



# MPSC

## State Civil Services

**Maharashtra Public Service Commission  
(Preliminary & Main)**

### **General Studies**

**Paper I – Volume 1**

## **Physical & World Geography**



# MPSC

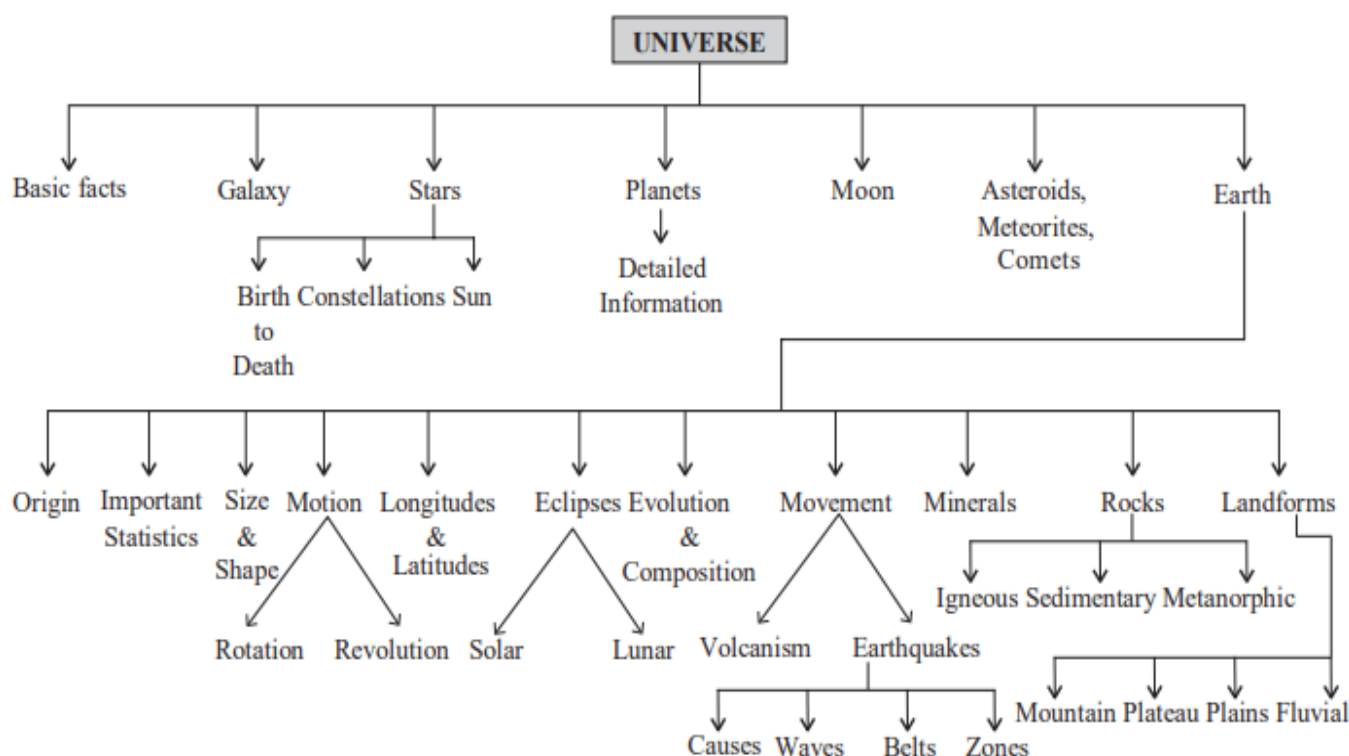
## PHYSICAL & WORLD GEOGRAPHY

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## UNIVERSE AND OUR PLANET EARTH

### Introduction

Astronomy is a science that asks fundamental questions about the very basic of things, the universe. The Universe is all of time and space and its contents. The Universe includes planets, stars galaxies, the contents of intergalactic space, the smallest subatomic particles, and all matter and energy. The observable universe is about 28 billion parsecs (91 billion light-years) in diameter at the present time. The size of the whole Universe is not known and may be either finite or infinite. Observations and the development of physical theories have led to inferences about the composition and evolution of the Universe.



### UNIVERSE

- Everything that exists, from the Galactic Mega clusters to the tiniest subatomic particles, comprises the Universe.
- As for the age of Universe, scientists agree that it is about 13.79 billion years old as 2015.
- The universe comprises of a number of galaxies.
- Optical and radio telescope studies indicate the existence of about 100 billion galaxies in the visible universe.
- The Big Bang Theory is most accepted for the origin of Universe in comparison to the Steady State and the Pulsating Universe Theory

## **GALAXY**

- Galaxy is a collection of millions or billions of stars and planets that are held together by gravitational pull.
- Milky Way is one such galaxy. The earth lies in this galaxy. It is called Milky Way, because it looks like a river of milky light flowing from one corner to another of the sky
- It is spiral in shape.
- We call it Akash Ganga.
- The nearest galaxy to Milky Way is Andromeda. Andromeda is a spiral galaxy and approximately 2.5 million light-years from the earth.

## **STARS**

- Luminous heavenly bodies which have their own light and other radiant energy are called star.
- They are made of extremely hot burning gases.
- Star reflects Looks -Red with low temperature, Yellow with higher and blue with very high temperature.

### **Star (Birth to Death)**

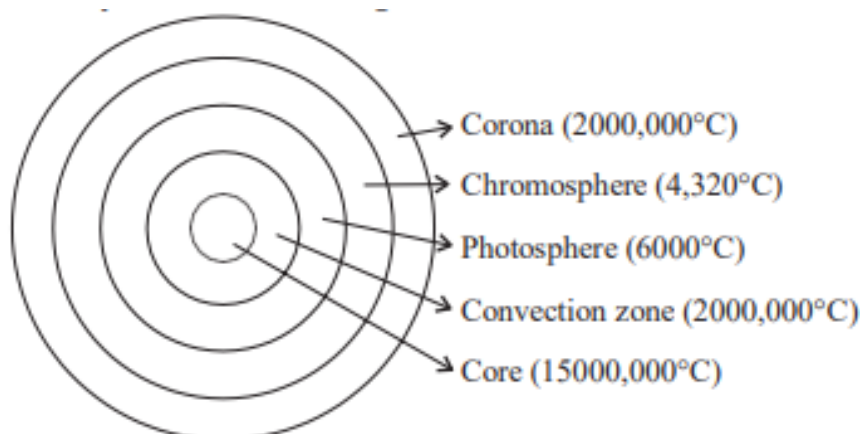
- Star starts its life as clouds of dust and gas known as Nebula.
- The gaseous matter of Nebula further contracts to make dense region named Proto Star.
- The Proto Star further condenses to a critical stage of mass where nuclear fusion begins and star finally comes into existence.
- When all the hydrogens of a star are used up then its helium begins fusing into carbon. At a stage helium's fusion and energy production inside the star stops. As a result stars core contracts under its own weight to a very high density to make a white Dwarf star.
- White Dwarf star becomes dark balls of matter on cooling to make Black Dwarf Star.
- The mass of white Dwarf Star is less than 1.44 times the mass of the Sun named as Chandrasekhar Limiting Mass.
- White Dwarf Star is a dead star because of the end of fusion reaction and energy production.
- It shines by radiating its stored heat.
- Giant star expands into Red Supergiant after consuming its fuel (H & He). At a stage, it explodes as Supernova or changes into Neutron or Black Holes.
- The nearest star to the Earth is the Sun followed by Proximal and Alpha Centauri and radiant energy. (4.35 light years)

## Constellations

- A Constellation is a group of stars that makes an imaginary shape in the sky at night.
- It helps in navigation of sea vessel during night as they are seen in a fixed direction at particular period of time in a year.
- Orion, Big Dipper, Great Bear, Cassiopeia are some examples of constellations.
- Orion or Mriga can be seen in the late evening during winter; Cassiopeia in the Northern Sky is seen during winter.
- Great Bear consists of Ursa Minor (Laghu Saptarishi) and Ursa Major (Vrihat Saptarishi), and can be seen in early night during summer.

## Sun

- It is a star made up of extremely hot gases, particularly by hydrogen (70%), Helium (26.5%) and others (3.5%) gases.
- It is 109 times bigger than the earth and weighs  $2 \times 10^{27}$  tonnes, and accounts for 99.83% of mass of the solar system.
- It is 150 million km away from the earth. The sun light takes 8 minutes to reach the earth's surface.
- It has immense gravitational pull which keeps the planets fixed in their orbit, revolving round the sun.
- It continuously gives off energy in the form of visible light, infra-red, ultra violet, X-rays, gamma rays, radio waves and plasma gas.
- The period of revolution of the sun around the galactic centre is 250 million year. This period is called as cosmic or galactic year.
- Sudden flash of brightness observed near the sun's surface which is a collection of magnetic energy including electrons, protons and nuclei is called as solar flares. They consist of particles and are harmful for satellite communication.
- The layers of sun are divided according to their brightness level which is represented in the write features of each layer shown in the figure.



- The core of the sun consists of hydrogen atoms which fuse together due to compression and creates helium. This is called as nuclear fusion.
- Nuclear fusion produces huge amount of energy. It is radiated outward to the surface, atmosphere and beyond.
- Convection zone is the next to the core of the sun. Here the temperature drops to 2 million degree C.
- Photosphere's temperature is 6,000°C.
- Atmosphere of the sun consists of chromosphere and corona. STARS GALAXY 8 | Page
- Corona is seen in a form of spectral lines emitted by iron, calcium and nickel ions. Ionization of these elements increases temperature of corona.
- Recently coronal heating puzzle has been related to magnetic carpet found in corona.
- The solar flare (wind) is a stream of charged particles released from upper atmosphere of the sun. These charged particles when get trapped by earth's magnetic field while entering in the upper atmosphere of the earth results in aurora (light) display.
- These auroral display in the northern hemisphere is called as Aurora Borealis (the Northern light) and when occurs in southern hemisphere is called as Aurora Australis (the Southern lights)
- Sun-spots are dark appearing areas present in photosphere from where solar flares originate. They are relatively a region cooler than its surrounding. It appears and disappears after every 11 years. This period is called Sunspot Cycle.
- Plage is a brighter region in the chromosphere near to sunspot.

## PLANETS

- Planets means 'wanderers'. There are eight planets in our solar system (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune).
- All these planets move around the sun in a fixed orbit. Which is elongated in shape (elliptical).
- A new planet 2003 UB 313 has been included recently in solar system. It is bigger than Pluto and farthest from the Sun.
- International Astronomical Union (IAU) recognized five dwarf planets such as : Ceres, Pluto, Haumea, Makemake, and Sedna.
- The planets are grouped into two :
  1. **Terrestrial planets:** These are dense rocky bodies and are called as earth like planets. Mercury, Venus, Earth, and Mars are included in it. They are also called as inner planets.

**2. Jovian Planets:** The outer planets which are gigantic in size and are gaseous in composition with large satellite are called as Jovian planets. These have similar features to that of Jupiter, thus called as Jupiter like planets.

### Pluto, the Dwarf Planet

- Pluto was known as the smallest planet in the solar system and the ninth planet from the sun.
- Today Pluto is called a “dwarf planet”.
- On average, Pluto is more than 3.6 billion miles away from the sun.
- Pluto is in a region called the Kuiper Belt. One day on Pluto is about 61/2 days on Earth.
- It has five moons. Its largest moon is named Charon Pluto’s four other moons are named Kerberos, Styx, Nix and Hydra

### Detail Information about the Planets

Planets/Features	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Equatorial & Diameter (km)	4,878	12,104	12,756	6,792	142,984	120,536	51,118	49,528
Mass (kg)	$3.28 \times 10^{23}$	$4.867 \times 10^{24}$	$5.972 \times 10^{24}$	$6.39 \times 10^{23}$	$1.8913 \times 10^{27}$	$5.683 \times 10^{26}$	$8.681 \times 10^{25}$	$1.024 \times 10^{26}$
Orbital Period (in days)	88	225	365	687	4,333	10,756	30,687	60,190
Inclination to Sun's Equator	3.38°	3.86°	7.25°	5.65°	6.07°	5.51°	6.48°	6.43°
Rotational Period (in days) and Direction	58.64 East to West	-243.02 West to East	1 East to West	1.03 East to West	0.41 East to West	0.43 East to West	-0.72 West to East	0.67 East to West
Distance from Sun (km)	$57.91 \times 10^6$	$10.82 \times 10^7$	$14.96 \times 10^7$	$22.79 \times 10^7$	$77.85 \times 10^7$	$14.33 \times 10^8$	$28.77 \times 10^8$	$44.98 \times 10^8$
Gravity (m/s <sup>2</sup> )	3.7	8.89	9.78	3.71	24.79	10.44	8.69	11.5
No. of Moons	0	0	1	2	67	62	27	14
Axis Tilt	0.04°	177.36°	23.44°	25.19°	3.13°	26.73°	97.77°	28.32°
Mean density (g/cm <sup>3</sup> )	5.43	5.25	5.52	3.93	1.33	0.71	1.27	1.67
Rings	no	no	no	no	yes	yes	yes	yes

## Mercury

- Mercury is the smallest planet in our solar system - only slightly larger than the Earth's moon.
- It is the closest planet to the sun at a distance of about 58 million km (36 million miles) or 0.39 AU.
- One day on Mercury takes 59 Earth days.
- Mercury is a rocky planet, also known as a terrestrial planet.
- Mercury's thin atmosphere, or exosphere, is composed mostly of oxygen (O<sub>2</sub>), sodium (Na), hydrogen (H<sub>2</sub>), helium (He), and potassium (K). Atoms that are blasted off the surface by the solar wind and micrometeoroid impacts create Mercury's exosphere.
- Only two missions have visited this rocky planet: Mariner 10 in 1974-5 and MESSENGER, which flew past Mercury three times before going into orbit around Mercury in 2011.
- Daytime Temperatures can reach 430° Celsius (800° Fahrenheit) and drop to -180° Celsius (-290° Fahrenheit) at night.

## Venus

- Venus is only a little smaller than the Earth.
- Venus is the second closest planet to the sun at a distance of about 108 million km (67 million miles) or 0.72 AU.
- One day on Venus lasts as long as 243 Earth days (the time it takes for Venus to rotate or spin once).
- Venus is a rocky planet, also known as a terrestrial planet. Venus' solid surface is a created and volcanic landscape.
- Venus' thick and toxic atmosphere is made up mostly of carbon dioxide (CO<sub>2</sub>) and nitrogen (N<sub>2</sub>), with clouds of sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) droplets.
- More than 40 spacecraft have explored Venus. The Magellan mission in the early 1990s mapped 98% of the planet's surface.
- The planet's extreme high temperatures of almost 480° Celsius (900° Fahrenheit) made it seem an unlikely place for life as we know it.
- Venus spins backwards (retrograde rotation) when compared to the other planets. This means that the sun rises in the west and sets in the east on Venus.

## Earth

- Earth is the third planet from the sun at a distance of about 150 million km (93 million miles). That's one Astronomical Unit (AU).
- A day on Earth is 24 hours (the time it takes the Earth to rotate or spin once).



- Earth's atmosphere is 78% nitrogen (N<sub>2</sub>), 21% oxygen (O<sub>2</sub>) and 1% other ingredients - the perfect balance for Earthlings to breathe and live. Many planets in our solar system have atmospheres, but only Earth is breathable.
- Earth has one moon. Another name for a moon is natural satellite.
- Earth is the perfect place for life as we know it.
- Our atmosphere protects us from incoming meteoroids, most of which break up in our atmosphere before they can strike the surface as meteorites.

## **Mars**

- Mars is the fourth planet from the sun at a distance of about 228 million km (142 million miles) or 1.52 AU.
- One day on Mars takes just a little over 24 hours (the time it takes for Mars to rotate or spin once).
- Mars is a rocky planet, also known as a terrestrial planet. Mars' solid surface has been altered by volcanoes, impacts, crustal movement and movement and atmospheric effects such as dust storms.
- Mars has a thin atmosphere made up mostly of carbon dioxide (CO<sub>2</sub>), nitrogen (N<sub>2</sub>) and argon (Ar).
- Mars has two moons named Phobos and Deimos.
- Several missions have visited this planet, from flybys and orbiters to rovers on the surface of the Red Planet. The first true Mars mission success was Mariner 4 in 1965. At this time in the planet's history, Mars' surface cannot support life as we know it. Current missions exploring Mars on the surface and from orbit are determining Mars' past and future potential for life.
- Mars is known as the Red Planet because iron minerals in the Martian soil oxidize, or rust, causing the soil and the dusty atmosphere to look red.
- About 1,300 Earths could fit inside

## **Jupiter**

- Jupiter is the fifth planet from the sun at a distance of about 778 million km (484 million miles) or 5.2 Astronomical Units (AU). Earth is one AU from the sun.
- One day on Jupiter takes about 10 hours (the time it takes for Jupiter to rotate or spin once).
- Jupiter is a gas-giant planet and therefore does not have a solid surface. Jupiter may have a solid, inner core about the size of the Earth.
- Jupiter's atmosphere is made up mostly of hydrogen (H<sub>2</sub>) and helium (He).
- Jupiter has 50 known moons, with an additional 17 moons awaiting confirmation of their discovery, that's total of 67 moons.

- Jupiter has a faint ring system that was discovered in 1979 by the Voyager-1 mission. All four giant planets in our solar system have ring systems.
- Many missions have visited Jupiter and its system of moons. The Juno mission will arrive at Jupiter in 2016.
- Jupiter cannot support life as we know it. However, some of Jupiter's moons have oceans underneath their crusts that might support life.

## **Saturn**

- Saturn is the sixth planet from the sun at a distance of about 1.4 billion km (886 million miles) or 9.5 AU.
- One day on Saturn takes 10.7 hours (the time it takes for Saturn to rotate or spin once).
- Saturn is a gas-giant planet and therefore does not have a solid surface.
- Saturn's atmosphere is made up mostly of hydrogen (H<sub>2</sub>) and helium (He).
- Saturn has 53 known moons with an additional nine moons awaiting confirmation of their discovery that is a total of 62 moons.
- Saturn has the most spectacular ring system, which is made up of seven rings with several gaps and divisions between them.
- Only a few missions have visited Saturn: Pioneer 11, Voyager 1 and 2 and Cassini-Huygens. Since 2004, Cassini has been exploring Saturn, its moons and rings.
- Fact: When Galileo Galilei was observing the planet Saturn in the 1600s, he noticed strange objects on each side of the planet and drew in his notes a triple-bodied planet system and later a planet with arms or handles. These "handles" were in fact the rings of Saturn.

## **Uranus**

- Uranus is the seventh planet from the sun at a distance of about 2.9 billion km (1.8 billion miles) or 19.19 AU.
- One day on Uranus takes about 17 hours (the time it takes for Uranus to rotate or spin once).
- Uranus is an ice giant. Most (80 % or more) of the planet's mass is made up of a hot dense fluid of "icy" materials – water (H<sub>2</sub>O), methane (CH<sub>4</sub>), and ammonia (NH<sub>3</sub>) – above a small rocky core.
- Uranus has an atmosphere which is mostly made up of hydrogen (H<sub>2</sub>) and helium (He), with a small amount of methane (CH<sub>4</sub>).
- Uranus has 27 moons. Uranus' moons are named after characters from the works of William Shakespeare and Alexander Pope.
- Uranus has 13 known rings. The inner rings are narrow and dark and the outer rings are brightly colored.

- Voyager 2 is the only spacecraft to have visited Uranus.
- Uranus cannot support life as we know it.
- Unlike any of the other planets, Uranus rotates on its side, which means it spins horizontally.

## **Neptune**

- Neptune is the eighth and farthest planet from the sun at a distance of about 4.5 billion km (2.8 billion miles) or 30.07 AU.
- One day on Neptune takes about 16 hours (the time it takes for Neptune to rotate or spin once).
- Neptune is a sister ice giant to Uranus.
- Neptune's atmosphere is made up mostly of hydrogen (H<sub>2</sub>), helium (He) and methane (CH<sub>4</sub>).
- Neptune has 13 moons. Neptune's moons are named after various sea gods and nymphs in Greek mythology.
- Neptune has six rings.
- Voyager 2 is the only spacecraft to have visited Neptune.
- Neptune cannot support life as we know it.

## **Moon**

- The moon is Earth's natural satellite and orbits the Earth at a distance of about 384 thousand km (239 thousand miles) or 0.00257 AU.
- The moon makes a complete orbit around Earth in 27 Earth days and rotates or spins at that same rate, or in that same amount of time. This causes the moon to keep the same side or face towards Earth during the course of its orbit.
- The moon is a rocky, solid-surface body, with much of its surface cratered and pitted from impacts.
- The moon has a very thin and tenuous (weak) atmosphere, called an exosphere.
- More than 100 spacecraft's have been launched to explore the moon. It is the only celestial body beyond Earth that has been visited by human beings.
- Twelve human beings have walked on the surface of the moon.

## **Asteroids**

- Asteroids are minor planets especially those of the inner solar system. • Asteroids orbit our sun in a region of space between the orbits of Mars and Jupiter known as the Asteroid Belt.
- Asteroids are solid, rocky and irregular bodies.
- Asteroids do not have atmospheres.

- More than 150 asteroids are known to have a small companion moon (some have two moons). The first discovery of an asteroid-moon system was of asteroid Ida and its moon Dactyl in 1993.
- Asteroids do not have rings. • NASA space missions have flown by and observed asteroids, and one spacecraft (NEAR Shoemaker) even landed on an asteroid (Eros). The Dawn mission is the first mission to orbit (2011) a main belt asteroid (Vesta).
- Asteroids cannot support life as we know it.
- Ceres, the first and largest asteroid to be discovered (1801 by Giuseppe Piazzi), encompasses over one-third of the estimated total mass of all the asteroids in the asteroid belt.

### **Meteorites**

- Meteorites may vary in size from tiny grains to large boulders. One of the largest meteorite found on Earth is the Hoba meteorite from southwest Africa, which weighs roughly 54,000 kg (119,000 pounds).
- Meteor showers are usually named after a star or constellation which is close to the radiant. Meteors and meteorites begin as meteoroids, which are little chunks of rock and debris in space.
- Most meteorites are either iron, stony or stony-iron.
- Leonid MAC (an airborne mission that took flight during the years 1998 - 2002) studied the interaction of meteoroids with the Earth's atmosphere.
- Meteoroids, meteors and meteorites cannot support life. However, they may have provided the Earth with a source of amino acids: the building blocks of life.
- Meteoroids become meteors or shooting stars when they interact with a planet's atmosphere and cause a streak of light in the sky. Debris that makes it to the surface of a planet from meteoroids are called meteorites.
- Meteorites may look very much like Earth rocks, or they may have a burned appearance. Some may have depression (thumbprint-like), roughened or smooth exteriors.
- Many of the meteor showers are associated with comets. The Leonids are associated with comet Tempel-Tuttle; Aquarids and Orionids with comet Halley, and the Taurids with comet Encke.

### **Comets**

- Comets are cosmic snowballs of frozen gases, rock and dust.
- A comet warms up as it comes near the sun and develops an atmosphere, or coma. The coma may be hundreds of thousands of kilometres in diameter.
- Comets do not have moons.

- Comets do not have rings.
- Several missions have visited, impacted and even collected samples from comets. Two recent missions are Stardust Next and Deep Impact EPOXI.
- When comets come around the sun, they leave a dusty tail. Every year the Earth passes through the comet tails, which allows the debris to enter our atmosphere where it burns up and creates fiery and colourful streaks (meteors) in the sky.
- Comets may not be able to support life themselves, but they may have brought water and organic compounds, i.e., the building blocks of life -- through collisions with the Earth and other bodies in our solar system.
- Comet Halley makes an appearance in the Bayeux tapestry from the year 1066, which chronicles the overthrow of King Harold by William the Conqueror at the Battle of Hastings

It is a short period comet visible from Earth every 75-76 years. Halley last appeared in the inner part of the solar system in 1986 and will next appear in mid - 2061.

<b>Who is Called What</b>	
Brightest Planet	Venus
Evening Star	Venus
Morning Star	Venus
Hottest Planet	Venus
Nearest Planet to Earth	Venus
Earth's twin	Venus
Fastest rotation in solar system	Jupiter
Slowest rotation in solar system	Venus
Green Planet	Uranus
Blue Planet	Earth
Red Planet	Mars
Smallest Planet	Mercury
Biggest Planet	Jupiter
Fastest revolution in Solar System	Mercury
Slowest revolution in Solar System	Neptune
Coldest Planet	Neptune
Closest star to the Sun	Proxima Centauri
Densest Planet	Earth
Least dense Planet	Saturn
Only satellite with an atmosphere like Earth	Titan
Smallest satellite	Deimos
Biggest Satellite	Gannymede

Venus is the hottest planet even though Mercury is the closest planet to the Sun. The reason behind it is that Venus has atmosphere made of carbon dioxide.

## **BLUE PLANET: THE EARTH**

The Earth is the only known planet where life exists. Its surface area is covered with two-third of water that is why we call it blue planet. Earth is the third planet from the sun, the densest planet in the solar system, the largest of the solar system's four terrestrial planets.

### **Origin of the Earth**

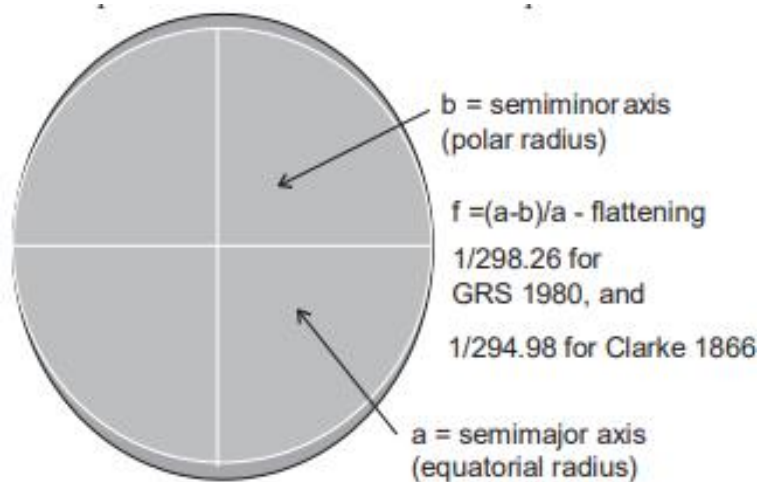
- A number of theories have been proposed by different philosophers.
- Immanuel Kant gave gaseous hypothesis based on Newtonian law related to gravitation and rotatory motion in 1755.
- Laplace gave Nebular hypothesis in 1786.
- Tidal hypothesis was given by James Jeans in 1929 and it was modified by Jeffrey and was called as Collision hypothesis.
- Big Bang theory was proposed by Georges Lemaitre (1927).
- According to Big Bang theory billion years ago cosmic matters were in highly compressed state. The expansion started with primordial explosion. It resulted in formation of supervened balls which travelled at a speed of thousands mile per second and gave rise to galaxies.
- The expansion of universe means increase in space between galaxies and formation of new galaxies.

### **Earth Statistics**

• Age of The Earth	: 4.5 to 4.6 billion years
• Water-land Ratio	: 70.8% Water & 29.2 % Land
• Earth's Circumference at the Equator	: 24,901.55 miles (40,075.16 km)
• Earth's Circumference between the North and South Poles	: 24,859.82 miles (40,008 km)
• Earth's Diameter at the Equator	: 7,926.41 miles (12,756.32 km)
• Average Distance from the Earth to the Sun	: 92,955,802 miles (149,579.870 km)
• Average Distance from the Earth to the Moon	: 238,855 miles (384,400.1 km)
• Highest Elevation on Earth	: Mt. Everest, Asia : 29,035 feet (8848 m)
• Tallest Mountain on Earth from Base to Peak	: Mauna Kea, Hawaii: 33,480 feet, i.e 10204 m (rising to 13796 feet above sea level) (10204 m, 4205 m)
• Point Farthest from the Center of the Earth	: The peak of the volcano chimborazo in Ecuador at 20561 feet (6269 m) is farthest from the center of the Earth due to its location near the equator and the oblateness of the Earth.
• Lowest Elevation on Land	: Dead Sea: 1369 feet below sea level (417 m)
• Deepest Point in the Ocean	: Challenger Deep (Mariana Trench) in Western Pacific Ocean: 36,740 feet (11022 m)
• Highest Temperature Recorded	: 136.8°F - AL Aziziyah, Libya, Sep. 13,1922 (58.4°C)
• Lowest Temperature Recorded	: -128.6°F - Vostok, Antarctica. July 21, 1983 (-89.2°C)
• Atmosphere content	: 78% nitrogen, 21% oxygen and 1% traces of argon, carbon dioxide and water.
• Rotation on Axis	: 23 hours and 56 minutes and 04.09053 second. But, it takes an additional four minutes for the earth to revolve to the same position as the day before relative to the sun (i.e. 24 hours)
• Revolution Around Sun	: 365 . 2425 day
• Chemical Composition of the Earth	: 32.1% Iron, 30.1% Oxygen, 15.1% Silicon, 13.9%, Magnesium, 2.9% Sulfur, 1.8% Nickel, 1.5% Calcium and 2.6% other.
• Standard Time zones	: 24

## Size and Shape of the Earth

- Shape of the Earth is called “geoid”
- The sciences of earth measurement is called “Geodesy”
- “ellipsoid” - reference to the Earth shape



The geoid bulges at the North Pole and is depressed at the South Pole

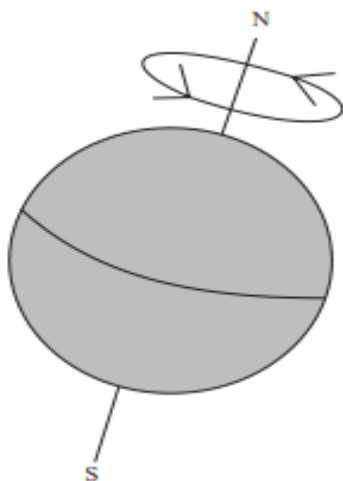
- Earth shape is affected by two main facts:
- It bulges in midriff, because of pliability of Earth’s lithosphere;
- Its shape is therefore an oblate spheroid.
- It has topographical irregularities.

## Motions of the Earth

The Earth is constantly in motion, revolving around the Sun S and rotating on its axis. These motions account for many of the phenomenon we see as normal occurrences: night and day, changing of the seasons, and different climates in different regions. With a globe ball properly mounted and rotating on its axis, the movements of the Earth around the Sun may be illustrated accurately.

### Rotation

The Earth spins on its axis from West to East (counter-clockwise). It takes the Earth 23 hours, 56 minutes, and 4.09 seconds to complete one full turn. Day and night are produced by the rotation of the Earth. The speed of rotation at any point upon the equator is at the rate of approximately 1,038 miles per hour, decreasing to zero at the poles.

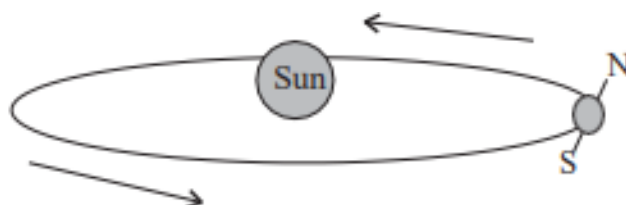


- **How rotation periods are calculated:** The period of rotation is calculated with reference to a star and with reference to the sun. When it is calculated with reference to a star, it is called a sidereal day and when it is calculated with reference to the sun, it is called a solar day.
- **Solar days and sidereal days:** The solar day is a time period of 24 hours, and the duration of a sidereal day is 23 hours 56 minutes. This difference of four minutes between a solar day and a sidereal day is due to the fact that the position of the Earth keeps changing with reference to the sun due to their motion around it; while with reference to a star at infinity, it will remain unchanged. Thus, a sidereal day is the actual time taken by the planet for a rotation of exactly 360 degrees on its axis.

## Revolution

While the Earth is spinning on its axis, it is revolving around the Sun in a counter-clockwise direction. It takes the Earth one full year to complete one full revolution around the Sun. This path is known as the Earth's orbit. It is very near a circle. The mean distance of the Earth from the Sun is about 93 million miles and the distance varies by 3 million miles, forming a slightly oval path.

The revolution of the Earth around the Sun traverse a distance of 595 million miles in 365 days, 6 hours, 9 minutes and 9.5 seconds. This means a speed of 18 miles a second (or 66,000 miles per hour) while at the same time rotating once each twenty-four hours.





Earth rotates in an elliptical orbit around the Sun

The orbit of the Earth around the sun is elliptical and not circular. Due to this, the distance between the Earth and the sun keeps changing.

- When this distance is minimum, the Earth is said to be in perihelion (around January 3).
- When the distance is the maximum, it is said to be in aphelion (around July 4).

The Earth's axis points constantly to the same point (the polar star) in the celestial sphere. As a consequence the latitude on the surface of the earth at which the sun's rays fall vertically keeps changing as the earth moves in its orbit around the sun. Due to this the earth attains four critical positions with reference to the sun.

1. **The equinoxes:** On 21st March, the Earth is so positioned with reference to the sun that the sun's rays are vertical at the equator and the entire world experiences equal day and night.
2. **The autumnal equinox:** A similar situation occurs on September 23.
3. **Summer solstice:** On 21st of June the sun's rays are vertical over the Tropic of Cancer as the north pole of the Earth is inclined at its maximum towards the sun. At this time, the North Pole experiences a long continuous day and the South Pole a long continuous night (ergo, what we know as summer solstice). The northern hemisphere has the summer season at this time and the southern hemisphere experiences winter now. Also the days are longer than the nights in the northern hemisphere at this time.
4. **Winter solstice:** On December 22, the position of the earth with respect to the sun is such that the South Pole is inclined at its maximum towards the sun and the Tropic of Cancer receives the vertical rays of the sun. This position is called the winter solstice when the sun shines continuously in the South Polar Region and it is a long continuous night at the North Pole. This is the winter season in the northern hemisphere and the summer in the southern hemisphere. During the winter solstice, the days are longer than the nights in the southern hemisphere.
  - Thus, the variation in the duration of day and night and the change of seasons are due to the earth's revolution and the inclination of the axis of the earth. Also the seasons are reversed from the northern to the southern hemisphere.

### **Longitudes and Latitudes**

Together, longitudes and latitudes form the Earth's geographical coordinates, and represent the angular distance of any location on the Earth from the Earth's Equator. Both latitudes and longitudes are measured in degrees.