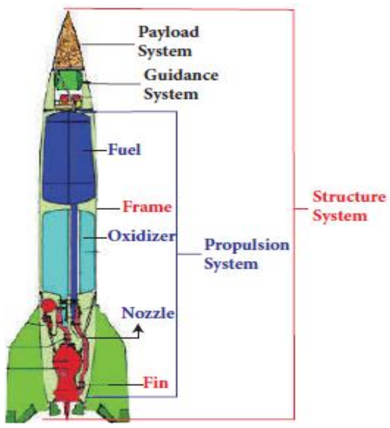
Rockets were invented in China, more than 800 years ago. The first rockets were a cardboard tube packed with gunpowder. They were called fire arrows. In 1232 AD, the Chinese used these 'fire arrows' to defeat the invading Mongol army. The knowledge of making rockets soon spread to the Middle East and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

More than all rockets enable us to put satellites, which are useful to us in a number of ways. Our country has effective rocket technology and has applied it successfully to provide so many space services globally.

Parts of Rockets

A rocket is a space vehicle with a very powerful engine designed to carry people or equipment beyond Earth and out into space. There are four major parts or systems in a rocket. They are:

- Structural system
- Payload system
- Guidance system
- Propulsion system



Parts of a Rocket

Structural system (Frame)

The structural system is the frame that covers the rocket. It is made up of very strong but light weight materials like titanium or aluminum. Fins are attached to some rockets at the bottom of the frame to provide stability during the flight.

Payload system

Payload is the object that the satellite is carrying into the orbit. Payload depends on the rocket's mission. The rockets are modified to launch satellites with a wide range of missions like communications, weather monitoring, spying, planetary exploration, and as observatories. Special rockets are also developed to launch people into the Earth's orbit and onto the surface of the Moon.

Guidance system

Guidance system guides the rocket in its path. It may include sensors, on-board computers, radars, and communication equipments.

Propulsion system

It takes up most of the space in a rocket. It consists of fuel (propellant) tanks, pumps and a combustion chamber. There are two main types of propulsion systems. They are: liquid propulsion system and solid propulsion system.

Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV) rockets are India's popular rockets.

Types of Propellants

A propellant is a chemical substance that can undergo combustion to produce pressurized gases whose energy is utilized to move a rocket against the gravitational force of attraction. It is a mixture, which contains a fuel that burns and an oxidizer, which supplies the oxygen necessary for the burning (combustion) of the fuel. The propellants may be in the form of a solid or liquid.

a. Liquid propellants

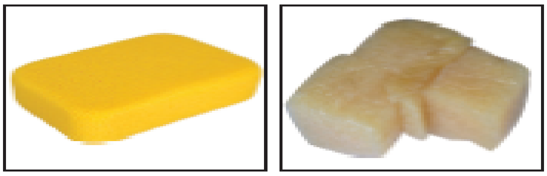
In liquid propellants fuel and oxidisers are combined in a combustion chamber where they burn and come out from the base of the rocket with a great force. Liquid hydrogen, hydrazine and ethyl alcohol are the liquid fuels. Some of the oxidizers are oxygen, ozone, hydrogen peroxide and fuming nitric acid.

Liquid Hydrogen

Fuming Nitric Acid

b. Solid propellants

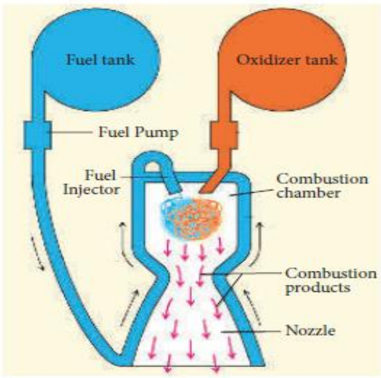
In solid rocket propellants fuel and oxidiser compounds are already combined. When they are ignited they burn and produce heat energy. Combustion of solid propellants cannot be stopped once it is ignited. Solid fuels used in rockets are polyurethanes and poly butadienes. Nitrate and chlorate salts are used as oxidizers



Polyurethanes Poly butadienes

c. Cryogenic propellants

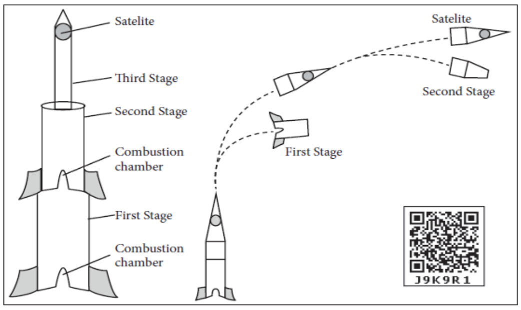
In this type of fuel, the fuel or oxidizer or both are liquefied gases and they are stored at a very low temperature. These fuels do not need any ignition system. They react on mixing and start their own flame.



Cryogenic Fuels

Launching of Satellite

Before being launched into the space, rockets will be held down by the clamps on the launching pad initially. Manned or unmanned satellites will be placed at the top of the rocket. When the fuel in the rocket is burnt, it will produce an upward thrust. There will be a point at which the upward thrust will be greater than the weight of the satellite. At that point the clamp will be removed by remote control and the rocket will move upwards. According to Newton's third law, for every action there is an equal and opposite reaction. As the gas is released downward, the rocket will move upward.



Launching of Rocket

To place a satellite in a particular orbit, a satellite must be raised to the desired height and given the correct speed and direction by the launching rocket. If this high velocity is given to the rocket at the surface of the Earth, the rocket will be burnt due to air friction. Moreover, such high velocities cannot be developed by a single rocket. So, multistage rockets are used. To penetrate the dense lower part of the atmosphere, initially the rocket rises vertically and then it is tilted by a guidance system.

India's Space Programmes

Within few years after the independence, India initiated space research activities. In 1969, Indian Space Research Organisation (ISRO) was formed with the objective of developing space technology and its application for different needs of the nation. India is focusing on satellites for communication and remote sensing, space transportation systems and application programmes. The first ever satellite Aryabhata was launched in 1975. Since then India has achieved a lot in space programmes equal to that of the developed nations.

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.

Chandrayaan – 1

Our country launched a satellite Chandrayaan-1 (meaning Moon vehicle) on 22nd October 2008 to study about the Moon. It was launched from Sathish Dhawan Space Center in Sriharikota, Andhra Pradesh with the help of PSLV (Polar Satellite Launch Vehicle) rocket. It was put into the lunar orbit on 8th November 2008.

The spacecraft was orbiting around the Moon at a height of 100 km from the lunar surface. It collected the chemical, the mineralogical and the geological information about the Moon. This mission was a major boost for the Indian space programs and helped to develop its own technology to explore the Moon. Chandrayaan-1 was operated for 312 days and achieved 95% of its objectives. The scientists lost their communication with the space craft on 28th August 2009. On the successful completion of all the major objectives, the mission was concluded.

Chandrayaan - 1

a. Objectives of Chandrayaan-1

The following were the objectives of Chandrayaan – 1 mission.

- To find the possibility of water on the Moon.
- To find the elements of matter on the Moon.
- To search for the existence of Helium-3.
- To make a 3-dimensional atlas of the Moon.
- To study about the evolution of the solar system.

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

b. Achievements of Chandrayaan-1

The following are the achievements of Chandrayaan-1 mission.

- The discovery of presence of water molecules in the lunar soil.
- Chandrayaan-1 confirmed that the Moon was completely molten once.
- Chandrayaan-1 has recorded images of the landing site of the US space-craft Apollo-15 and Apollo-11.

Know your Scientist

Dr.MylsamyAnnadurai 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.

- **It has provided high-resolution spectral data on the mineralogy of the Moon.**
- **The existence of aluminium, magnesium and silicon were picked up by the X-ray camera.**
- **More than 40,000 images have been transmitted by the Chandrayaan-1 camera in 75 days.**
- **The acquired images of peaks and craters show that the Moon mostly consists of craters.**
- **Chandrayaan-1 beamed back its first images of the Earth in its entirety.**
- **Chandrayaan-1 has discovered large caves on the lunar surface that can act as human shelter on the Moon.**

Mangalyaan (Mars vehicle)

After the successful launch of Chandrayaan-1, ISRO planned an unmanned mission to Mars (Mars Orbiter Mission) and launched a space probe (space vehicle) on 5th November 2013 to orbit Mars orbit. This probe was launched by the PSLV Rocket from Sriharikota, Andrapradesh. Mars Orbiter Mission is India's first interplanetary mission. By launching Mangalyaan, ISRO became the fourth space agency to reach Mars.

Mangalyaan probe traveled for about a month in Earth's orbit, and then it was moved to the orbit of Mars by a series of projections. It was successfully placed in the Mars-orbit on 24th September 2014.

Mars Orbiter Mission successfully completed a period of 3 years in the Martian orbit and continues to work as expected. ISRO has released the scientific data received from the MOM in the past two years (up to September 2016).

More to know

Mars is the fourth planet from the Sun. It is the second smallest planet in the solar system. Mars is called as the Red Planet because of its reddish colour. Iron Oxide present in its surface and also in its dusty atmosphere gives the reddish colour to that planet. Mars rotates about its own axis once in 24 hours 37 minutes. Mars revolves around the Sun once in 687 days. The rotational period and seasonal cycles of Mars are similar to that of the Earth. Astronomers are more curious in the exploration of Mars. So, they have sent many unmanned spacecrafts to study the planet's surface, climate, and geology.

a. Objectives of Mangalyaan

The following are the objectives of Chandrayaan – 2 mission.

- **To develop the technology required for interplanetary mission.**
- **To explore the surface of Mars.**
- **To study the constituents of the Martian atmosphere.**

- **To provide information about the future possibility of life and past existence of life on the planet**.

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.

Chandrayaan - 2

ISRO has currently launched a follow on mission to Chandrayaan-1 named as Chandrayaan-2, on 22nd July 2019. Chandrayaan 2 mission is highly complex mission compared to previous missions of ISRO. It brought together an Orbiter, Lander and Rover. It aims to explore South Pole of the Moon because the surface area of the South Pole remines in shadow much larger than that of North Pole.

Orbiter

It revolves around the moon and it is capable of communicating with Indian Deep Space Network (IDSN) at Bylalu as well as Vikram Lander.

Lander

It is named as Vikram in the memory of Dr.Vikram A. Sarabhai, the father of Indian space program.

Rover

It is a 6 wheeled robotic vehicle named as 'Pragyan' (Sanskrit word) that means wisdom. Chandrayaan-2 was successfully inserted into the lunar orbit on 20th August 2019. In the final stage of the mission, just 2.1 km above the lunar surface, Lander 'Vikram' lost its communication with the ground station on 7th September 2019. But the Orbiter continues its work successfully.

Vikram Lander

Know your Scientist

Dr.Kailasavadivoo 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.

More to know

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.

NASA (National Aeronautics and Space Administration)

NASA is the most popular space agency whose headquarters is located at Washington, USA. It was established on 1st October 1958. It has 10 field centers, which provide a major role in the execution of NASA's work. NASA is supporting International Space Station which is an international collaborative work on space research. It has landed rovers on Mars, analysed the atmosphere of Jupiter, explored Saturn and Mercury.

The Mercury, Gemini and Apollo programs helped NASA learn about flying in space. NASA's robotic space probes have visited every planet in the solar system. Satellites launched by NASA have revealed a wealth of data about Earth, resulting in valuable information such as a better understanding of weather patterns. NASA technology has contributed to make many items used in everyday life, from smoke detectors to medical tests.

Apollo Mission

Apollo Missions are the most popular missions of NASA. These missions made American Astronauts to land on the Moon. It consists of totally 17 missions. Among them Apollo -8 and Apollo-11 are more remarkable. Apollo-8 was the first manned mission to go to the Moon. It orbited around the Moon and came back to the Earth.Apollo-11 was the first 'Man Landing Mission' to the moon. It landed on the

Moon on 20th July 1969. Neil Armstrong was the first man to walk on the surface of the Moon.

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

NASA's work with ISRO

NASA made an agreement to work with ISRO to launch the NISAR Satellite (NASA-ISRO Synthetic Aperture Radar) and Mars Exploration Missions.

Work of Indians at NASA

People of Indian origin in America are working in NASA and they have made remarkable contribution to NASA.

KalpanaChawla

KalpanaChawla was born on 17th March 1962 in Karnal, Punjab. In 1988, she joined the NASA. She was selected to take part in the Colombia Shuttle Mission in 1997 and she became the first Indian women astronaut to go to space. On her second mission on the Colombia Shuttle, she lost her life, when the shuttle broke down. KalpanaChawla travelled over 10.4 million miles in 252 orbits of the earth, logging more than 372 hours in space.

Sunitha Williams

Sunitha Williams was born on 19th September 1965 in USA. She started her career as an astronaut in August 1998. She made two trips to the International Space Station. She set a record of the longest space walking time by a female astronaut in 2012, with a total space walk of 50 hour and 40 minute (7 space walks). She is one of the crew of NASA's Manned Mars Mission.

9th book
Unit – 9 – Universe

Building block of the Universe

- The basic constituent of the universe is luminous matter i.e., galaxies which are really the collection of billionsof 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 × 1012 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.

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 all the matter were ejected 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, the carbon, calcium, and iron, and silicon are formed in the cores of stars. 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.

Galaxies

- 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 (1011) galaxies in the observable universe. 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.

- 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.

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 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. 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 appeartobe 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.

- 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 constellation outlines. There are 88 formally accepted constellations. Aries, Gemini, Leo, Orion, Scorpius and Cassiopeia are some of the constellations.

- The Solar System Sun and the 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.

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. It is this energy which makes Sun shine and provide heat. 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. Sun is believed to be more than 4.6 billion years old.

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 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.

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.

- 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 9.1 tells about the length of a day on each planet.

- The planets are spaced unevenly. The first four planets are relatively close together and close to the Sun. They form the inner solar

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

- 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.

- 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.

- 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. 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.

- 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: 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. From space, the 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.

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.

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. 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). 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.

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.

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.

- 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= $\frac{\sqrt{GM}}{(R+h)}$ **where,**

G = Gravitational constant (6.673 × 10–11 Nm2kg-2)
M = Mass of the Earth (5.972 × 1024 kg)
R = Radius of the Earth (6371 km)
h = Height of the satellite from the surface of the Earth.

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.

Time period of a Satellite

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

Time period, T = $\frac{\textit{Distance covered}}{\textit{Orbital Velcity}}$

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

Substituting the value of v, we get

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

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. Kepler's three laws of planetary motion can be described as below.

First Law – The Law of Ellipses

All planets revolve around the Sun in elliptical orbits with Sun at one of their foci.
Second Law – The Law of Equal Areas The line connecting the planet and the Sun covers equal areas in equal intervals of time.

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.

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 presentin 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.

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. 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.

- 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,.

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.

11th geography

Unit II - The Solar System and the Earth

Theories of the Earth's origin

- There are many theories supporting the origin of the earth. One of the earlier and popular arguments of the earth's origin was by a German professor Immanuel Kant. Mathematician Laplace revised it in 1796. It was known as Nebular Hypothesis. It considered that planets were formed out of a cloud of materialassociated with a youthful sun, which was slowly rotating. Lyttleton propounded the accretion theory of the earth's formation. According to this theory, approximately 4.6 billion years ago, the solar system was a cloud of dust and gas known as a solar nebula. As the solar nebula began to spin, the gravity collapsed the materials on itself and it formed the sun in the centre of the solar system. When the sun formed, the remaining materials began to clump up. Small particles drew together, bound by the force of gravity, into larger particles. The solar wind swept away lighter elements, such as hydrogen and helium, from the closer regions. It left only heavy rocky materials to create planets like the Earth. But farther away, the solar winds had less impact on lighter elements, allowing them to coalesce into gas giants. In this way, planets, moons, asteroids, comets, etc., were created.

Voyager 2 travelling at the speed of more than 62,764.416 km/h will still take morethan 296,000 years to pass Sirius, the brightest star in our night sky.

- Earth's rocky core formed first when heavy elements collided and bound together. Dense materials sank to the center, while the lighter material created the crust. The planet's magnetic field probably formed around this time. Gravity captured some of the gases that made up the planet's early atmosphere.

Modern theories of the origin of the Universe

- The most popular argument regarding the origin of the universe is the Big Bang Theory. It is also called expanding universe hypothesis. In 1927, Abbe Georges Lemaitre, a Belgian astronomer was the first to propose, a theory on the origin of the universe. It was Edwin Hubble who provided the evidence that the universe is expanding. It was called, 'the Big Bang Theory'. According to it, the universe was formed during a period of inflation that began about 13.75 billion years ago.

- Like a rapidly expanding balloon, it swelled from a size smaller than an electron to nearly its current size within a fraction of a second. Matter from the universe was thrown out with great force in all directions and started expanding outwards. From this matter, many groups of stars were formed which we call 'galaxies'. A galaxy is a system of billions of stars, stellar remnants, interstellar gas, dust, and dark matter. The word galaxy is derived from the Greek word Galaxias, literally “milky”, a reference to the Milky Way (Figure 2.1). The Milky Way is the galaxy that contains our Solar System.

Galaxies are in three major forms:

- Spiral Galaxies: It consists of a fat and rotating disk of stars, gases and dust. It has a central concentration of stars known as the ‘bulge’. The Milky Way and the Andromeda are spiral galaxies.

- Elliptical Galaxies: It contains older stars with fewer gases. Messier89 galaxy is an elliptical galaxy.

- Irregular Galaxies: They are youthful galaxies with more dust and gases. This can make them very bright. Large Magellanic Cloud is an example of irregular galaxy.
- Initially, the universe was saturated only by energy. Some of this energy set into particles, which assembled into light atoms like hydrogen and helium. These atoms grouped first into galaxies, then stars and all the other elements. This is generally agreed-upon concept of our universe's origin as estimated by scientists.

- In fact, the stars, planets and galaxies that can be detected make up only 4 percent of the universe, according to astronomers. The other 96 percent of the substances in the universe cannot be seen or easily understandable.

- The new measurement technique called gravitational lensing confirmed the age of the universe and the strength of dark energy. Dark energy is responsible for the accelerating expansion of the universe. Scientists used gravitational lensing to measure the distances light travelled from a bright, active galaxy to the earth and some details of its expansion.

Three scientists, Saul Perlmutter, Brian Schmidt and Adam Riess won the Nobel Prize in Physics (2011) for their discovery that the universe is just expanding and picking up speed.

Star and Constellations

- A star is type of astronomical object which has its own light and heat. The nearest star to earth is the Sun. Sirius is brighter star than the sun. 'Proxima Centaur? is the closest star to the sun. Star is formed when enough dust and gas clump together because of the gravitational forces. Star changes its formsduring its lifetime such as-red giant, white dwarf, neutron star and black hole.

- Constellation (Figure 2.2) is a group of stars that forms a particular shape in the sky. In 1929, the International Astronomical Union (1AU) adopted official constellation boundaries that defined 88 official constellations thatexist today. Earlier Ptolemy, in his book Almagest, listed 48 constellations.

- Ursa Major (Figure 2.3) is a constellation that can be seen in the northern hemisphere and part of the southern hemisphere. Ursa Major means Great Bear in Latin.

The Solar system

- A solar system consists of a star (Figure 2.4) at the centre and the eight planets, moons, asteroids, comets and meteoroids that revolve it. The eight planets, namely the Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune, revolvearound the sun in fixed elliptical paths known as 'orbits'. Most stars host their own planets. So there are billions of other solar systems in the Milky Way galaxy alone.

- Solar systems can also have more than one star. These are called binary star systems if there are two stars or multi-star systems if there are three or more stars. Our solar system is located in an outer spiral arm of the vast Milky Way galaxy. Our solar system orbits the centre of the Milky Way Galaxy at about 828,000 km/h. Our solar system takes about 230 million years to complete one orbit around the galactic centre.

- The solar system is believed to have been formed about 4.6 billion years ago. The solar system also includes the Kuiper Belt that lies past Neptune's orbit. This is a sparsely occupied ring of icy bodies. This is almost all smaller than the dwarf planet Pluto. Beyond the fringes of the Kuiper belt (Figure 2.5) is the Oort cloud. This giant spherical shell surrounds our solar system. It has never been directly observed,by gravitational attraction, producing immense pressure and temperature at its core. There are three main layers in the Sun's interior: the core, the radioactive zone, and the convective zone (Figure 2.6). The core is at the centre. It is the hottest region, where the nuclear fusion reaction to give the sun power. Moving outward next come the radioactive (or radiation) zone. Its name is derived from the way energy is carried outward through this layer, carried by photons as thermal radiation. The third and final region of the solar interior is named the convective (or convection) zone. It is also named after the dominant mode of energy flow in this layer. The boundary between the Sun's interior and the solar atmosphere is called the photosphere. It is what we see as the visible 'surface' of the Sun.

- Did you know that the Sun has an atmosphere? Te lower region of the solar atmosphere is called the chromosphere. Its name is derived from the Greek word chroma (meaning colour), for it appears bright red when viewed during a solar eclipse. A thin transition region, where temperature rises sharply, separates the chromospheres from the vast corona above. The uppermost portion of the Sun's atmosphere is called the corona, and is surprisingly much hotter than the Sun's surface (photosphere) The upper corona gradually turns into the solar wind. Solar wind is a flow of plasma that moves outward through our solar system into interstellar space.

- Therefore, the Sun has six regions: the core, the radioactive zone, and the convective zone in the interior; the photosphere; the chromospheres; and the corona. The temperature of the sun'ssurface is about 5,500 to 6,000 degrees Celsius.

- At the core, the temperature is about 15 million degrees Celsius, which is sufficient to sustain thermonuclear fusion. This is a process in which atoms combine to form larger atoms and in this process, released, staggering amounts of energy. Specifically, in the Sun's core, hydrogen atoms fuse to make helium.

Size and Distance

- The sun has a radius of 695,508 kilometres. It is far more massive than earth and 3,32,946 Earths equal to the mass of the Sun. The Sun's volume would need 1.3 million Earths to fill it.

Venus is hotter than Mercury because Venus has an atmosphere which is thicker and made almost entirely of carbon dioxide

Orbit and Rotation

- The Milky Way has four main spiral arms: the Norma and Cygnus arm, Sagittarius, Scutum-Crux, and Perseus. The Sun is located in a minor arm, the Sagittarius arm. From there, the Sun orbits the centre of the Milky Way Galaxy, bringing the planets, asteroids, comets and other objects along with it. Our solar system is moving with an average velocity of 828,000 kilometres per hour. It takes about 230 million years to make one complete orbit around the Milky Way. The Sun's spin has an axial tilt of 7.25 degrees with respect to the plane of the planets' orbits. Since the Sun is not a solid body, different parts of the Sun rotate at different rates. At the equator, the Sunspins around once about every 25 days, but at its poles the Sun rotates once on its axis every 36 Earth days. Most of the materials are pulled toward the centre to form our Sun. The Sun alone accounts for 99.8% of the mass of the entire solar system.

- Like all stars, the Sun will someday run out of energy. When the Sun starts to die, it will swell so big that it will engulf Mercury y and Venus and maybe even Earth. Scientists predict that the Sun is a little less than halfway through its lifetime and will last another 6.5 billion years before it shrinks down to be a white dwarf.

The Planets

- The word planet in Greek means 'wanderer'. Planet is the celestial body which does not have light or heat of its own. A planet should possess the following qualities:

❖ It should orbit around the sun.
❖ It should not be a satellite of any planet

Due to its own mass and self-gravity, it should get a spherical shape and Any other celestial body should not cross in its orbit.

- The planets are classified in order of their distance from the sun and based on their characteristics. They are:

- The inner planets or terrestrial planets or rocky planets. Mercury, Venus, Earth and Mars are called inner or terrestrial planets.

- The outer planets or gaseous planets or giant planets. Jupiter, Saturn, Uranus and Neptune are called outer or gaseous planets.

Each planet spins on its own axis. Tis movement is called rotation. One rotation makes one 'planet day'. The planets moving around the sun is called revolution or a 'planet-year'.

Planets in the Solar System

Name of the Planet	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Diameter (KM)	4,879	12,104	12,756	6,794	1,42,984	1,20,536	51,118	49,528
Density (kg/m3)	5,427	5,427	5,514	3,933	1,326	687	1,271	1,638
Rotation Period (hours)	1,407.6	-5,832.5	23.9	24.6	9.9	10.7	17.2	16.1
Length of Day (hours)	4,222.6	2,802	24	24.7	9.9	10.7	17.2	16.1
The Average distance from the sun(10^6 km)	57.9	108.2	149.6	227.9	778.6	1,433.5	2,872.5	4,495.1
Orbital	88	224.7	365.3	687	4331	10,747	30,589	59,800

Period (days)								
Number of Satellites	0	0	1	2	67	53	27	13

The Mercury

- Mercury is the nearest planet to the sun and it is the smallest planet in the solar system. It does not have any satellite. It rotates on its own axis in 58.65 earth days while it takes 88 Earth days to complete one revolution around the sun. Mercury is 0.4 astronomical units away from the Sun. The sunlight takes 3.2 minutes to travel from the Sun to Mercury. Mercury is the second hottest planet though it is nearest to the sun.

The Venus

- 'Venus' is the second nearest planet to the sun. It is also called as 'Earth's Sister' planet due to its similar size and mass as that of our Earth. It is the hottest planet in the solar system and experiences a mean surface temperature of 462°C. It is popularly known as "Morning star and Evening star" It is seen in the east sky before sunrise (dawn) in the morning and in the west sky after the sunset (twilight). It rotates clockwise i.e. east to west direction on its own axis. The rotation and orbit of the Venus are unusual in several ways. Venus is one of just two planets that rotate from east to west. Only Venus and Uranus have this 'backwards' rotation. It completes one rotation in 243 Earth days which is the longest day of any planet in our solar system. The Venus takes 224.7 Earth days to complete one revolution around the sun, and it has no natural satellites. Venus is 0.7 astronomical units away from the sun. The sunlight takes 6 minutes to travel from the sun to Venus.

The Earth

- Earth is the third nearest planet to the sun. It is the fifth largest planet in the solar system. The Earth's orbit lies between the orbits of Venus and Mars. It takes 23 hours 56 minutes and 4 seconds for the earth to complete one rotation on its own axis. The Earth takes 365.25 days (Table 2.1) to complete one revolution around the Sun. Earth's surface temperature varies from - 88° to 58°C and it is the densest planet in the solar system.

- The Earth is a unique planet because of its distance from the sun, its motions, atmosphere with oxygen, presence of water and moderate temperature. The earth is neither too close nor too far from the sun. It is the only known planet to support life. It is also known as the 'Blue Planet' because of the presence of water. Earth has only one natural satellite called the Moon. The sun light takes about 8.3 minutes to reach the earth.

The Mars

- Mars is the fourth nearest planet to the sun and it is the second smallest planet in the Solar system. It is also described as the "Red planet". It is reddish in colour due to the presence of iron oxide on its surface. The landmass of Mars and Earth are very similar. It takes 24 hours and 37 minutesto complete one rotation on its axis and its takes 687 days to complete one revolution around the Sun. The surface temperature of the Mars is ranging from -153° to 20°C. With the exception of the Earth, Mars probably is the most hospitable to life. This planet has seasons, polar ice caps, volcanoes, canyons and weather. Mars has two satellites namely Phobos and Deimos.

The Jupiter

- Jupiter is the largest planet in the solar system. It is made primarily of gases and is therefore known as 'Giant Gas planet'. It takes 9 hours 55 minutes to complete one rotation on its axis and it takes 11.86 years to complete one revolution. Jupiter has the shortest day in the solar system. Jupiter has a faint ring system around it. They are mostly comprised of dust particles. Jupiter has 67 confirmed satellites orbiting the planet. Ganymede, the satellite of Jupiter, is the largest natural satellite in the solar system (even bigger than the planet Mercury).

The Saturn

- Saturn is the sixth planet from the sun and the second largest planet in the solar system. Saturn is called as the Ringed Planet. It is because of large, beautiful and extensive ring systems that encircles the planet. These rings are mostly made from the chunksof ice and carbonaceous dust. Saturn is the only planet in our solar system whose average density is less than water.

- The Saturn has 30 rings and 53confrmed natural satellites. The Saturn takes 10 hours 34 minutes to complete one rotation on its axis and it takes 29.4 years to complete one revolution around the sun.

The Uranus

- Uranus is the seventh planet from the sun and it is not visible to the naked eye. Like Venus, Uranus also rotates on its axis from east to west. Uranus is inclined on its axis at an angle of 98 degrees. The planet is almost lying on its side as it goes around the sun. The sunlight, thus, is received mostly in the polar areas. Hydrogen, helium and methane are the major gases of its atmosphere. It is very cold due to its great distance from the sun. Uranus is named after the ancient Greek god of the sky. It has a dense atmosphere primarily consisting of methane, which lends it a bluish-green appearance. Uranus also has rings and twenty-seven satellites.

The Neptune

- Neptune is the eighth planet from the sun. It takes 16 hours to complete one rotation on its own axis and it takes nearly 165 years to revolve around the sun. It has 13 natural satellites and 5 rings. It is the coldest planet in the Solar System because it is the farthest planet from the Sun. Neptune was the first planet located through mathematical calculations. Neptune is our solar system's windiest planet.

Dwarf Planets

- Dwarf planets are tiny planets in our solar system. Any celestial body orbiting around the sun, weighing for the self-gravity and nearly be round in shape is called 'Dwarf Planet'. It should not be a satellite of any planet. They are five in number Ceres, Pluto, Heumea, Makemake and Eris. As Pluto has not cleared the neighbourhood around its orbit, it is officially demoted in 2006 from its ninth position as a planet.

North Pole of the Uranus experiences 21 years of night time in winter, 21 years of daytime in summer and 42 years of day and night in the spring and fall.

Satellites

- The word 'Satellite' means companion. The moon was the only known satellite in the Solar System until 1610. Today, there are 163 known satellites in the Solar System. The satellites move around a planet from West to East. They do not have own light, but reflect the light of the Sun. They have no atmosphere and water.

Moon: the Earth's Satellite

- The moon is located at a distance of 8, 84,401 km from the earth (Figure 2.7). The moon revolves around the earth. The moon takes 27 days and 7 hours and 43 minutes for both its rotation and revolution around the earth.

- Hence, the observers on the earth could see only one side of the moon.The moon is the fifth largest natural satellite in the solar system. The moon was likely to be formed after a Mars-sized body collided with Earth. There are many craters, high and steep mountains of different sizes which cast shadows on the Moon's surface. The light which is reflected by the Moon will reach the Earth in just one and a quarter seconds.

Apollo 11 was the first manned mission to land on the Moon sent by NASA. Two American Astronauts Neil Armstrong and Edwin Aldrin set foot on the moon's surface on the waterless Sea of Tranquillity on 20th July, 1969. They stayed there for 21 hours 38 minutes and 21 seconds on the moon. Michael Collins piloted Apollo 11.

- Since the moon is smaller than the earth, it has 1/6 of the gravitational pull of the earth. So, man weighs 6 times less on the moon than the earth.

Asteroids

- Asteroids are small rocky celestial bodies that revolve around the Sun, like other planets. They are also called ‘Minor Planets’. Tere are lots of asteroids in the solar system. Larger asteroids are called Planetoids. Theseare found in between the planets Mars and Jupiter. Tis belt is known as ‘Asteroid belt’. The diameter of the asteroids varies from 100 km to a size of a pebble. The asteroids may be the fragments of a planet exploded in the past or some parts of comets. The new asteroids are being discovered continuously.

Comets

- Comets are the most exciting heavenly bodies and have ever been the objects of man’s curiosity as well as fear. The word Comet (Figure 2.8) is derived from the Greek word Aster Kometes meaning ‘Long Haired Star’. They are made up of small ice particles and meteoric fragments. They revolve around the Sun. But their orbits are irregular. Sometimes they get very close (Perihelion) to the sun and in other times they go far away (Aphelion) from the sun.

The best known Comet, Halley s Comet, appears once in every 76 years. The Halley s Comet was seen last in 1986 and it will be seen again on 28th July 2061.

Titan – only moon with clouds and atmosphere

Titan is Saturn’s largest moon and the second largest (after Ganymede of Jupiter) in the solar system. It is the only moon in the solar system with clouds and a dense, planet-like atmosphere.

Scientists believe that conditions on Titan are similar to Earth’s early years (the main difference is that, because of is closer to the sun, Earth has always been warmer). According to NASA, “In many respects, Titan, is one of the most Earth-like worlds we have found to date”.
Titan was discovered by Dutch astronomer Christiaan Huygens in 1655. The Huygens lander probe sent to the moon aborad NASA’s Cassini spacecraft by the European Space Agency is named in his honour. Huygens was the first human-built object to land on Titan’s surface. Diameter:5,150 kilometres, about half the size of Earth and almost as large as Mars. Surface temperature:-179 degrees Celsius, which makes water as hard as rocks and allows methane to be found in its liquid form. Surface pressure. Earth’s pressure at sea level is 1 bar while Titan’s is 1.6 bars. Orbital period: 15;945 days. Titan’s mass is composed mainly of water in the form of ice and rocky material. Titan has no magnetic field.

Meteors

- There is a bright streak of light flashing seen often in the sky during night for a few seconds. They are called as 'shooting stars'. They are the removed pieces of rocks mainly from the Asteroid belt. Tey are called Meteoroids before they enter into our atmosphere. Tey enter into the atmosphere with great speed. But most of them are burnt when they enter into the atmosphere.

- After entering into our atmosphere they are called as Meteors. Some pieces do not burn fully and they fall on the earth and make craters. The large unburned pieces of rocks that fall on the earth are called Meteorites.

- Examples for Meteorite Fall: Meteor crater in Northern Arizona and Lake Lonar in Buldhana District of Maharastra in India were created by meteor impacts.

Shape and size of the Earth

- It once was believed that the Earth was flat and that ships could sail over the edge. This view persisted even in the middle ages and was an issue in recruitment of Columbus.

- Early Greek view was that the world was surrounded by the ocean (Oceanus), origin of all rivers. Anaximander (600 B.C) proposed that cylindrical earth was surrounded by celestial sphere. Pythagoras (582-507 B.C.) believed that the Earth was a sphere, which was considered the most harmonious geometric shape. Aristotle (384-322 B.C.) described observations that supported the theory that the Earth was a sphere. These included the fact that the shadow of the moon is circular in lunar eclipses and constellations were higher in the sky as one travelled south. Eratosthenes

- (275-195 BCE) estimated size of earth from observations that the elevation of the sun varied with position on the Earth's surface in Egypt. Observations of the following suggested that the Earth is a sphere.

Mountain peaks lit by the Sun after sunset.

- Ships disappear below the horizon as they sail across ocean.

The moon looks like a disc.
The Earth casts a circular shadow during lunar eclipses.

- The Earth is an oblate spheroid, bulged at the equator and fattened at the poles. It is called 'Geoid' (Figure 2.9) meaning the earth is earth-shaped. The bulge at the equator is caused by the centrifugal force of the Earth's rotation. The gravitational pull of the earth is the strongest at the fattened poles and it is weaker towards the equator.

- The Sun's gravitational pull differs in force at the poles. The North Pole points in the same direction to the North Star when it revolves about the Sun. If the Earth would not have been tilted on its axis, the days and nights would have been of same duration always.

Motions of the earth

The earth has two basic movements: 1) Rotation and 2) Revolution.

Galactic movement: This is the movement of the earth with the sun and the rest of the solar system in an orbit around the centre of the MilkyWay Galaxy. This, however, has little effect upon the changing environment of the earth.

1. Rotation:

- The spinning of the earth around its axis is called the rotation of the earth. The axis is the imaginary line passing through the centre of the earth. The earth completes one rotation in 23 hours, 56 minutes and 4.09 seconds. It rotates in an eastward directionopposite to the apparent movement of the sun. The earth's axis is inclined at an angle of 66½0 to the orbital plane as it moves around the sun. We can say, the earths axis is tilted at an angle of 23½° (Figure 2.10) from a perpendicular to the elliptic plane. The velocity of earth's rotation varies depending on the distance of a given place from the equator.The rotational velocity at the poles is nearly zero. The greatest velocity of the rotation is found at the equator. The velocity of rotation at the equator is 1,670 km per hour.

Effects of earth's rotation: The rotation of the earth causes the following effects:

- The apparent rising and setting of the sun is actually caused by the earth's rotation which results in the alternate occurrence of day and night everywhere on the earth's surface.

- Rotation of the earth is also responsible for the difference in time between different places on the earth. A 24 hour period divided by 360 degreesgives a difference of 4 minutes for every degree of longitude that passes the sun. The hour (60 minutes) is thus 1/24 of a day.

- When you observe through a moving train, trees, houses and fields on the other side of the track appear to move in the direction opposite to that of the speeding train. The apparent movement of the sun and the other heavenly bodies in relation to the rotating earth is similar. As the earth rotates from west to east, the sun, moon, planets and stars appear to rise in the east and set in the west.

- Rotation causes the working of the Coriolis force which results in the deflection of the winds and the ocean currents from their normal path.

- Tide is caused by the rotation of the earth apart from the gravitational pull of the sun and the moon.

- Rotation causes a flattening of Earth at the two poles and bulging at the Equator. Hence, there is a difference in diameter at the poles and equator.

- Circle of Illumination: The line around the earth separating the light and dark is known as the circle of illumination (Figure 2.11).

- It passes through the poles and allows the entire earth to have an equal amount of time during the daylight and night time hours. This line can be seen from space, and the exact location of the line is dependent on the various seasons.

Revolution of the Earth

- The movement of the earth in its orbit around the sun in an anti-clockwise direction, that is, from west to east is called revolution of the earth. The earth revolvesin an orbit at an average distance of 150 million km. The distance of the earth from sun varies time to time due to the elliptical shape of the orbit. About January 3rd the earth is closest to the sun and it is said to be at Perihelion ('peri' means close to and Helios means sun). At Perihelion, the distance is 147 million km.

- Around July 4th the earth is farthest from the sun and it is said to be at Aphelion (Ap means away and Helios means sun). At Aphelion the distance of the earth is 152 million km away from the sun.

- The period taken by the earth to complete one revolution around the sun is 365 days and 6 hours (5 hours, 48 minutes and 45 seconds) or 365¼ days. The speedof the revolution is 1,07,000 km per hour. The speed is 30 km per second. The bullet from a gun travels with a speed of 9 km per second.

Period of Revolution and Leap year

- The period of time the earth takes to make one revolution around the sun determines the length of one year. The earth takes 365 days and 6 hours to complete one revolution. Earth takes 365.25 days to complete one trip around the Sun .That extra quarter of a day presents a challenge to our calendar system, which has one year as 365 days. To keep our yearly calendars consistent with our orbit around the Sun once in, every four years we add one day.

- The extra day added to is called a leap day, and the year the extra day is added to is called a leap year. The extra day is added to the month of February which has 29 days in a leap year.

Effects of revolution of the earth

- The revolution of the earth around the sun results in the following

Cycle of seasons,bVariation in length of days and nights,

- Variation in distribution of solar energy over the earth and the temperature zones.

Seasons

- The seasons are caused due to the combined effect of the earth's revolution and the tilt of its axis in the same direction throughout the year. In general, spring, summer, autumn and winter are the four seasons (Figure 2.12). The latitude atwhich the sun appears directly overhead changes as the earth orbits the sun. The sun appears to follow a yearly pattern of northward and southward motion in the sky, known as the 'apparent movement of the sun'. It gives an impression that the sun is continuously swinging north and south of the equator. Actually it is the earth that is moving around the sun on its tilted axis. It varies when observed on a daily and monthly basis, at different times of the year. On 21 March and 23 September the sun rises precisely in the east and sets exactly in the west.

Equinoxes and solstices

- You already knew that the sunrays are vertical at noon. The vertical rays fall on a small area, giving more heat.

Equinoxes

- Equinoxes occur when the earth reaches the points in its orbits where the equatorial and the orbital planes intersect, causing the sun to appear directly overhead at the equator. During the equinoxes the periods of day light and darkness are equal all over the world. On 21 March the sun is directly overhead at the equator. Throughout the world, on this day all the places experience almost equal hours of day and night. This position of the sun is called spring equinox. Again on 23 September the sun is directly overhead on the equator and it is called autumn equinox.

Position of the earth on 21 March

- Neither pole is inclined towards the sun. The rays of the sun fall vertically on the equator. All the places have equal days and nights as both the poles receive therays of the sun. It is spring in the northern hemisphere and autumn in the southern hemisphere. This day (21 March) is known as spring equinox.

Position of the earth on 23 September.

- Neither pole of the earth is inclined towards the sun. The rays of the sun fall vertically on the equator. All the places have equal days and nights. It is autumn in the northern hemisphere and spring in the southern hemisphere. Tis day (23 September) when sun's rays for fall vertically on the equator, is known as autumnal equinox (Figure 2.13).

Position of the earth on 21 June

- The North Pole is inclined or tilted towards the sun. It, therefore, experiences complete light for 24 hours. The South Pole is tilted away from the sun so it is in complete darkness for 24 hours. The rays of the sun fall vertically at the tropic of cancer (23½º N). In the Northern hemisphere, the days are longer than the nights (Table 2.2). It is summer in the northern hemisphere and winter in the southern hemisphere. The day 21 June is known as summer solstice.

Position of the earth on 22 December

- The South Pole is inclined towards the sun and the North Pole is away from it. The rays of the sun fall vertically at the tropic of Capricorn (23½º S). The greater part of the southern hemisphere gets the direct rays of the sun so the days are long and the nights are short here. In the northern hemisphere the nights are longer than the days at this time. The southern hemisphere has summer. The northern hemisphere has winter. This day (22 December), when the sun's rays fall vertically on the Tropic of Capricorn, is known as winter solstice.

Eclipses

- Let us understand the effect of the revolution of the earth on the length of the days and the nights. The duration of the daylight varies with latitude and seasons.

- An eclipse is a complete or partial obscuration of light from a celestial body and it passes through the shadow of another celestial body. The eclipses are of two types. They are:

Solar Eclipse

- It occurs on New Moon days, when the moon is between the Sun and the Earth. Thus it obscures a part of the Sun viewed from the Earth, but only from a small area of the world. It lasts only for a few minutes. A partial solar eclipse (Figure 2.14) happens when the moon partially covers the disc of the sun. An annular solar eclipse occurs when themoon passes centrally across the solar disc. During a total solar eclipse, the moon's shadow is short enough to cover the whole sun. The outer regions still glow and look bright as a ring. Such a phenomenon is called Diamond Ring

Geo connects History

Secret to Great Pyramid's Near Perfect Alignment Possibly Found!

The Great Pyramid of Giza, 4,500 years ago, is an ancient feat of engineering. Now an archaeologist has figured out how the Egyptians may have aligned the pyramid almost perfectly along the cardinal points, north-south-east-west. Egyptians may have used the autumn equinox. Methods used by the ancient Egyptians to align the pyramids along the cardinal points are accurate.

On the day of the fall equinox, a surveyor placed a rod into the ground and tracked its shadow throughout the day. The result was a line running almost perfectly east-west. Te Egyptians could have determined the day of the fall equinox by counting forward 91 days after the summer solstice.

Rotation	Revolution
Spinning of the earth from west to east on its axis	Movement of the earth around the sun in its elliptical orbit.
It takes 24 hours to complete a rotation (or a day)	It takes 365 ¼ days to complete on revolution (Or a year)
It is known as the daily or diurnal movement.	It is known as the annual movement of the earth.
Rotation causes days and nights to alternate, tides, deflection of winds and ocean currents and also gives the earth its shape.	Revolution results in the varying lengths of day and night,, changes in the altitude of the midday sun and change of seasons.

Lunar Eclipse

- It occurs on a Full Moon position when the earth is between the sun and the moon. The earth's shadow obscures themoon as viewed from the earth. A partial lunar eclipse can be observed when only a part of the moon's surface is obscured by earth's umbra (Figure 2.15). A penumbral lunar eclipse happens when the moon travels through the faint penumbral portion of the earth's shadow. A total lunar eclipse occurs when the earth umbra obscures the entire the moon's surface. Lunar eclipse can be seen from anywhere on the night side of the Earth. It lasts for a few hours due to the smaller size of the moon.

- The changing angles between the earth, the sun and the moon determine the phases of the moon. Phases of the moon (Figure 2.16) start from the 'New Moon' every month. Then, only a part of the Moon is seen bright called 'Crescent', which develops into the 'first quarter'. With the increasing brightness it turns into three quarters known as 'Gibbous' and then it becomes a 'Full Moon'. These stages are the waxing moon. After the full moon, the moon starts waning or receding through the stages of Gibbous, last quarter, crescent, andfinally becomes invisible as dark New Moon.

The varying lengths of daylight in different latitudes

- It is evident from the table that the duration of daylight is 12 hours throughout the year at the equator only. As one moves away from the equator, the seasonal variations in the duration of daylight increase. The seasonal variations in the duration of daylight are maximum at the polar region.

Effects of the spherical shape of the earth

Variation in the amount of solar radiation received:

- If the earth were a flat surface, oriented at right angle to the sun, all the places on the earth would have received the same amount of radiation. But the earth is spherical/ geoid. Hence the sunrays do not heat the higher latitudes of the earth as much as the tropics. On any given day only the places located atparticular latitude receive vertical rays from the sun. As we move north or south of this location, the sun's rays strike at decreasing angles. The yearly fluctuations in the angle of the sun's rays and the length of the days change with the continual change of the earth's position in its orbit around the sun at an inclination of 66½ to the orbital plane.

Difference in the angle of the sun's rays striking diferent parts of the earth.

- Away from the equator, the sun's rays strike the earth's surface at particular angle. The slanting rays are spread over a large area and do not heat with the same intensity as the direct rays. As we go pole wards, the rays spread over the regions beyond the Arctic and the Antarctic circles in an extremely slanting manner. This is how we get the various temperature zones.

- Lower the degree of latitude; higher the temperature. Not only that, the rays striking at a low angle must travel through a greaterthickness of the atmosphere than the rays striking at a higher angle. The rays striking at a lower angle are subject to greater depletion by refection and absorption by the atmosphere.

Temperature zones

- The spherical shape of the earth along with its movement around the sun causes differences in the angles at which the sun's rays fall on the earth's surface. This causes a difference in the distribution of heat on the earth's surface.

- As a result, the world has been divided into three distinct heat zones or temperature zones. They are the Torrid zone, Temperate zone and Frigid zone. You will learn more about it under the unit atmosphere.

Time Zones of the World

- People during the medieval period were using sundials and water clocks to observe the Sun's meridian passing at noon. In 17th century, the people started using pendulum clock which did not show accurate time while travelling in the sea. Later chronometer was invented in 1764. Chronometer measures time accurately and the mariners widely used this during the 19th century. But in many towns and cities clocks were set based on sunset and sunrise. The use of local solar time hindered the development of railways and telecommunications. A time zone is a region on the earth where uniform standard time should be maintained for transport, commercial and social purposes. For example, if different time zones were followed, the trains coming from different regions, sharing single track may meet with accidents.

- The world time zone (Figure 2.17) was formed, relating longitude and the rotation of the earth. The Prime Meridian is the centre of time zone extending from 7½°W and 7½ ° E longitudes. The 24 hours time zone system had been developed so that all the time zones should be referred with respect to Greenwich Mean Time. Earth was divided into 24 time zones, each one zone for one hour of the day. It is because earth rotates 15° of longitude in one hour (360° divided by 24 hours). The time when solar noon occurs at the Prime Meridian is fixed as noon for all places between 7½° E and 7½° W.

Daylight Saving Time

In the mid latitude countries of Europe, North America, Australia and South America, the day time are longer in summer than the night. In spite of employing daylight duration, the clocks are adjusted 1 hour forward in spring and 1 hour backward in autumn. This time is generally known as 'the Daylight Saving Time' (DST).

Time Zones

- On its axis, the earth rotates 360 degrees every 24 hours. You can look at it as it takes one day to complete a full circle. Divided up into an hourly rate, the earth rotates 15 degrees every hour (360/24). This number plays an important role in determining time zones. You have already learned about the latitudes and longitudes and their importance in the lower classes.

- An important factor in determining time zones is the lines of latitude and longitude, imaginary lines known as latitudes and longitudes dividing theearth. Latitude lines are drawn east - west and they measure the location in northern and southern hemisphere. The line starts at the equator and measure distance from 0 degrees to 90 degrees north and also 0 degrees to 90 degrees south. They also become shorter farther away from the equator. On the other hand, longitude lines are drawn north - south and they measure eastern and western hemisphere. They start at the Prime Meridian (or 0 degree) and measure from 0 degrees to 180 degrees east and 180 degrees west. Unlike lines of latitude, these lines are fairly equal in length. The origin of this spherical coordinate system is at 0 degree latitude and 0 degree longitude. This spot can be found in the Atlantic Ocean just south west of Africa. Also, the two lines connect at 180 degrees or at the International Date Line (Figure 2.18). This too helps to determining different time zones of the world.

- Together all of the above information can be used to calculate the difference of time between two locations. First, we need to know what longitudes the two places are located.

- Next, you would need to find the differences in longitude (in degrees) between the two places. If both places are located on the same side of the Prime Meridian, then the numbers are just simply subtracted to find the difference. If they are on the opposite side of the Prime Meridian then the two numbers should be added together to find the difference.

- Third, we need to divide the difference (measured in degrees) by 15 since there are 15 degrees in every hour. This will give us the difference in time between the two locations. So if you know what time it is in one location, and the longitude of another location, then just simple addition or subtraction problem will give us the time in a different time zone. Let's look at another way we may have to calculate the difference between times of two locations.

- Another calculation you may have to make is over the International Date Line. This line is strategically placed in the Pacific Ocean so that no two neighbouring cities are one day apart in time. It can be difficult to calculate though the International Date Line when trying to determine the amount of time difference between locations on either side. This calculation is very similar to the situation with the Prime Meridian. We must start by finding the difference in longitude (or degrees) of the two places. We do this by adding the two numbers. Then, divide by the 15 degrees that occurs in one hour and this will give you the time difference between two locations throughthe International Date Line. And again, just add or subtract that difference from the time that we already know to come up with the new time in the new time zone.

Example of Time Calculations

- To review, to find the difference between the two longitudes and divide by 15, this gives you the difference in hours between the two locations. Second, add or subtract the number of hours from the time of day that was already known, we will need to add the numbers if we are going east, and subtract if we are going west. Here are some examples of how we may need to calculate the difference of time zones.

- If you are in London at 12:00, and want to know what time it is in Japan, you would need to first figure out that London is 0 degrees (right on the prime meridian), and Japan is 135 degrees East. So the difference is 135 degrees (135-0), divided by 15 which equals 9. It means there is a 9-hour difference between London and Japan. Since Japan is further east than London is, you would add 9 hours to 12:00. The answer is at 12:00 noon London time, it is 9:00pm in Japan.

- Now we suppose imagine that we are going through the International Date Line. Pretend you are in Japan, which is 135 degrees east and you wanted to know what time it is in Hawaii, which is 150 West. Well, there is 45 (180-135) degrees difference between Japan and the IDL. Also there is 30 (180-150) degrees difference between the IDL and Hawaii. Therefore the difference in time is (45 + 30/15 = 5) 5 hours. Now the tricky part is that Japan and Hawaii are on different days. It is one day ahead on the left side of the IDL compared to the right side. If it is3:00pm in Japan on Thursday that means it is 3:00 + 5 hours = 8:00pm in Hawaii. However notice that when crossing the IDL we subtract a day going east. So, in Hawaii it is 8:00pm on Wednesday.

- Now note that Latitudinal lines are imaginary horizontal lines over the Earth's globe. 0° longitudinal line is Equator. Earth completes one rotation on its axis in 24 hours and in the process turns a complete circle of 360°. This means Earth rotates 360°/24 = 15° in one hour. Every gain or loss of 1° longitude stands for 4 minutes.

360° = 24 hours = 1440 min
Difference of time for 15° longitude = one hour.
Difference of time for 1° longitude = 4 minutes.

Longitude Calculations Procedures

First locate the two places involved
find the longitude difference
Convert the longitude difference to time and,
Adjust the time according to the direction of movement, (west or east).

Example 1

Ponni starts her journey at longitude 0° at 12 noon and she's moving towards eastward of longitude 10°. Calculate the time that Ponni will arrive at her destination.

Solution

Initial time = 12 noon
Destination = 10°E

Conversion of degree to time 1 hour =15°
and 4 minutes =1°
Hence 10° = (4 x 10) minutes
= 40 minutes
Destination time = Initial time + calculated time
= 12 noon + 40minutes
= 12:40pm

Example 2

If the time at village A (long 75° W) is 5:00 pm on Friday. Calculate the time and day at village B (long 120°E)

Solution

360° = 24hrs
15° = 1 hour
1° = 4 minutes
Village A = 75°W
Village B = 120°E
We will add (west and east)
(75 + 120)° = 195°
195 divided by 15°= 13hrs
Destination time = initial + calculatedtime
= 5:00 + 13hrs
= 18:00
18:00 = 6:00

Answer = 6:00am on Saturday

Example 3

Calculate the local time in New York (USA) longitude 75°W, when it is 10am in Nigeria of longitude 15°E

Solution

Initial time = 10:00am
New York = 75°W
Nigeria = 15° E We will add (west and east)
(75 + 15)° = 90°
90° divided by 15° = 6 hrs
Destination time = initial + calculated time
= 10:00am + 6hrs
= 14:00pm
14:00pm = 4:00pm

Answer = 4:00pm

Physical Quantities

9th book

Unit – 1 Measuremet

Physical Quantities and Units

Physical quantities

Physical quantity is a quantity that can be measured. Physical quantities can be classified into two: fundamental quantities and derived quantities. Quantities which cannot be expressed in terms of any other physical quantities are called fundamental quantities. Example: Length, mass, time, temperature etc. Quantities which can be expressed in terms of fundamental quantities are called derived quantities. Example: Area, volume and density etc.

Physical quantities have a numerical value and a unit of measurement (say, 3 kilogram). Suppose you are buying 3 kilograms of vegetable in a shop. Here, 3 is the numerical value and kilogram is the unit. Let us study about units now.

Units

A unit is a standard quantity with which the unknown quantities are compared. It is defined as a specific magnitude of a physical quantity that has been adopted by law or convention. For example, feet is the unit for measuring length. That means, 10 feet is equal to 10 times the definite pre-determined length, called feet

Earlier, different unit systems were used by people from different countries. Some of the unit systems followed earlier are given below in foot is the singular of feet

System	Length	Mass	Time
CGS	centimetre	gram	Second
FPS	foot	pound	Second
MKS	metre	kilogram	second

But, at the end of the Second World War there was a necessity to use worldwide system of measurement. Hence, SI (International System of Units) system of units was developed and recommended by General Conference on Weights and Measures at Paris in 1960 for international usage.

SI System of Units

SI system of units is the modernised and improved form of the previous system of units. It is accepted in almost all the countries. It is based on a certain set of fundamental units from which derived units are obtained by proper combination. There are seven fundamental units in the SI system of units. They are also known as base units and they are given in **Table 1.2**

The units used to measure the fundamental quantities are called fundamental units and the units which are used to measure the derived quantities are called derived units.

Table 1.2 Fundamental quantities and their units

Fundamental quantities	Unit	Symbol
Length	metre	M
Mass	kilogram	KG
Time	second	S
Eletirc current	ampere	A
Luminous intensity	candela	CD
Amount of substance	mole	MOL

S.No	Physical quantity	Expression	Unit
1	Area	length × breadth	M2
2	Volume	area × height	M2
3	Density	mass / volume	Kgm3
4	Velocity	displacement / time	Ms-1
5	Momentum	mass × velocity	mass × velocity
6	Acceleration	velocity / time	Ms-2
7	Force	mass × acceleration	Kgms-2 or N
8	Pressure	force / area	Nm-2 or Pa
9	Energy (work)	force × distance	Nm or J
10	Surface tension	force / length	Nm–A

In order to measure very large distance (distance of astronomical objects) we use the following units.

- Astronomical unit
- Light year
- Parsec

Astronomical unit (AU): It is the mean distance of the centre of the Sun from the centre of the Earth. 1 AU = 1.496 × 10 11 m (Figure 1.1).

Light year: It is the distance travelled by light in one year in vacuum and it is equal to 9.46 × 1015 m.

Parsec: Parsec is the unit of distance used to measure astronomical objects outside the solar system.
1 Parsec = 3.26 light year.

Larger units	In metre
Kilometre (km)	103 m
Astronomical unit(AU)	1.496 × 1011 m
Light year (ly)	9.46 × 1015 m
Parsec (pc)	3.08 × 1016 m

The nearest star alpha centauri is about 1.34 parsec from the sun. Most of the stars unaided eye in the night sky are within 500 parsec distance from the sun.

To measure small distances such as distance between two atoms in a molecule, size of the nucleus and wavelength etc. we use submultiples of ten. These quantities are measured in Angstrom unit (Table 1.5).

Smaller units	In metre
Fermi (f) *	10^{-15} m
Angstrom (A°)*	10^{-10} m
Nanometre (nm)	10^{-9} m
Micron (micrometre μ m)	10^{-6} m
Millimetre (mm)	10^{-3} m
Centimetre (cm)	10^{-2} m

* Unit outside SI system and still accepted for use.
Mass

Mass

Mass is the quantity of matter contained in a body. The SI unit of mass is kilogram (kg). One kilogram is the mass of a particular international prototype cylinder made of platinum-iridium alloy, kept at the International Bureau of Weights and Measures at Sevres, France.

The units gram (g) and milligram (mg) are the submultiples of ten (1/10) of the unit kg. Similarly quintal and metric tonne are multiples of ten (× 10) of the unit kg.

1 g = 1/1000 × 1 kg = 0.001 kg
1 mg = 1/1000000 × 1 kg = 0.000001 kg
1 quintal = 100 × 1 kg = 100 kg
1 metric tonne = 1000 × 1 kg = 10 quintal

Atomic mass unit

Mass of a proton, neutron and electron can be determined using atomic mass unit (amu).

1 amu = (1/12)th of the mass of C12 atom

Time

Time is a measure of duration of events and the intervals between them. The SI unit of time is second. One second is the time required for the light to propagate 29,97,92,458 metres through vacuum. It is also defined as 1/86, 400th part of a mean solar day. Larger units for measuring time are day, month, year and millennium etc. 1 millenium = 3.16 × 109 s.

Temperature

Temperature is the measure of hotness or coldness of a body. SI unit of temperature is kelvin (K). One kelvin is the fraction (1/273.16) of the thermodynamic temperature of the triple point of water (The temperature at which saturated water vapour, pure water and melting ice are in equilibrium). Zero kelvin (0 K) is commonly known as absolute zero. The other units for measuring temperature are degree celsius (°C) and fahrenheit (F).

Unit Prefixes

Unit prefixes are the symbols placed before the symbol of a unit to specify the order of magnitude of a quantity. They are useful to express very large or very small quantities. k(kilo) is the unit prefix in the unit, kilogram. A unit prefix stands for a specific positive or negative power of 10. k stands for 1000 or 103. Some unit prefixes are given in Table-6.

The physical quantities vary in different proportion like from 10-15 m being the diameter of nucleus to 1026 m being the distance between two stars and 9.11 × 10 31 kg being the electron mass to 2.2 × 1041 kg being the mass of the milky way galaxy.

Power of 10	Prefix	Symbol
10^{15}	peta	P
10^{12}	Tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	Kilo	k
10^{2}	hecto	h
10^{1}	deca	da
10^{-1}	deci	d
10^{-2}	Centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n

10^{-12}	Pico	p
10^{-15}	femto	f

Rules and Conventions for Writing Si Units and their Symbols

1. The units named after scientists are not written with a capital initial letter. E.g. newton, henry, ampere and watt.
2. The symbols of the units named after scientists should be written by the initial capital letter. E.g. N for newton, H for henry, A for ampere and W for watt.
3. Small letters are used as symbols for units not derived from a proper noun. E.g. m for metre, kg for kilogram.
4. No full stop or other punctuation marks should be used within or at the end of symbols. E.g. 50 m and not as 50 m.
5. The symbols of the units are not expressed in plural form. E.g. 10 kg not as kgs.
6. When temperature is expressed in kelvin, the degree sign is omitted. E.g. 283 K not as 283° K (If expressed in Celsius scale, degree sign should be included e.g. 100° C not as 100 C, 108° F not as 108 F).
7. Use of solidus is recommended for indicating a division of one unit symbol by another unit symbol. Not more than one solidus is used. E.g. ms-1 or m/s. J/K/mol should be JK-1 mol-1
8. The number and units should be separated by a space. E.g.15 kgms-1 not as 15kgms-1.
9. Accepted symbols alone should be used. E.g. ampere should not be written as amp and second should not be written as sec.
10. The numerical values of physical quantities should be written in scientific form. E.g. the density of mercury should be written as 1.36 × 104 kg m-3 not as 13600 kg m-3.

Screw Gauge

In our daily life, we use metre scale for measuring lengths. They are calibrated in cm and mm scales. The smallest length which can be measured by metre scale is called least count. Usually the least count of a scale is 1 mm. We can measure the length of objects up to mm accuracy using this scale. But this scale is not sufficient for measuring the size of small spherical objects. So, Vernier caliper and screw gauge are used.

- ❖ Can you ask for milligram measures of groceries or gram measures of rice from the nearby shop? Can you ask for millimetre measure of cloth? What are the things that you could buy in smaller measures? Why?

Vernier scale

The diameters of spherical objects such as cricket ball and hollow objects such as a pen cap cannot be measured with a meter scale. For that we use an instrument named Vernier caliper which can measure the inner and outer diameters of objects.

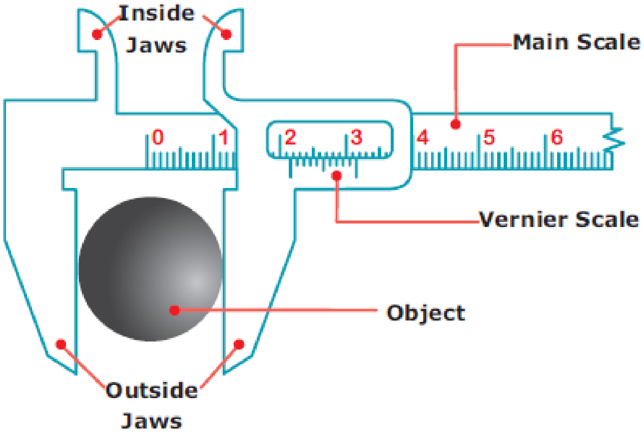
Pierre Vernier (1580 - 1637) was a French government official. Vernierwas taught mathematics and science by his father who was a lawyer and engineer. He worked much of the time as an engineer, working on the fortifications of various cities. Like many other mathematicians and scientists of that period, Vernier worked on cartography and on surveying. His interest in surveying led him to develop instruments for surveying and this prompted the invention of a precise instrument called Vernier caliper.

Description of Vernier caliper

The Vernier caliper consists of a thin long steel bar graduated in cm and mm. This is the main scale. To the left end of the steel bar an upper and a lowerjaw are fixed perpendicular to the bar. These are named as fixed jaws. To the right of the fixed jaws, a slider with an upper and a lower moveable jaw is fixed. The slider can be moved or fixed to any position using a screw. The Vernier scale is marked on the slider and moves along with the movable jaws and the slider. The lower jaws are used to measure the external dimensions and the upper jaws are used to measure the internal dimensions of objects. The thin bar attached to the right side of the Vernier scale is used to measure the depth of hollow objects.

Usage of Vernier caliper

The first step in using the Vernier caliper is to find out its least count, range and zero error.



Least count

Least count of the instrument (L.C)

$$= \frac{Value\ of\ one\ smallest\ main\ scale\ division}{Total\ number\ of\ vernier\ scale\ division}$$

The main scale division can easily be obtained by inspecting the main scale. It will be in centimeter, further divided into millimetre. The value of the smallest main scale division is 1 mm. The Vernier scale division is obtained by counting number of division in it. In the Vernier scale there will be 10 divisions.

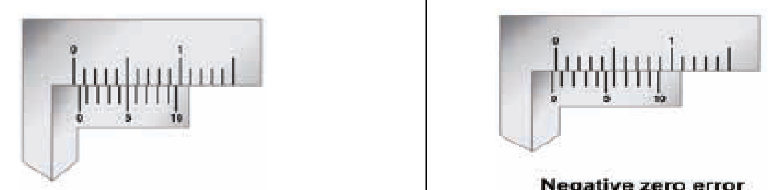
$$L.C = \frac{1mm}{10} = 0.1mm = 0.01cm$$

Zero error

Unscrew the slider and move it to the left, such that both the jaws touch each other. Check whether the zero marking of the main scale coincides with that of the Vernier scale. If they are not coinciding with each other, the instrument is said to possess zero error. Zero error may be positive or negative. If the zero mark of the Vernier is shifted to the right, it is called positive error. On the other hand, if the Vernier zero is shifted to the left of the main scale zero marking, and then the error is negative.

Positive zero error

Figure 3(a) shows the positive zero error. From the figure you can see that zero of the vernier scale is shifted to the right of zero of the main scale. In this case the reading will be more than the actual reading. Hence, this error should be corrected. In order to correct this error, find out which vernier division is coinciding with any of the main scale divisions. Here, fifth vernier division is coinciding with a main scale division. So, positive zero error = +5 x LC = +5 x 0.01 = 0.05 cm.



a. Positive zero error

b. Negative zero error

Figure 3 Positive zero error Negative zero error

Negative zero error

Now look at the Figure 3(b). You can see that zero of the vernier scale is shifted to the left of the zero of the main scale. So, the obtained reading will be less than the actual reading. To correct this error we should first find which vernier division is coinciding with any of the main scale divisions, as we found in the previous case. In this case, you can see that sixth line is coinciding. But, to find the negative error, we can count backward (from 10). So, the fourth line is coinciding. Therefore, negative zero error = –4×LC = –4×0.01 = –0.04 cm.

Example:

Calculate the positive and negative error from the given Figure 4.

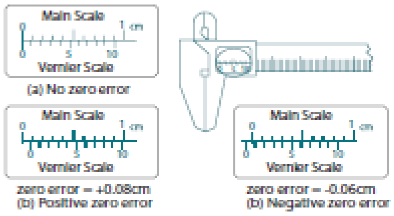


Figure 4 Zero error

Solution:

Case (a): Zero of the vernier scale and zero of the main scale are coinciding with each other. So there is no zero error.

Case (b): The zero of veriner scale is shifted to the right from the zero of the main scale. It is positive error. The 8th division of vernier scale coincides with one of the main scale divisions. So the positive error = (8×0.01cm) = 0.08 cm.

Case (c): The zero of veriner scale is shifted to the left from the zero of main scale. It is negative error. The 4th division of vernier scale (6th from backward) coincides with one of the main scale divisions. So the negative zero error = –(6×0.01cm)= –0.06 cm.

Once you are able to calculate the zero error, you can get the correct reading using the formula:

The correct reading = Main scale reading + (VC × LC) ± (Zero correction)

Zero Correction:

If error is positive the we should subtract that error value. If error is negative, we should add that error value.

For example, let us calculate the correct reading, if the main scale reading is 8 cm, vernier coincidence is 4 and positive zero error is 0.05 cm,

The correct reading = 8 cm + (4 × 0.01cm)- 0.05 cm = 8 + 0.04 - 0.05 = 8 -0.01 =7.99 cm

Let us try another one. The main scale reading is 8 cm and vernier coincidence is 4 and negative zero error is 0.02 cm, then the correct reading:

= 8 cm+(4×0.01 cm)+(0.02 cm)

= 8+0.04+0.02 = 8.06 cm.

We can use Vernier caliper to find different dimensions of any familiar object. If the length, width and height of the object can be measured, volume can be calculated. For example, if we could measure the inner diameter of a beaker (using appropriate jaws) as well as its depth (using the depth probe) we can calculate its inner volume.

Example:
Calculate the diameter of the sphere which is shown in the Figure 5. Assume the scale has no zero error.

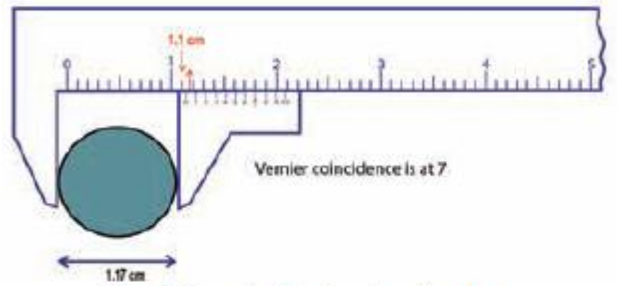


Figure 5 Measuring the diameter of a sphere

The diameter (D) of the sphere = Main scale reading (MSR) + (Vernier scale coincidence (VC) × least count (LC))± ZE. In this case the zero of the vernier scale is right after the main scale reading 1.1. So the main scale reading is 1.1 cm. The vernier scale coincidence is 7. The least count is 0.01 cm. The diameter of the sphere = 1.1 cm + (7 × 0.01cm)–0 = 1.1 + 0.07 = 1.17 cm.

Digital Vernier caliper

Today, we are living in a digital world and the digital version of the vernier callipers are available now. Digital Vernier caliper (Figure 6) has a digital display onthe slider, which calculates and displays the measured value. The user need not manually calculate the least count, zero error etc.

Figure 6 Digital Vernier caliper

Screw Gauge

Measurements made with a Vernier caliper can be made in centimetre only. Hence to measure the length and thickness of very small objects we use a screw gauge. This instrument can measure the dimensions upto 1/100th of a millimetre or 0.01 mm. With the screw gauge it is possible to measure the diameter of a thin wire and the thickness of thin metallic plates.

Description of screw gauge

The screw gauge consists of a U shaped metal frame. A hollow cylinder is attached to one end of the frame. Grooves are cut on the inner surface of the cylinder through which a screw passes (Figure 7).On the cylinder parallel to the axis of the screw there is a scale which is graduated in millimetre called Pitch Scale (PS). One end of the screw is attached to a sleeve. The head of the sleeve (Thimble) is divided into 100 divisions called the Head scale.

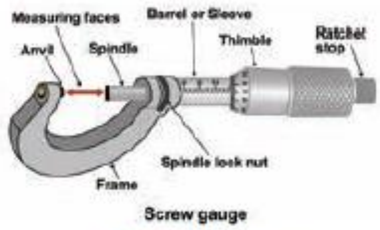


Figure 7 Screw gauge

The end of the screw has a plane surface (Spindle). A stud (Anvil) is attached to the other end of the frame, just opposite to the tip of the screw. The screw head is provided with a ratchat arrangement (safety device) to prevent the user from exerting undue pressure.

Using the screw gauge

The screw gauge works on the principal that when a screw is rotated in a nut, the distance moved by the tip of the screw is directly proportional to the number of rotations.

Pitch of the screw

The pitch of the screw is the distance between two successive screw threads. It is also equal to the distance travelled by the tip of the screw for one complete rotation of the head. It is equal to 1 mm in typical screw gauges.

$$\text{Pitch of the screw} = \frac{Distance\ moved\ by\ the\ Pitch}{No.of\ rotations\ by\ Head\ scale}$$

Least count of a screw gauge

The distance moved by the tip of the screw for a rotation of one division on the head scale is called the least count of the screw gauge.

Least count of the instrument (L.C.)

$$= \frac{Value\ of\ one\ smallest\ pitch\ scale\ reading}{Total\ number\ of\ Head\ scale\ division}$$

LC= — =0.01 mm

Zero Error of a screw gauge

When the plane surface of the screw and the opposite plane stud on the frame area brought into contact, if the zero of the head scale coincides with the pitch scale axis there is no zero error (Figure 8).

Positive zero error

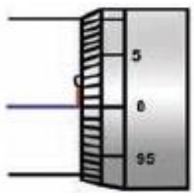
When the plane surface of the screw and the opposite plane stud on the frame are brought into contact, if the zero of the head scale lies below the pitch scale axis, the zero error is positive (Figure 9). For example, the 5th division of the head scale coincides with the pitch scale axis, then the zero error is positive and is given byZ.E = + (n × LC) where ‘n’ is the head scale coincidence. In this case, Zero error = + (5 × 0.01) = 0.05mm. So the zero correction is – 0.05 mm.

Negative zero error

When the plane surface of the screw and the opposite plane stud on the frame are brought into contact, if the zero of the head scale lies above the pitch scale axis, the zero error is negative (Figure 10). For example, the 95th division coincides with the pitch scale axis, then the zero error is negative and is given by

$$ZE = -(100 - n) \times LC$$
$$ZE = -(100 - 95) \times LC$$
$$= -5 \times 0.01$$
$$= -0.05 \text{ mm}$$

The zero correction is + 0.05mm.

		
F. 8 No zero error	**F. 9 Positive Zero error**	**F.10 Negative Zero Error**

To measure the thickness of a thin coin using a screw gauge

- Determine the pitch, the least count and the zero error of the screw gauge
- Place the coin between the two studs
- Rotate the head until the coin is held firmly but not tightly, with the help of the ratchat
- Note the reading of the pitch scale crossed by the head scale (PSR) and the head scale division that coincides with the pitch scale axis (HSC)
- The width of the coin is given by PSR + CHSR (Corrected HSR). Repeat the experiment for different positions of the coin
- Tabulate the readings
- The average of the last column readings gives the width of the coin

❖ The shell of an egg is 12%of its mass. A blue whale can weigh as much as 30 elephants and it is as long as 3 large tour buses.

Measuring Mass

We commonly use the term 'weight' which is actually the 'mass'. Many things are measured in terms of 'mass' in the commercial world. The SI unit of mass is kilogram. In any case, the units are based on the items purchased. For example, we buy gold in gram or milligram, medicines in milligram, provisions in gram and kilogram and express cargo in tonnes.

Can we use the same instrument for measuring the above listed items? Different measuring devices have to be used for items of smaller and larger masses. In this section we will study about some of the instruments used for measuring mass.

Common (beam) balance

A beam balance compares the sample mass with a standard reference mass. (Standard reference masses are 5g, 10g, 20g, 50g, 100g, 200g, 500g, 1kg, 2kg, 5kg). This balance can measure mass accurately up to 5g (Figure 11).

Two pan balance

This type of balance is commonly used in provision and grocery shops (Figure 12). This balance compares the sample mass with the standard reference mass. The pans rest on top of the beam and can be conveniently placed on a table top. This balance can measure mass accurately upto 5 g.

Physical balance

This balance is used in labs and is similar to the beam balance but it is a lot more sensitive and can measure mass of an object correct to a milligram (Figure 13).The standard reference masses used in this physical balance are 10 mg, 20 mg, 50 mg, 100 mg, 200 mg, 500 mg, 1 g, 2g, 5 g, 10 g, 20 g, 50 g, 100g, and 200 g.

Digital balance

Nowadays for accurate measurements digital balances are used, which measures mass accurately even up to a few milligrams, the least value being 10 mg (Figure 14). This electrical device is easy to handle and commonly used in jewellery shops and labs.

Spring balance

This balance helps us to find the weight of an object. It consists of a spring fixed at one end and a hook attached to a rod at the other end. It works by 'Hooke's law' which explains that the addition of weight produces a proportional increase in

the length of the spring (Figure 15). A pointer is attached to the rod which slides over a graduated scale on the right. The spring extends according to the weight attached to the hook and the pointer reads the weight of the object on the scale.
Solve – The mass of 40 apples in a box is 10 kg. (i) Find the mass of a dozen of them (ii) Express the mass of one apple in gram.

Figure 11 Common beam balance

Figure 12 Two pan balance

Figure 13 Physical balance

Figure 14 Digital balance

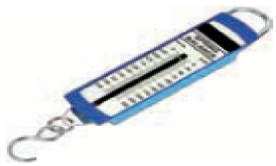


Figure 15 Spring balance

Difference between mass and weight

Mass (m) is the quantity of matter contained in a body. Weight (w) is the normal force (N) exerted by the surface on the body to balance against gravitational pull on the object. In the case of spring scale the tension in the spring balances the gravitational pull on the object. When the man is standing on the surface of the earth or floor, the surface exerts a normal force on the body which is equivalent to gravitational force. The gravitational force acting on the object is given by 'mg'. Here m is mass of the object and 'g' is acceleration due to gravity.
If a man has a mass 50 kg on the earth, then what is his weight?

Weight (w) = mg
Mass of a man = 50 kg
His weight = 50 × 9.8
w = 490 newton

No	Mass	Weight
1.	Fundamental quantity	Derived quantity
2.	Has magnitude alone-scalar quantity	Has magnitude and direction vector quantity
3.	It is the amount of matter contained in a body	It is the normal force exerted by the surface on the object against gravitational pull
4.	Remains the same	Varies from place to place
5.	It is measured using physical balance	It is measured using spring balance
6.	Its unit is kilogram	Its unit is newton

The pull of gravity on the Moon is 1/6 times weaker than that on the Earth. This causes the weight of the object on the Moon to be less than that on the Earth.Acceleration due to gravity on the Moon = $1.63 m/s^2$. If the mass of a man is 70 kg then his weight on the Earth is 686 N and on the Moon is 114 N. But his mass is still 70 kg on the Moon.

Accuracy in Measurements

When measuring physical quantities, accuracy is important. Accuracy represents how close a measurement comes to a true value. Accuracy in measurement is centre in engineering, physics and all branches of science. It is also important in our daily life. You might have seen in jewellery shops how accurately they measure gold. What will happen if little more salt is added to food while cooking? So, it is important to be accurate when taking measurements.

Faulty instruments and human error can lead to inaccurate values. In order to getaccurate values of measurement, it is always important to check the correctness of the measuring instruments. Also, repeating the measurement and getting the average value can correct the errors and give us accurate value of the measured quantity.

11th Physics

1st lesson

NATURE OF PHYSICAL WORLD AND MEASUREMENT

SIGNIFICANT FIGURES

Definition and Rules of Significant Figures

Suppose we ask three students to measure the length of a stick using metre scale (the least count for metre scale is 1 mm or 0.1 cm). So, the result of the measurement (length of stick) can be any of the following, 7.20 cm or 7.22 cm or 7.23 cm. Note that all the three students measured first two digits correctly (with confidence) but last digit varies from person to person. So, the number of meaningful digits is 3 which communicate both measurement (quantitative) and also the precision of the instrument used. Therefore, significant number or significant digit is 3. It is defined as **the number of meaningful digits which contain numbers that are known reliably and first uncertain number.**

Examples: The significant figure for the digit 121.23 is 5, significant figure for the digit 1.2 is 2, significant figure for the digit 0.123 is 3, significant digit for 0.1230 is 4, significant digit for 0.0123 is 3, significant
digit for 1230 is 3, significant digit for 1230 (with decimal) is 4 and significant digit for 20000000 is 1 (because 20000000=2 × 107 has only one significant digit, that is, 2).

In physical measurement, if the length of an object is l = 1230 m, then significant digit for l is 4.

The rules for counting significant figures are given in Table 1.9.

EXAMPLE

State the number of significant figures in the following

i) 600800 iv) 5213.0 ii) 400 v) 2.65 × 1024 m iii) 0.007 vi) 0.0006032

Solution: i) four ii) one iii) one iv) five v) three vi) four

Rounding Off

Calculators are widely used now-a-days to do calculations. The result given by a calculator has too many figures. In no case should the result have more significant figures than the figures involved in the data used for calculation. The result of calculation with numbers containing more than one uncertain digit should be rounded off. The rules for rounding off are shown in Table 1.10.

EXAMPLE

Round off the following numbers as indicated

i) 18.35 up to 3 digits ii) 19.45 up to 3 digits iii) 101.55 × 106 up to 4 digits iv) 248337 up to digits 3 digits v) 12.653 up to 3 digits

ii)

Table 1.9 Rules for counting significant figures

	Rule	Example
i)	All non-zero digits are significant	1342 has **four** significant figures
ii)	All zeros between two non zero digits are significant	2008 has **four** significant figures
iii)	All zeros to the right of a non-zero digit but to the left of a decimal point are significant.	30700. has **five** significant figures
iv)	a) For the number without a decimal point, the terminal or trailing zero(s) are not significant.	a) 30700 has **three** significant figures
	b) All zeros are significant if they come from a measurement	b) 30700 m has **five** significant figures
v)	If the number is less than 1, the zero (s) on the right of the decimal point but to left of the first non zero digit are not significant.	0.00345 has **three** significant figures
vi)	All zeros to the right of a decimal point and to the right of non-zero digit are significant.	40.00 has **four** significant figures and 0.030400 has **five** significant figures
vii)	The number of significant figures does not depend on the system of units used	1.53 cm, 0.0153 m, 0.0000153 km, all have **three** significant figures

Note: 1 Multiplying or dividing factors, which are neither rounded numbers nor numbers representing measured values, are exact and they have infinite numbers of significant figures as per the situation. For **example,** circumference of circle $S = 2\pi r$, Here the factor 2 is exact number. It can be written as 2.0, 2.00 or 2.000 as required.

Note: 2 The power of 10 is irrelevant to the determination of significant figures.

For **example** $x = 5.70 \text{ m} = 5.70 \times 10^2 \text{ cm} = 5.70 \times 10^3 \text{ mm} = 5.70 \times 10^{-3} \text{ km}$.

In each case the number of significant figures is **three.**

Table 1.10 Rules for Rounding Off

Rule	Example
i) If the digit to be dropped is smaller than 5, then the preceding digit should be left unchanged.	i) 7.32 is rounded off to 7.3 ii) 8.94 is rounded off to 8.9
ii) If the digit to be dropped is greater than 5, then the preceding digit should be increased by 1	i) 17.26 is rounded off to 17.3 ii) 11.89 is rounded off to 11.9
iii) If the digit to be dropped is 5 followed by digits other than zero, then the preceding digit should be raised by 1	i) 7.352, on being rounded off to first decimal becomes 7.4 ii) 18.159 on being rounded off to first decimal, become 18.2
iv) If the digit to be dropped is 5 or 5 followed by zeros, then the preceding digit is not changed if it is even	i) 3.45 is rounded off to 3.4 ii) 8.250 is rounded off to 8.2
v) If the digit to be dropped is 5 or 5 followed by zeros, then the preceding digit is raised by 1 if it is odd	i) 3.35 is rounded off to 3.4 ii) 8.350 is rounded off to 8.4

Mechanics and properties of matter

11th vol II
UNIT 7: PROPERTIES OF MATTER

Microscopic understanding of various states of matter:

- In extreme environments, matter can exist in other states such as plasma, Bose-Einstein condensates. Additional states, such as quark-gluon plasmas are also believed to be possible. A major part of the atomic matter of the universe is hot plasma in the form of rarefied interstellar medium and dense stars.

- If a body regains its original shape and size after the removal of deforming force, it is said to be elastic and the property is called elasticity. The force which changes the size or shape of a body is called a deforming force.

Examples: Rubber, metals, steel ropes

- If a body does not regain its original shape and size after removal of the deforming force, it is said to be a plastic body and the property is called plasticity. Example: Glass

Stress:

When a body is subjected to such a deforming force, internal force is developed in it, called as restoring force. The SI unit of stress is $N\,m^{-2}$ or pascal (Pa) and its dimension is $[M\,L^{-1}T^{-2}]$. Stress is a tensor.

$$\boldsymbol{stress, \sigma = \frac{Force}{Area} = \frac{F}{A}}$$

Types of stress:

1. Tangential or shearing stress
2. Longitudinal or perpendicular stress:
   a) Compressive stress
   b) Tensile stress
3. Volume stress: pressure exerted on a body which is immersed in a liquid.

Strain:

- Strain measures the degree of deformation and is a dimensionless quantity.

$$\boldsymbol{strain, \varepsilon = \frac{change\ in\ size}{original\ size} = \frac{\Delta l}{l}}$$

$$\boldsymbol{longitudnal\ strain, \varepsilon_l = \frac{increase\ in\ length\ of\ the\ rod}{original\ length\ of\ the\ rod} = \frac{\Delta l}{l}}$$

Tensile strain: If the length is increased from its natural length
Compressive strain: If the length is decreased from its natural length

$$shearing\ strain, \varepsilon_s = \frac{x}{h} = \tan\theta \approx \theta = angle\ of\ shear$$

$$volume\ strain, \varepsilon_V = \frac{\Delta V}{V}$$

Elastic limit:

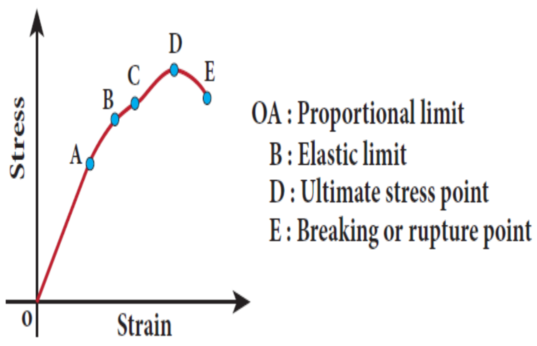
- The maximum stress within which the body regains its original size and shape after the removal of deforming force is called the elastic limit.

Hooke's law states that the stress is proportional to the strain in the elastic limit.

$$\sigma \propto \varepsilon$$

Stress- strain curve:

The point A is called limit of proportionality because above this point Hooke's law is not valid. The slope of the line OA gives the Young's modulus of the wire.
The point B is known as yield point (elastic limit).
If the wire is stretched beyond the point B (elastic limit), stress increases and the wire will not regain its original length after the removal of stretching force.



- ✓ The maximum stress (here D) beyond which the wire breaks is called *breaking stress* or *tensile strength.* The corresponding point D is known as *fracture point*. The region BCDE represents the plastic behaviour of the material of the wire.

Moduli of elasticity:

$$young\ modulus, Y = \frac{longitudnal\ stress}{longitudnal\ strain} = \frac{\sigma_l}{\varepsilon_l}$$

The SI unit of young modulus is $N\ m^{-2}$or pascal (Pa)

$$bulk\ modulus, K = \frac{normal\ stress}{volume\ strain} = -\frac{\sigma_n}{\varepsilon_V} = -\frac{\Delta P}{\frac{\Delta V}{V}}$$

The SI unit of bulk modulus is $N\ m^{-2}$or pascal (Pa).

$$\text{rigidity modulus or shear modulus}, \eta_R = \frac{\text{shearing stress}}{\text{shearing strain}} = \frac{\sigma_s}{\varepsilon_s} = \frac{\frac{F_t}{\Delta A}}{\theta}$$

The SI unit of rigidity modulus is $N\ m^{-2}$ or pascal (Pa).

Compressibility:

- The reciprocal of the bulk modulus is called compressibility. It is defined as the fractional change in volume per unit increase in pressure. Since, gases have small value of bulk modulus than solids, their, values of compressibility is very high

$$\boldsymbol{compressibility, C = \frac{1}{K} = -\frac{\varepsilon_V}{\sigma_n} = -\frac{\frac{\Delta V}{V}}{\Delta P}}$$

In a cycle, the tyre should be less compressible for its easy rolling. In fact the rear tyre is less compressible than front tyre for a smooth ride.

Materials	Young modulus(Y) 10^{10} N m^2	Bulk modulus(k) 10^{10} N m^2	Shear modulus(n_g) 10^{10} N m^2
steel	20.0	15.8	8.0
Aluminium	7.0	7.0	2.5
Copper	12.0	12.0	4.0
Iron	19.0	8.0	5.0
glass	7.0	3.6	3.0

Material	**Poisson's ratio**
Rubber	0.4999
Gold	0.42-0.44
Copper	0.33
Stainless steel	0.30-0.31
Steel	0.21-0.26
Cast iron	0.21-0.26
Concrete	0.1-0.2
Glass	0.18-0.3
Foam	0.10-0.50
Cork	0.0

Poisson's ratio:

$$\boldsymbol{Poisson'sratio, \mu = \frac{lateral\ strain}{longitudnal\ strain} = -\frac{\frac{d}{D}}{\frac{l}{L}} = -\frac{L}{l} \times \frac{d}{D}}$$

- Negative sign indicates the elongation along longitudinal and contraction along lateral dimension. So, Poisson's ratio has no unit and no dimension (dimensionless number)

Elastic energy:

$$\boldsymbol{elastic\ potential\ energy, W = \frac{1}{2}Fl}$$

$$energy\ density, u = \frac{elastic\ potential\ energy}{volume} = \frac{1}{2}\frac{Fl}{AL} = \frac{1}{2}\frac{F}{A}\frac{l}{L}$$
$$= \frac{1}{2}(stress \times strain)$$

Applications of elasticity:

- To reduce the bending of a beam for a given load, one should use the material with a higher Young's modulus of elasticity (Y). The Young's modulus of steel is greater than aluminium or copper. Iron comes next to steel. This is the reason why steel is mostly preferred in the design of heavy duty machines and iron rods in the construction of buildings.Steel is more elastic than rubber. If an equal stress is applied to both steel and rubber, the steel produces less strain. The object which has higher young's modulus is more elastic.

Fluids:

$$Pressure, P = \frac{F}{A}$$

- Pressure is a scalar quantity. The SI unit of pressure is $N\,m^{-2}$or pascal (Pa) and its dimension is $[M\,L^{-1}T^{-2}]$. One 'atm' is defined as the pressure exerted by the atmosphere at sea level. i.e., 1 atm = 1.013 x 10^5Pa or $N\,m^{-2}$

$$density, \rho = \frac{m}{V}$$

- The dimensions and S.I unit are $[M\,L^{-3}]$ and $kg\,m^{-3}$. It is a positive scalar quantity.

$$relative\ density = \frac{density\ of\ substance}{density\ of\ water\ at\ 4°C}$$

It is a dimensionless positive scalar quantity.
The density of mercury is 13.6 × $10^3 kg\ m^{-3}$. Its relative density is equal to 13.6.

Pressure due to fluid column at rest:

$$\boldsymbol{P = P_a + \rho g h}$$

Where P_a is the atmospheric pressure.

- ❖ The liquid pressure is the same at all points at the same depth. This statement can be demonstrated by an experiment called 'hydrostatic paradox'.
- ❖ The decrease of atmospheric pressure with altitude has an unwelcome consequence in daily life. For example, it takes longer time to cook at higher altitudes. Nose bleeding is another common experience at higher altitude because of larger difference in atmospheric pressure and blood pressure.

❖ Take a metal container with an opening. Connect a vacuum pump to the opening. Evacuate the air from inside the container.Due to the force of atmospheric pressure acting on its outer surface, the shape of the container crumbles.

✓ Take a glass tumbler. Fill it with water to the brim. Slide a cardboard on its rim so that no air remains in between the cardboard and the tumbler. Invert the tumbler gently. The water does not fall down. This is due to the fact that the weight of water in the tumbler is balanced by the upward thrust caused due to the atmospheric pressure acting on the lower surface of the cardboard that is exposed to air.

Pascal's law and its application:

- If the pressure in a liquid is changed at a particular point, the change is transmitted to the entire liquid without being diminished in magnitude.

Application of Pascal's law- hydraulic lift

$$P = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$F_2 = \frac{F_1}{A_1} \times A_2 = \frac{A_2}{A_1} \times F_1$$

- Therefore by changing the force on the smaller piston A, the force on the piston B has been increased by the factor $\frac{A_2}{A_1}$and this factor is called the mechanical advantage of the lift.

Buoyancy:

Archimedes principle:

- When a body is partially or wholly immersed in a fluid, it experiences an upward thrust equal to the weight of the fluid displaced by it and its upthrust acts through the centre of gravity of the liquid displaced.

Upthrust or buoyant force = weight of liquid displaced.

Law of floatation:

- The law of floatation states that a body will float in a liquid if the weight of the liquid displaced by the immersed part of the body equals the weight of the body

- If an object floats, the volume of fluid displaced is equal to the volume of the object submerged and the percentage of the volume of the object submerged is equal to the relative density of an object with respect to the density of the fluid in which it floats.

- When the ballast tanks are filled with air, the overall density of the submarine becomes lesser than the surrounding water, and it surfaces (positive buoyancy). If the tanks are flooded with water replacing air, the overall density becomes greater than the surrounding water and submarine begins to sink (negative buoyancy). To keep the submarine at any depth, tanks are filled with air and water (neutral buoyancy).

Examples of floating bodies:

i) A person can swim in sea water more easily than in river water.
ii) Ice floats on water.
iii) The ship is made of steel but its interior is made hollow by giving it a concave shape.

Viscosity:

- An ideal liquid is incompressible (i.e., bulk modulus is infinity) and in which no shearing forces can be maintained (i.e., the coefficient of viscosity is zero). Viscosity is defined as 'the property of a fluid to oppose the relative motion between its layers'.

$$F = -\eta A \frac{dv}{dx}$$

- Whereη is called the coefficient of viscosity of the liquid and the negative sign implies that the force is frictional and it opposes the relative motion. The kinetic energy of the substance is dissipated as heat energy. The dimensional formula for coefficient of viscosity is $[M\ L^{-1}T^{-1}]$

Streamline flow (or) steady flow (or) laminar flow :

- When a liquid flows such that each particle of the liquid passing through a point moves along the same path with the same velocity as its predecessor then the flow of liquid is said to be a *streamlined flow*. This is possible below critical velocity.

Turbulent flow:

- Velocity changes both in magnitude and direction from particle to particle and hence, the path taken by the particles in turbulent flow becomes erratic and whirlpool-like circles called eddy current or eddies when velocity of flow is greater than the critical velocity v_s.

Reynold's number:

S.no	Reynold's number	Flow
1	Rc< 1000	Streamline

2	1000<Rc<2000	Unsteady
3	Rc>2000	Turbulent

$$Reynold's number, R_C (or) K = \frac{\rho v D}{\eta}$$

- *Law of similarity* which states that when there are two geometrically similar flows, both are essentially equal to each other, as long as they embrace the same Reynold's number.

Terminal velocity:

The forces acting on the sphere falling in a liquid are

- gravitational force of the sphere acting vertically downwards,
- upthrust U due to buoyancy and
- viscous drag acting upwards

- A stage is reached when the net downward force balances the upward force and hence the resultant force on the sphere becomes zero. The maximum constant velocity acquired by a body while falling freely through a viscous medium is called the terminal velocity v_T

$$terminal\ velocity, v_T = \frac{2}{9} \times \frac{r^2(\rho - \sigma)g}{\eta}$$

1) If σ is greater than ρ, then the term (ρ - σ) becomes negative leading to a negative terminal velocity. That is why air bubbles rise up through water or any fluid. This is also the reason for the clouds in the sky to move in the upward direction.

2) The terminal speed of a sphere is directly proportional to the square of the radius of the sphere. Hence, larger raindrops fall with greater speed as compared to the smaller raindrops.

3) If the density of the material of the sphere is less than the density of the medium, then the sphere shall attain terminal velocity in the upward direction. That is why gas bubbles rise up in soda water.

Stoke's law:

$$viscous\ force, F = 6\pi\eta r v$$

- Since the raindrops are smaller in size and their terminal velocities are small, remain suspended in air in the form of clouds. As they grow up in size, their terminal velocities increase and they start falling in the form of rain.

This law explains the following:

a) Floatation of clouds
b) Larger raindrops hurt us more than the smaller ones
c) A man coming down with the help of a parachute acquires constant terminal velocity.

Poiseuille's equation:

- He derived an expression for the volume of the liquid flowing per second through the capillary tube. The conditions to be retained are,

    - The flow of liquid through the tube is streamlined.
    - The tube is horizontal so that gravity does not influence the flow
    - The layer in contact with the wall of the tube is at rest
    - The pressure is uniform over any cross section of the tube

$$volume\ of\ the\ liquid\ flowing\ per\ second, v = \frac{\pi r^4 P}{8\eta l}$$

Applications of viscosity:

(1) The oil used as a lubricant for heavy machinery parts should have a high viscous coefficient. To select a suitable lubricant, we should know its viscosity and how it varies with temperature

(2) The highly viscous liquid is used to damp the motion of some instruments and is used as brake oil in hydraulic brakes.
(3) Blood circulation through arteries and veins depends upon the viscosity of fluids.

(4) Millikan conducted the oil drop experiment to determine the charge of an electron. He used the knowledge of viscosity to determine the charge.

Surface tension:

- The force between the like molecules which holds the liquid together is called '*cohesive force*'. When the liquid is in contact with a solid, the molecules of the solid and liquid will experience an attractive force which is called '*adhesive force*'.

- Laplace and Gauss developed the theory of surface and motion of a liquid under various situations.

- These molecular forces are effective only when the distance between the molecules is very small about 10^{-9}m (i.e., 10 Å). The distance through which the influence of these molecular forces can be felt in all directions constitute a range and is called *sphere of influence*.

- When any molecule is brought towards the surface from the interior of the liquid, work is done against the cohesive force among the molecules of the surface. This work is stored as potential energy in molecules. So the molecules on the surface will have greater potential energy than that of molecules in the interior of the liquid. But for a system to be under stable equilibrium, its potential energy (or surface energy) must be a minimum. Therefore, in order to maintain stable equilibrium, a liquid always tends to have a minimum number of molecules. In other words, the liquid tends to occupy a minimum surface area. This behaviour of the liquid gives rise to surface tension.

Examples of surface tension:

1) Water bugs and water striders walk on the surface of water. The water molecules are pulled inwards and the surface of water acts like a springy or stretched membrane.

2) The hairs of the painting brush cling together when taken out of water. This is because the water films formed on them tends to contract to a minimum area.

3) Needle floats on water due to surface tension.

Factors affecting surface tension of a liquid:

1) Presence of contamination

2) Presence of dissolved substances:
For example, a highly soluble substance like sodium chloride (NaCl) when dissolved in water (H20) increases the surface tension of water. But the sparingly soluble substance like phenol or soap solution when mixed in water decreases the surface tension of water.

3) Electrification:
Surface tension decreases as the area of liquid surface increases.

4) Temperature:
Surface tension decreases with increase in temperature

$$\boldsymbol{T_t = T_0(1 - \alpha t)}$$

- Where, $T0$ is the surface tension at temperature 0°C and a is the temperature coefficient of surface tension. It is to be noted that at the critical temperature, the surface tension is zero as the interface between liquid and vapour disappear.

- Van der Wall suggested the important relation between the surface tension and the critical temperature as $T_t = T_0\left(1 - \frac{t}{t_c}\right)^n$

Where value of n differs for different liquids.

Surface energy and surface tension:

- The work done in increasing the surface area per unit area of the liquid against the surface tension force is called the surface energy of the liquid.

$$surface\ energy = \frac{work\ done\ in\ increasing\ surface\ area}{increase\ in\ surface\ area} = \frac{W}{\Delta A}$$

It is expressed in $J\ m^{-2}$ or $N\ m^{-1}$.
Surface tension is the energy per unit area of the surface of a liquid

$$T = \frac{F}{l}$$

SI unit and dimensions of T are Nm^{-1} and MT^{-2}.

- Surface energy per unit area of surface is numerically equal to the surface tension.

- It should be remembered that a liquid drop has only one free surface. Therefore, the surface area of a spherical drop of radius r is equal to $4\pi r^2$, whereas, a bubble has two free surfaces and hence the surface area of a spherical bubble is equal to $2 \times 4\pi r^2$.

Angle of contact:

- The angle between the tangent to the liquid surface at the point of contact and the solid surface inside the liquid is known as the *angle of contact between the solid and the liquid*. It is denoted by θ.

- It is the factor which decides whether a liquid will spread on the surface of a chosen solid or it will form droplets on it.

- Soaps and detergents are wetting agents. When they are added to an aqueous solution, they will try to minimize the angle of contact and in turn penetrate well in the cloths and remove the dirt. On the other hand, water proofing paints are coated on the outer side of the building so that it will enhance the angle of contact between the water and the painted surface.

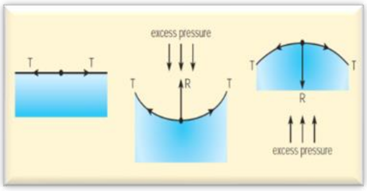
    (i) If $T_{sa} > T_{sl}$ (water-plastic interface) then the angle of contact θ is acute angle as cosθ is positive.

(ii) If $T_{sa} < T_{sl}$ (water-leaf interface) then the angle of contact is obtuse angle as cosθ is negative.

(iii) If $T_{sa} > T_{la} + T_{sl}$ then there will be no equilibrium and liquid will spread over the solid.

Excess of pressure inside a liquid drop, a soap bubble and an air bubble:

- As a consequence of surface tension, the liquid-air interfaces have energy and for a given volume, the surface will have a minimum energy with least area. Due to this reason, the liquid drop becomes spherical (for a smaller radius).



1) When liquid is plane, resultant force acting on the molecule is zero. Thus pressure on both sides is equal.

2) For a convex surface, the resultant force is directed inwards towards the centre of curvature, whereas the resultant force is directed outwards from the centre of curvature for a concave surface. Thus, for a curved liquid surface in equilibrium, the pressure on its concave side is greater than the pressure on its convex side.

Excess pressure inside an air bubble is $\Delta P = P_2 - P_1 = \frac{2T}{R}$

Excess pressure inside a soap bubble is $\Delta P = \frac{4T}{R}$

Excess pressure inside liquid drop is $\Delta P = \frac{2T}{R}$, where T is the surface tension and R is radius of the bubble.

- The smaller the radius of a liquid drop, the greater is the excess of pressure inside the drop. It is due to this, the tiny fog droplets are rigid enough to behave like solids.

- When an ice-skater skate over the surface of the ice, some ice melts due to the pressure exerted by the sharp metal edges of the skates, the tiny droplets of water act as rigid ball- bearings and help the skaters to run along smoothly.

Capillarity:

- The tube having a very small diameter is called a 'capillary tube'. When a glass capillary tube open at both ends is dipped vertically in water, the water in the tube will rise above the level of water in the vessel. In case of mercury, the liquid is depressed in the tube below the level of mercury in the vessel

- The rise or fall of a liquid in a narrow tube is called capillarity or capillary action. Depending on the diameter of the capillary tube, liquid rises or falls to different heights.

Contact angle	Strength of		Degree of wetting	Miniscus	Rise or fall of liquid in the capillary tube
	Cohesive force	Adhesive force			
θ=0	Weak	Strong	Perfect Wetting	Plane	Neither rises nor is depressed
θ<90	Weak	Strong	High	Concave	Rise of liquid
θ>90	Strong	Weak	Low	Convex	Fall of liquid

Practical applications of capillarity

- ❖ Due to capillary action, oil rises in the cotton within an earthen lamp. Likewise, sap rises from the roots of a plant to its leaves and branches.
- ❖ Absorption of ink by a blotting paper
- ❖ Capillary action is also essential for the tear fluid from the eye to drain constantly.
- ❖ Cotton dresses are preferred in summer because cotton dresses have fine pores which act as capillaries for sweat.

Surface tension by capillary rise method:

$$\textbf{surface tension}, \mathbf{T} = \frac{r\rho g h}{2\cos\theta}$$

Where h is the capillary rise, θ is angle of contact, ρ is density of liquid and r is radius of tube.

Applications of surface tension:

• Mosquitoes lay their eggs on the surface of water. To reduce the surface tension of water, oil is poured. This breaks the elastic film of water surface and eggs are killed by drowning.

• Chemical engineers must finely adjust the surface tension of the liquid, so it forms droplets of designed size and so it adheres to the surface without smearing. This is used in desktop printing, to paint automobiles and decorative items.

• Specks of dirt get removed when detergents are added to hot water while washing clothes because surface tension is reduced.

• A fabric can be made waterproof, by adding suitable waterproof material (wax) to the fabric. This increases the angle of contact

Bernoulli's theorem:

$$\mathbf{av = constant}$$

- where a is cross sectional area of pipe and v is velocity of fluid. The volume flux or flow rate remains constant throughout the pipe. It is called the equation of continuity and it is a statement of conservation of mass in the flow of fluids.

Bernoulli's theorem and its applications:

- In 1738, the Swiss scientist Daniel Bernoulli He proposed a theorem for the streamline flow of a liquid based on the law of conservation of energy. The sum of pressure energy, kinetic energy, and potential energy per unit mass of an incompressible, non-viscous fluid in a streamlined flow remains a constant.

$$\frac{p}{\rho} + \frac{1}{2}v^2 + gh = constant$$

- Bernoulli's relation is strictly valid for fluids with zero viscosity or non-viscous liquids.

- When fluid flows through a horizontal pipe,

h = 0. Thus, $\frac{p}{\rho} + \frac{1}{2}v^2 = constant$

ApplicationsofBernoulli's theorem:

1) **Blowing of roofs during wind storm:**

- Roofs are designed with a slope. During cyclones, the roof is blown off without damaging the other parts of the house. In accordance with the Bernoulli's principle, the high wind blowing over the roof creates a low-pressureP_1. The pressure under the roof $P_2$is greater. Therefore, this pressure difference (P_2–P_1) creates an up thrust and the roof is blown off.

2) **Aerofoil lift:**

- The wings of an airplane (aerofoil) are so designed that its upper surface is more curved than the lower surface and the front edge is broader than the real edge. As the aircraft moves, the air moves faster above the aerofoil than at the bottom.According to Bernoulli's Principle, the pressure of air below is greater than above, which creates an upthrust called the dynamic lift to the aircraft.

3) **Bunsen burner:**

- In this, the gas comes out of the nozzle with high velocity, hence the pressure in the stem decreases. So outside air reaches into the burner through an air vent and the mixture of air and gas gives a blue flame

4) **Venturimeter:**

- This device is used to measure the rate of flow (or say flow speed) of the incompressible fluid flowing through a pipe.

Pressure difference, $\Delta P = \rho \frac{v_1^2}{2} \frac{(A^2 - a^2)}{a^2}$

Speed of flow at end of tube A, $v_1 = \sqrt{\frac{2(\Delta P)a^2}{\rho(A^2 - a^2)}}$

Volume of liquid flowing out of second is

$$V = aA\sqrt{\frac{2(\Delta P)}{\rho(A^2 - a^2)}}$$

5) **Other applications:**

- This Bernoulli's concept is mainly used in the design of carburetor of automobiles, filter pumps, atomizers, and sprayers. The carburetorhas a very fi ne channel called nozzle through which the air is allowed to flow in larger speed. In this case, the pressure is lowered at the narrow neck and in turn, the required fuel or petrol is sucked into the chamber so as to provide the correct mixture of air and fuel necessary for ignition process.

More to know

A single strand of spider silk can stop flying insects which are tens and thousands times its mass. The young's modulus of the spider web is approximately $4.5 \times 10^9\ N\ m^{-2}$.

Force, Motion and Energy
6th term 1
Unit 2Forces and Motion

Motion and Rest
What is rest? What is motion?

Suppose there is a book on your table right in the middle. Is the book moving? You will say "it is not moving; it is at rest". If you push the book to one side of the table to clear space for keeping your notebook, then you will say the book is moving.

When the book was at the same place with respect to the table, you say the book was at rest; but when it was pushed from one place on the table to another place, you say it was moving.

When there is a change of position of an object with respect to time, then it is called motion, if it remains stationary it is called rest.

Contact, Non-Contact Forces

In all the above cases, the force is executed by touching the body. so, these type of force is called Contact Force. Mysteriously ripen coconut falls to the ground. What pulls it to the ground? We would have heard of the 'force of gravity' of Earth. Gravity pulls the ripen coconut from the tree to the ground.

Bring a magnet near the small iron nail. Suddenly the nail jumps into the air and sticks with the magnet. Observe that the magnet and the nail did not touch each other. Still, there was a pulling force that made the nail to jump towards the magnet. In these two examples, the force is applied without touching the object. Such forces are known as "non-contact forces"

Forces can be classified into two major types; contact and non-contact forces. Wind is making a fag flutter, a cart pulled by a bullock are contact forces. Magnetism, gravity are some examples of non-contact forces.

Periodic and non- periodic motions

A fly buzzing around the room is a combination of all these and flight path is zigzag.

You can classify the motion according to the path taken by the object.
Linear- moving in a straight line, like a person walking on a straight path, free fall.
Curvilinear - moving ahead but changing direction, like a throwing ball.
Circular -moving in a circle, swirling stone tied to the rope.
Rotatory -The movement of a body about its own axis, like a rotating top.

Oscillatory -coming back to the same position after a fixed time interval, like a pendulum.
Zigzag (irregular)- like the motion of a bee or people walking in a crowded street.

Oscillations at Greater Speed

Ask your friend to hold the two ends of a stretched rubber band. Strike it in the middle. Do you see it oscillates very fast? When the oscillation is very swift, it is called as vibration

Fast oscillations are referred to as vibrations.

Uniform and non-uniform motion

Suppose a train leaves Thiruchirapalli and arrives at Madurai. Is the train travelled in an uniform speed? First, the train was stationary. When the train left the station, the motion was slow and only after it left some distance that it gathered speed. After that it slowed down while crossing bridges and stop at intermediate stations for passengers. Finally, as the train approached Madurai, again, it slowed and finally came to a halt. That is the speed was not same all through the journey time. That is the speed was non-uniform. This motion is said to be non-uniform motion.

In a nutshell, we can classify the motion in terms a) path b) if it is periodic or not c) if the speed is uniform or not. However, in real life, the motions are combinations many types.

Robots are automatic machines. Some robots can perform mechanical and repetitive jobs faster, more accurately than people. Robots can also handle dangerous materials and explore distant planets. The term comes from a Czech word, 'robota' meaning 'forced labour'. Robotics is the science and study of robots.

What Can Robots Do?

Robots can sense and respond to their surroundings. They can handle delicate objects or apply great force-for example, to perform eye operations guided by a human surgeon, or to assemble a car. With artificial intelligence, robots will also be able to make decisions for themselves.

How Do Robots Sense?

The quadruped al military robot

Electronic sensors are a robot's eyes and ears. Twin video cameras give the robot a 3-D view of the world. Microphones detect sounds. Pressure sensors give the robot a sense of touch, to judge how hard to grip an egg. Heavy luggage built-in computers send and receive information with radio waves.

Artificial Intelligence

Artificial intelligence attempts to create computer programs that think like human brains. Current research has not achieved this, but some computers can be programmed to recognize faces in a crowd.

Can Robots Think?

Articulated welding robots (Industrial) Robots can think. They can play complex games, such as chess, better than human beings. But will a robot ever know that it is thinking? Humans are conscious-we know we are thinking-but we don't know how consciousness works. We don't know if Robots can ever be conscious.

Nano robotics

Future of Nano robotics
Nano-robots or Nano bots are robots scaled down to microscopic size in order to put them into very small spaces to perform a function. Future Nano bots could be placed in the blood stream to perform surgical procedures that are too delicate or too difficult for standard surgery. Imagine if a Nano bot could target cancer cells and destroy them without touching healthy cells nearby.

7^{TH} TERM 1
UNIT 2. Force and Motion

Speed - Velocity
Speed
Recapitulation

Speed is the rate of change of distance .
Speed = distance /time
Unit is metre/second (m/s)
We can classify speed into two types.

Uniform speed

If a body in motion covers equal distances in equal intervals of time, then the body is said to be in uniform speed.

Non- uniform speed

If a body covers unequal distances in equal intervals of time, the body is said to be in non-uniform speed.
Average speed = total distance travelled / time taken to travel the distance.

Velocity

Velocity is the rate of change in displacement.
Velocity (v) = displacement / time
SI unit of velocity is meter / second (m/s).

1 km/h = 5/18 m/s

How we got this ?
1 km = 1000 m
1 h = 3600 s
1 km / h = 1000 m / 3600 s = 5/ 18 m /s

If an athlete in the diagram takes 25 s to complete a 200 m sprint event. Find her speed and velocity.

Speed = distance / time

= 200 / 25
= 8 m/s

velocity = displacement /time

= 50 / 25
= 2 m/s

Uniform velocity

A body has uniform velocity, if it covers equal displacement in the same direction in equal intervals of time. E.g. light travels through vacuum.

Non uniform velocity

If either speed or direction changes, the velocity is non uniform. E.g. a train starting and moving out of the station.

Average velocity

Average velocity = total displacement / total time taken
E.g. Figure shows a car that travels 5 km due east and makes a U – turn to travel another 7 km. If the time taken for the whole journey is 0.2 h. Calculate the average velocity of the car.
Average velocity = total displacement/time taken. (taking the direction due east of point O as positive)

= (5 – 7) / 0.2
= –2 / 0.2
= –10 km/h (or) –10 × 5/18 = 25/9
= –0.28 m / s

The triangle method can help you to recall the relationship between velocity (v), displacement (d), and time(t).
v = d / t , t = d / v, d = v × t

Acceleration

Acceleration (a)

Acceleration is the rate of change in velocity. In other words if a body changes its speed or dirction then it is said to be accelerated.

Acceleration = change in velocity/ time
= [final velocity (v) – intial velocity (u)] / time (t)

a = (v–u) / t

SI unit of acceleration is m/s2
In other words, the object undergoes acceleration when its speed and/or direction change(s).

Positive acceleration

If the velocity of an object increases with respect to time, then the object is said to be in positive acceleration or just acceleration.

Negative acceleration or deceleration or retardation

If the velocity of an object decreases with respect to time, then the object is said to be in negative acceleration or deceleration or retardation.

The velocity of a golf ball rolling in a straight line changes from 8 m/s to 2 m/s in 10 s. What is its deceleration, assuming that it is decelerating uniformly?

Initial velocity (u) = 8 m/s
Final velocity (v) = 2 m/s
Time taken(t) = 10 s
Acceleration (a) = (v – u)/t
= (2 – 8)/10
= –0.6 m/s²
The deceleration is –0.6 m/s²

Uniform acceleration

An object undergoes uniform acceleration when the change (increase or decrease) in its velocity for every unit of time is the same. Table shows a moving bus with uniform acceleration.

When the velocity of the object is increasing by 20 m/s the acceleration is 20 m/s^2. When the velocity of the object is decreasing by 20 m/s the deceleration is 20 m/s^2.

Non – uniform acceleration

An object undergoes non uniform acceleration if the change in its velocity for every unit of time is not the same.

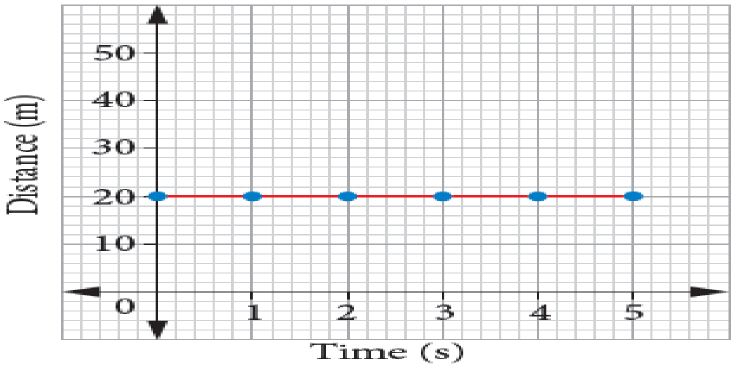
Time(s)	0	1	2	3	4	5
Change in Velocity(m/s)	0	10	30	20	10	20

Note that the change in velocity is not the same for every second. The moving object is undergoing non uniform acceleration.

Distance – Time Graphs

Figure shows a car travelling along a straight line away from the starting point O. The distance of the car is measured for every second. The distance and time are recorded and a graph is plotted using the data. The results for four possible journeys are shown below.

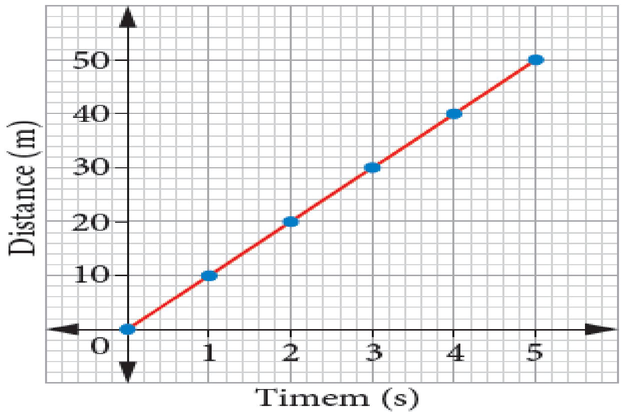
Time (s)	0	1	2	3	4	5
Distance(m)	20	20	20	20	20	20



The graph has zero gradient. The distance is a constant for every second.

(b) Car travelling at uniform speed of 10 m s^{-1}

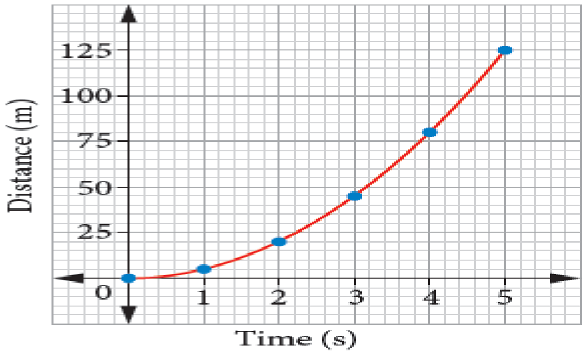
Time (s)	0	1	2	3	4	5
Distance (m)	0	10	20	30	40	50



The graph has a zero constant gradient. The distance increases 10 m every second.

(C) Car travelling at increasing speed

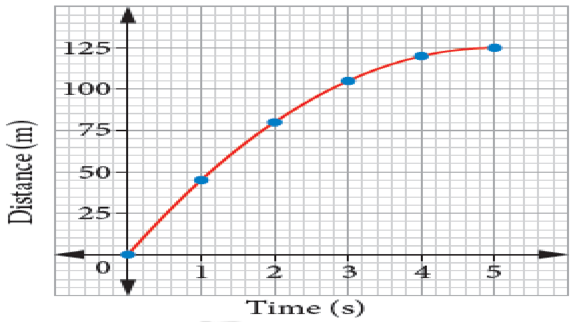
Time (s)	0	1	2	3	4	5
Distance(m)	0	5	20	45	80	125



The graph has an increasing gradient. The speed increases The instantaneous speed of the car at t = 3 s is given by the gradient of the tangent at the point.

(D) Car travelling at decreasing speed

Time (s)	0	1	2	3	4	5
Distance	0	45	80	105	120	125

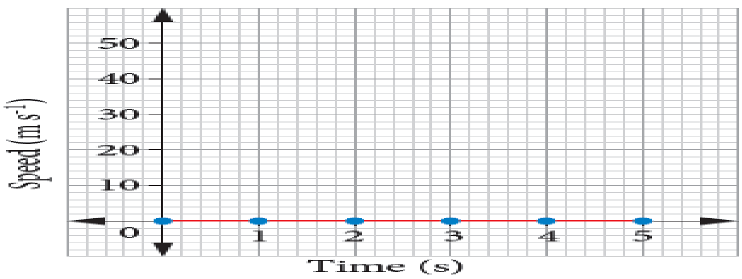


Speed – time graphs

Let us consider a bus travelling from Thanjavur to Trichy. The speed of the bus is measured for every second. The speed and time are recorded and a graph is plotted using the data. The results for four possible journeys are shown.

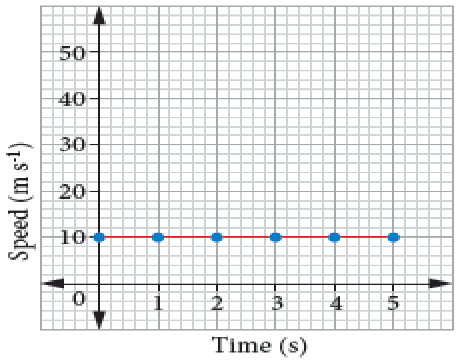
1. Bus at rest

Time (s)	0	1	2	3	4	5
Speed(ms^{-1})	0	0	0	0	0	0



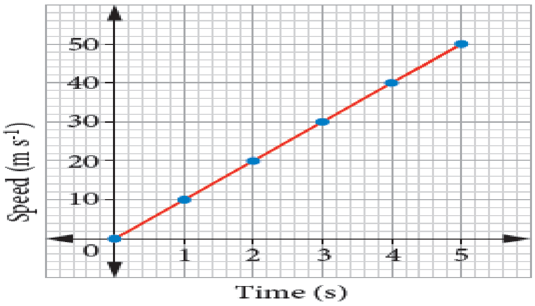
2. Bus travelling at uniform speed of m/s

Time(s)	0	1	2	3	4	5
Speed($m\ s^{-1}$)	10	10	10	10	10	10



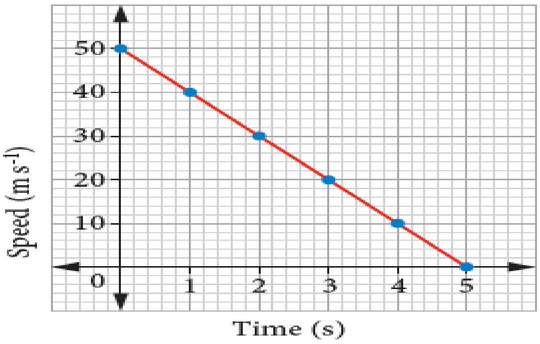
3. Bus travelling with uniform acceleration

Time	0	1	2	3	4	5
Speed (m s^{-1})	10	10	20	30	40	50



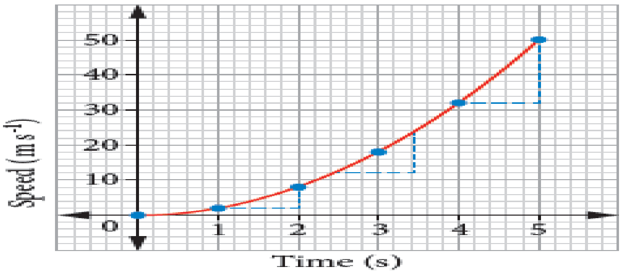
4. Bus travelling with uniform deceleration

Time (s)	0	1	2	3	4	5
Speed ms-1)	50	40	30	20	10	0



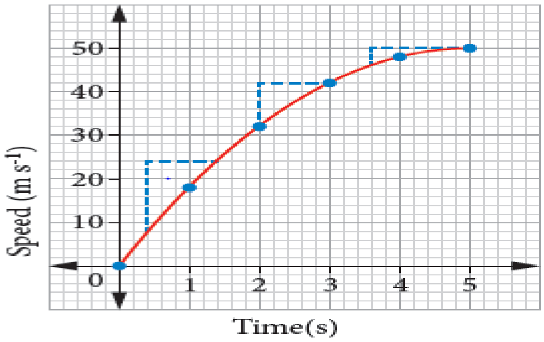
5. Bus travelling with increasing acceleration (non – uniform acceleration)

Time(s)	0	1	2	3	4	5
Speed (ms^{-1})	0	2	8	18	32	50



6. Bus travelling with decreasing acceleration (non – uniform acceleration)

Time (s)	0	1	2	3	4	5
Speed (ms^{-1})	0	18	32	42	48	50



Comparisons between distance – time and speed – time graphs

Speed – time graphs and Distance – time graphs look very similar, but they give different information. We can differentiate them by looking at the labels.

From A to B	From B to C	From C to D
Car accelerates uniformly from rest.	Car moves at constant speed.	Car decelerates uniformly to a stop.

Centre of Gravity and Stabilty
Centre of gravity

Try to balance a cardboard on your figure tip. What do we observe. We observe there is only one point which the cardboard is balanced. The point which the cardboard is balanced is called the cenre of gravity of the cardboard.

Centre of gravity: The centre of gravity of an object is the point through which the entire weight of the object appears to act.
How to we find the centre of gravity of a object?

Centre of gravity for Regular – shaped objects

Generally the centre of gravity of the geometrical shaped object lie on the geometric centre of the object.
Examples of centre of gravity for Regular-shaped objects. 1. Weight of Card,

2. Weight of Triangle, 3. Weight of Disc, 4. Weight of Ring.

What about irregular shaped objects?

Apparatus: Irregularly shaped card, string, pendulum bob, stand
1. Make three holes in the lamina.
2. Suspend the lamina from the optical pin through one of the holes as shown.
3. Suspend the plumbline from the pin and mark the position of the plumbline on the lamina.
4. Draw lines on the lamina representing the positions of the plumbline.
5. Repeat the above steps for the holes.
6. Label the intersection of the three lines as X, the position of the centre of gravity of the lamina.

Meter Rule

The ruler is in equilibrium when supported at its centre of gravity.
For a regular object such as a uniform meter rule, the centre of gravity is at the centre of the object. When the object is supported at that point, it will be balanced. If it is supported at any other point, it will topple.

Stability

Stability is a measure of the body's ability to maintain its original position.
The three types of stability are
(a) Stable equilibrium
(b) Unstable equilibrium
(c) Neutral equilibrium

Stable Equilibrium

The frustum can be tilted through quite a big angle without toppling.
Its centre of gravity is raised when it is displaced.
The vertical line through its centre of gravity still falls within its base.
So it can return to its orginalpositionl.

Unstable Equilibrium

The frustum will topple with the slightest tilting. Its centre of gravity is lowered when it is displaced.

Neutral Equilibrium

(d) It causes frustum to topple.
(e) The frustum will rolls about but does not topple.
(f) Its centre of gravity remains at the same height when it is displaced.
(g) The body will stay in any position to which it has been displaced.

Condition for Stability

To make a body more stable.
Lower its centre of gravity.
Increase the area of its base.
This box is at the point of tipping over.
A heavy base lowers at the centre of gravity So the box does not tip over.
A brode base makes the box more difficult to tip over

The Thanjavur Doll

It is s type of traditional Indian toy made of terracotta material. The centre of gravity and the total weight of the doll is concentrated at its bottom most point, generating a dance-like continuous movement with slow oscillations.

Real Life Applications of Centre of Gravity

It is for the reasons of stability that the luggage compartment of a tour bus is located at the bottom and not on the roof. Extra passengers are not allowed on the upper deck of a crowded double decker bus. Racing cars are built low and broad for stability. Table lamps and fans are designed with large heavy bases to make them stable.

Science Today Typical Speeds

Tortoise 0.1 m/s
Person walking 1.4 m / s
Falling raindrop 9-10 m / s
Cat running 14 m/s
Cycling 20-25 km/h
Cheetah running 31 m/s
Bowling speed of fast bowlers 90-100 miles /h
Badminton smash 80-90 m/s Passenger jet 180 m/s

8^{TH} TERM 1
Unit-2 Forces and Pressure

Definition of force

Force is that which changes or tends to change: i) the state of rest or ii) the state of uniform motion of a body or iii) the direction of a moving body or iv) the shape of a body.

Pushes and pulls are forms of forces. The direction of a force is in the direction in which a push or a pull is applied. Thus, force is a vector quantity, which has magnitude and direction. It is measured with a unit called "newton (N)".

Thrust

It is a force acting perpendicularly on any given surface area of a body. It is measured by the unit newton.

Pressure

The effect of force can be measured using a physical quantity called pressure. It can be defined as the amount of force or thrust acting perpendicularly on a surface of area one square meter of a body. Unit of pressure is pascal (Pa) or N m^{-2}.

Pressure = $\frac{Thrust(or)Force}{Area}$, P = F A. The SI unit of pressure is pascal (named after the French scientist Blaise Pascal). 1 pascal = 1 N m^{-2}

Pressure exerted by a force depends on the magnitude of the force and the area of

SOLVED PROBLEM:

Calculate the pressure exerted by the foot of an elephant using the following data. Average weight of an elephant is 4000 N. Surface area of the sole of its foot is 0.1m2 .

Solution:

Average weight of the elephant = 4000 N
Weight of one leg = force exerted by one leg = 4000/4 = 1000 N
Area of the sole of one foot = 0.1 m^2.

Pressure= $\frac{Force}{Area} = \frac{1000}{0.1}$

= 10000 $\frac{N}{m2}$ = 10^4 N m^{-2}

Pressure exerted by one leg of the elephant is 10,000 newton on one square metre.

Increasing pressure:

The effect of pressure can be increased by increasing the thrust or by decreasing the area of the surface of the body experiencing the thrust.

Examples:

The axe, nail, knife, injection needle, bullet etc., all these are having sharp fine edges so as to exert a larger pressure on a smaller area of the body; in order to get the maximum effect from them.

It is very difficult to walk on sand. But, camels can walk easily on it because they have large padded feet, which increase the area of contact with the sandy ground. This reduces the pressure and enables them to walk easily on the sand.

Examples:

More number of wheels are provided for a heavy goods-carrier for decreasing the pressure; thereby increasing the area of contact on the road.
Broader straps are provided on a back-pack for giving a lower pressure on the shoulders by providing a larger area of contact with the shoulder.
It is difficult to drive an automobile, which has flattened tyres.

PRESSURE EXERTED BY AIR - ATMOSPHERIC PRESSURE

You all know very well that air fills the space all around us. This envelope of air is called as atmosphere. It extends up to many kilometres above the surface of the Earth. All objects on the surface of the Earth experience the thrust or force due to this atmosphere.

The amount of force or weight of the atmospheric air that acts downward on unit surface area of the surface of the Earth is known as atmospheric pressure. It can be measured using the device called barometer. The barometer was invented by "Torricelli".

Atmospheric pressure decreases with altitude from the surface of the Earth.

Atmospheric pressure can be measured by the height of the mercury column in a barometer. The height of the mercury column denotes the atmospheric pressure at that place at a given time in 'millimetre of mercury'.

Even if you tilt the tube at various angles, you will see that the level of mercury will not vary. At sea level, the height of the mercury column is around 76 cm or 760 mm. The pressure exerted by this mercury column is considered as the pressure of magnitude 'one atmosphere' (1atm).

1atmospheric peressure =1at = pressure exerted by the mercury column of height 76 cm in the barometer = 1.01×10^5 N m^{-2}.
In the SI system 1 atm = 1,00,000 pascal (approximately).
SI unit of atmospheric pressure is Nm^{-2} or pascal.
To realise the effect of atmospheric pressure:

FORCES IN LIQUIDS

Buoyant force of a liquid

An upward force is exerted by water on a floating or a partly submerged body. This upward force is called buoyant force. The phenomenon is known as "buoyancy". This force is not only exerted by liquids, but also by gases. Liquids and gases together are called fluids.

This upward force decides whether an object will sink or float. If the weight of the object is less than the upward force, then the object will float. If not, it will sink.

A body floats if the buoyant force > its weight; A body sinks if its weight > buoyant force.

Pressure exerted by liquids

Liquids do not have a definite shape. The force acting on unit area of the surface, on which the liquid is placed, is called the static pressure of the liquid. Liquids exert a pressure not only on the base of their container/vessel, but also on its side walls. The pressure exerted by a liquid depends upon the depth of the point of observation considered in it.

An instrument used to measure the difference in the liquid pressure is called a "manometer". You can measure the pressure of fluids enclosed in a definite container using the manometer.

a) Pressure exerted by a liquid on the base of a container depends upon the height of the liquid column:

You have already studied that the atmospheric pressure is measured in terms of the height of the mercury column in a barometer.

b) Liquids exert the same pressure in all directions at a given depth:
c) Liquid pressure varies with the depth:

Home Assignments

1. Ask your family doctor how blood pressure is to be measured?
2. Read the life history of Blasie Pascal.

Pascal's law:

The pressure applied at any point of a liquid at rest, in a closed system, will be distributed equally through all regions of the liquid.

Application of Pascal's law:

Some of the following examples highlight their working according to Pascal's law.

In an automobile service station, the vehicles are lifted upward using the hydraulic lift, which works as per Pascal's law.
The automobile brake system works according to Pascal's law.
The hydraulic press is used to make the compressed bundles of cotton or cloth so as to occupy less space.

All the above questions have an answer, i.e., "due to surface tension".

Surface tension is the property of a liquid. The molecules of a liquid experience a force, which contracts the extent of their surface area as much as possible, so as to have the minimum value. Thus, the amount of force acting per unit length, on the surface of a liquid is called surface tension. It has the unit N m^1.

Application of surface tension:

Water molecules rise up due to surface tension. Xylem tissues are very narrow vessels present in plants. Water molecules are absorbed by the roots and these vessels help the water to rise upward due to "capillarity action" (you will study this topic in the forth-coming classes), which is caused by the surface tension of water.

For a given volume, the surface area of a sphere is the minimum. This is the reason for the liquid drops to acquire a spherical shape. Water strider insect slides on the water surface easily due to the surface tension of water.

During a heavy storm, sailors pour soap powder or oil into the sea near their ship to decrease the surface tension of sea water. This process reduces the impact of the violent water current against the all of ship.

VISCOUS FORCE OR VISCOSITY
Definition:

When a liquid is flowing, there is a frictional force between the successive layers of the liquid. This force which acts in order to oppose the relative motion of the layer is known as viscous force. Such a property of a liquid is called viscosity.

Viscosity force is measured by the unit called poise in CGS and kg m^{-1} s^{-1} or N s m^{-2} in SI.

Friction

Reason: Ram's brother falls down due to the lack of friction between his feet and the banana peels.

You have studied that forces are classified into two types: contact force and non-contact force. Now, you are going to study one of the contact forces, i.e., friction.

It is easy to hold a tumbler due to the friction between the surfaces of your palm and the tumbler. But, when oil is applied to your palm, the contact force between your fingers and the tumbler is reduced. So, the friction is reduced. Hence, it is difficult to hold it with an oily hand.

Origin of friction

Frictional force or friction arises when two or more bodies in contact move or tend to move, relative to each other. It acts always in the opposite direction of the moving body. This force is produced due to the geometrical dissimilarities of the surface of the bodies, which are in relative motion.

Effects of friction:

Friction can produce the following effects:
a) Friction opposes motion.
b) Friction causes wear and tear of the surfaces in contact.
c) Friction produces heat.

Types of friction:

Friction can be classified into two basic types: static friction and kinetic friction.

Static friction: The friction experienced by the bodies, which are at rest is called static friction. (E.g.: all the objects rigidly placed to be at rest on the Earth, a knot in a thread.)

Kinetic friction: Friction existing during the motion of bodies is called kinetic friction.
Further, kinetic friction can be classified into two: sliding friction and rolling friction.

Sliding friction: When a body slides over the surface of another body, the friction acting between the surfaces in contact is called sliding friction.

Rolling friction: When a body rolls over another surface, the friction acting between the surfaces in contact is called rolling friction.

Rolling friction is less than sliding friction. That is why wheels are provided in vehicles, trolleys, suitcases etc.

Reason: When you push the book, the pencils roll in the direction of the applied force. They prevent the contact of the book with the rough surface. Rolling pencils offer the least amount of friction. So, it is easy to displace the book in comparison with sliding it on the table.

This method is often used in moving heavy wood from one place to another.

Factors affecting friction
a) Nature of a surface:
b) Weight of the body:

It is easy to pedal your cycle without any load on its carrier. With a load placed on its carrier, it is difficult to move it because the weight on the carrier increases the friction between the surface of the tyre and the road.

c) Area of contact:

For a given weight, the friction is directly related to the area of contact between the two surfaces. If the area of contact is greater, then, the friction will be greater too.

A road roller has a broad base, so it offers more friction on the road. But, a cycle has the least friction, since the area of contact of the tyre with the surface of the road is less.

Advantages of friction

Friction is a necessity in most of our day to day activities. It is desirable in most situations of our daily life.

We can hold any object in our hand due to friction. We can walk on the road because of friction. The footwear and the ground help us to walk without slipping.

Writing easily with a pen on paper is due to friction. Automobiles can move safely due to friction between the tyres and the road. Brakes can be applied due to frictional resistance on brake shoes. We are able to light a matchstick, sew clothes, tie a knot or fix a nail in the wall because of friction.

Though it is giving a negative effect, in most of our day to day life friction helps us to make our life easy. So, it is called as "necessary evil".

Disadvantages of friction

Friction wears out the surfaces rubbing with each other, like screws and gears in machines or soles of shoes. To overcome the friction an excess amount of effort has to be given to operate a machine. This leads to wastage of energy.
Friction produces heat, which causes physical damage to the machines.

Increasing and decreasing friction

a) Area of contact:

Friction can be increased by increasing the area of the surfaces in contact. Have you seen the sole of a shoe, which has grooves? It is done to provide the shoes a better grip with the floor, so that you can walk safely. Treaded tyres (tyres with slots and projections) are used to increase the friction.

Brake shoes in a cycle have to be adjusted so that they are as close as possible to the rim of the wheel, in order to increase the friction.

E.g.: Sumo players, Kabbadi players rub their hand with mud, to get a better grip. Football shoes are having soles with many projections, for providing a stronger grip with the ground.

b) Using lubricants:

A substance, which reduces the frictional force, is called a lubricant. E.g.: grease, coconut oil, graphite, castor oil, etc.
The lubricants fill up the gaps in the irregular surfaces between the bodies in contact. This provides a smooth layer thus preventing a direct contact between their rough surfaces.

c) Using ball bearing:

Since, the rolling friction is smaller than sliding friction, sliding is replaced by rolling with the usage of ball bearings. You can see lead shots in the bearing of a cycle hub.