IAS BABA

GEOGRAPHY HANDOUTS

PEP - 2025

PRELIMS EXCLUSIVE PROGRAMME

ONE STOP DESTINATION FOR PRELIMS PREPARATION

TOPICS: Big Bang Theory, Expansion of universe and Red-shift phenomenon, Planets, Sun, Moon, Asteroids, Venus, Mars, Goldilock zone, Sun – solar waves, lagrange point, Revolution of planets – Laws of revolution, Rotation of planets, Effects of rotation, Longitude – important longitudes, gaining and losing the time, Moon – rotation and revolution of moon, phases of moon, lunar calendar Solar and lunar eclipse Polestar Life cycle of star Black Hole

PYQs

Q.1) Variations in the length of daytime and night time from season to season are due to

a) the earth's rotation on its axis
b) the earth's revolution around the sun in an elliptical manner
c) latitudinal position of the place
d) revolution of the earth on a tilted axis

Q.2) On 21st June, the Sun

a) does not set below the horizon at the Arctic Circle
b) does not set below the horizon at Antarctic Circle
c) shines vertically overhead at noon on the Equator
d) shines vertically overhead at the Tropic of Capricorn

Q.3) In the northern hemisphere, the longest day of the year normally occurs in the:

a) First half of the month of June
b) Second half of the month of June
c) First half of the month of July
d) Second half of the month of July

Q.4) The term 'Goldilocks zone' is often seen in the news in the context of:

a) The limits of habitable zones above the surface of the Earth
b) Regions inside the Earth where shale gas is available
c) Search for Earth-like planets in outer space
d) Search for meteorites containing precious metals

Q.5) What explains the eastward flow of the equatorial counter-current?

a) The Earth's rotation on its axis
b) Convergence of the two equatorial currents
c) Difference in salinity of water
d) Occurrence of the belt of calm near the equator

Q.6) Which of the following is/are cited by the scientists as evidence/evidence for the continued expansion of the universe?

1. Detection of microwaves in space
2. Observation of redshift phenomenon in space
3. Movement of asteroids in space
4. Occurrence of supernova explosions in space

Select the correct answer using the codes given below:

a) 1 and 2 only
b) 2 only
c) 1, 3 and 4
d) 1, 2, 3 and 4

Universe

The most widely accepted model for the origin and evolution of the universe is the Big Bang theory. According to this theory, the universe began as an incredibly hot, dense singularity about 13.8 billion years ago and has been expanding and cooling ever since.

The Big Bang Theory considers the following stages in the development of the universe.

- In the beginning, all matter forming the universe existed in one place in the form of a **"tiny ball" (singular atom)** with an unimaginably small volume, infinite temperature and infinite density.
- At the Big Bang the "tiny ball" **exploded violently**. This led to a huge expansion. It is now generally accepted that the event of the big bang took place **13.8 billion years** before the present. The expansion continues even to the present day.
- As it grew, some energy was converted into matter. There was particularly rapid expansion within fractions of a second after the bang.
- In the first moments after the Big Bang, the universe was extremely hot and dense. As the universe cooled, conditions became just right to give rise to the building blocks of matter, like the quarks and electrons of which we are all made.

The **theory of cosmic inflation**, proposed by **Alan Guth** in 1980, extends the Big Bang model by suggesting that in the first fraction of a second after the Big Bang, the universe underwent a **period of exponential expansion**. This inflationary epoch helps explain several puzzles:

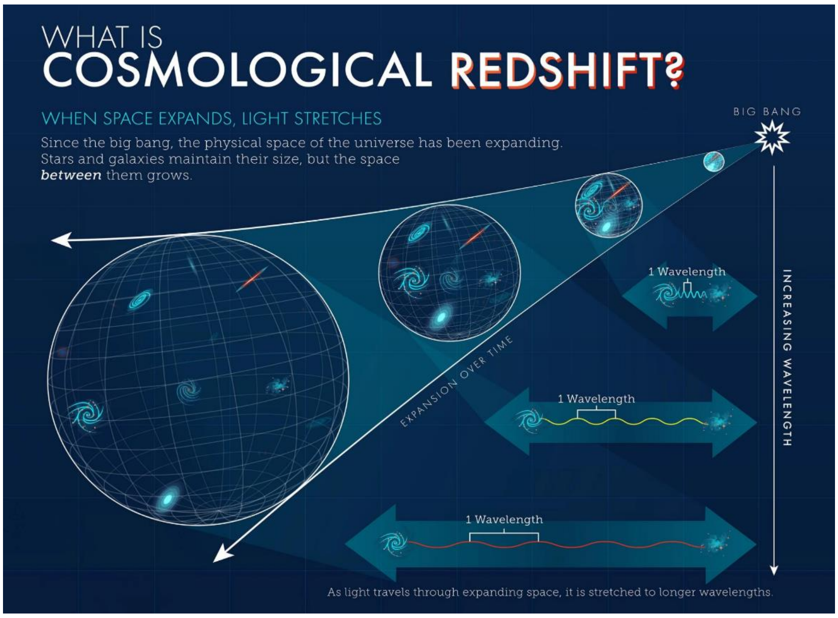
1. The **Flatness Problem**: Why the universe appears flat on large scales.
2. The **Horizon Problem**: Why distant parts of the universe have similar temperatures despite not being in causal contact.

Inflation theory proposes that quantum fluctuations during this brief period were stretched to cosmic scales, seeding the **large-scale structure of the universe** we see today.

In 1929, American astronomer **Edwin Hubble** discovered that the distances to far-away galaxies were proportional to their redshifts. Hubble's observation implied that **distant galaxies were moving away from us**, as the farthest galaxies had the fastest apparent velocities.

Hubble reasoned that if the galaxies are moving away from us, then at some time in the past, they must have been clustered close together. Hubble's discovery was the first observational support for **Georges Lemaitre's Big Bang theory** of the universe, proposed in 1927. Lemaitre proposed that the universe expanded explosively from an extremely dense and hot state (scientists call it the Singularity), and continues to expand today.

Red Shift Phenomenon- Redshift is a fundamental tool in understanding the universe's expansion. It provides **direct evidence of cosmic expansion** through the observation that distant galaxies are moving away from us. **Edwin Hubble**'s discovery of the relationship between a galaxy's distance and its redshift, known as Hubble's Law, demonstrates that **more distant galaxies recede faster**, supporting the expanding universe model. Redshift enables astronomers to **estimate cosmic distances**, study the early universe, and calculate the current expansion rate **(Hubble constant)**. It led to the discovery of accelerating expansion and the concept of **dark energy.** Redshift surveys help map the universe's large-scale structure, while the cosmic microwave background's redshift offers insights into the early universe. By allowing precise measurements of cosmic motion and distances, redshift has become crucial in testing and refining cosmological models, providing a comprehensive view of the universe's past, present, and future expansion.



An alternative to expansion theory was **Hoyle's concept of steady state.** It considered the universe to be roughly the **same at any point of time**. Other theories formulating the origin of Universe includes **Theory of Mirage** of a Black Hole, **Plasma Theory** of creation of Universe and **White Hole Theory** (These don't require detailed explanation, knowing the name of such theories is enough at this stage) However, with greater evidence becoming available about the expanding universe, scientific community at present favours argument of expanding universe.

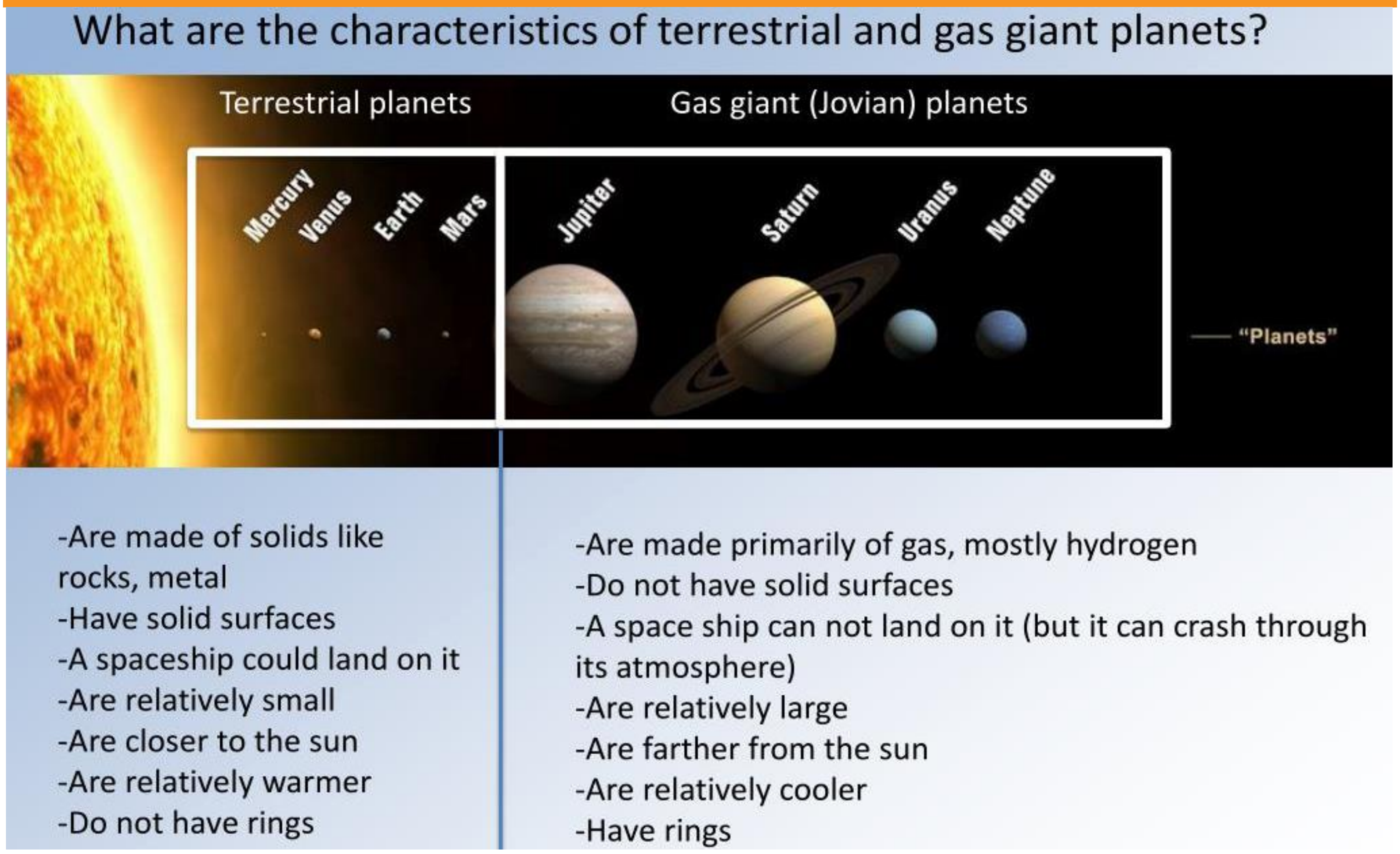
Formation of Galaxies and Stars

The distribution of matter and energy was not even in the early universe. These initial density differences gave rise to differences in gravitational forces and it caused the matter to get drawn together. These formed the bases for the **development of galaxies**. A galaxy contains a large number of stars. A galaxy starts to form by accumulation of hydrogen gas in the form of a **very large cloud** called a **nebula.**

Eventually, growing nebula develop localised **clumps of gas**. These clumps continue to grow into even denser gaseous bodies, giving rise to formation of stars.

The formation of stars is believed to have taken place some 5-6 billion years ago.

Our solar system



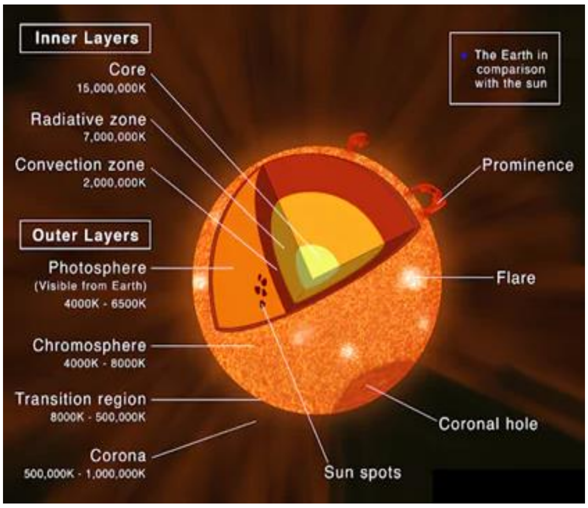
Our solar system, formed approximately **4.6 billion years ago**, is a vast cosmic neighbourhood centred around the Sun. It encompasses **eight diverse planets** orbiting at varying distances, accompanied by at least 146 moons of various sizes and compositions. The system also includes an abundance of smaller celestial bodies, including millions of **asteroids** and **comets**, which populate the spaces between planets. **Interplanetary dust** and gas permeate the entire system, filling the seemingly empty voids. This complex arrangement of celestial objects, held together by the **Sun's gravitational influence**, continues to fascinate astronomers and space enthusiasts alike.

The Sun

The sun is by far the largest object in our solar system, containing **99.8%** of the **solar system's mass.**

According to NASA, with the use of spectrographs, it is clear that the Sun is made up of gas, about **91% hydrogen** and **8.9% helium.** Compared with other stars, the sun is relatively small and just one of the billions of stars in the **Milky Way.**
The temperature at its surface is about **5500 degrees Celsius**. In the centre, the temperature is about 15 million degrees Celsius.

Interestingly, temperature of the **corona**, outermost region of the Sun's atmosphere, is **more than 1 million degrees Celsius.**



At such high temperatures and pressures, the Sun becomes a **nuclear reactor**, where hydrogen is converted to helium. At the same time, huge amounts of radiation are produced.

Its period of **surface rotation** is about 26 days at its equator but longer at higher latitudes.

Every **11 years** or so, the **Sun's magnetic field completely flips.** This means that the Sun's north and south poles switch places. Then it takes about another 11 years for the Sun's north and south poles to flip back again.

Solar phenomenon

Solar Cycle: The solar cycle is the approximately **11-year periodic variation** in the Sun's activity. It is characterised by changes in the **number of sunspots, solar flares**, and other solar phenomena. The cycle is driven by the Sun's magnetic field and affects space weather and Earth's upper atmosphere.

Solar Maximum: Solar maximum is the period of **greatest solar activity** during the solar cycle. It is characterised by a **high number of sunspots**, **increased solar flares**, and coronal mass ejections. Solar maximum can impact Earth's magnetosphere, potentially affecting satellites and power grids.

Solar Minimum: Solar minimum is the period of **least solar activity** during the solar cycle. It is characterised by **few or no sunspots** and **reduced solar flare activity**. During solar minimum, the Sun's magnetic field is at its weakest and most dipolar state.

Solar wind: Solar wind is a **stream of charged particles** emanating from the Sun's corona, consisting primarily of protons and electrons. It travels at **high speeds** through space, carrying the Sun's magnetic field and interacting with planetary magnetic fields. This phenomenon causes **auroras, geomagnetic storms, shapes comet tails,** and **defines the heliosphere** - the Sun's sphere of influence. Recent probe by NASA to the Sun, **Parker Solar Probe**, has become the first man-made object to touch the surface of the Sun and has provided great scientific insights into the working of the Sun and the Solar winds.

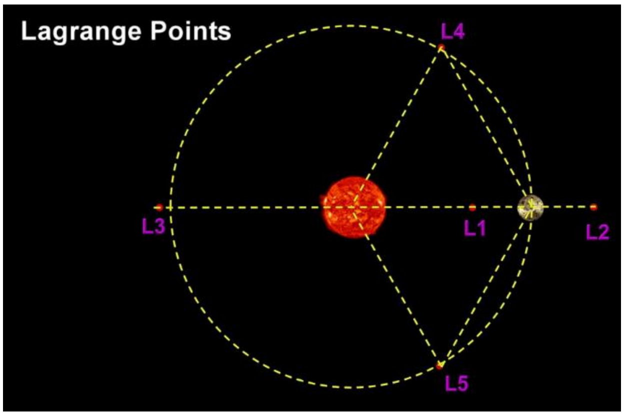
Sunspots: These are **temporary dark spots** on the Sun's surface caused by intense magnetic activity. They appear darker because they are **cooler than the surrounding areas**, typically lasting for days to months and varying in size from about 16 km to 160,000 km in diameter.

Solar flares: These are **sudden, intense brightenings** on the Sun's surface, often associated with sunspots. Solar flares release **massive amounts of energy** in the form of electromagnetic radiation and charged particles, which can affect Earth's magnetosphere and potentially disrupt communications and power grids.

Coronal Mass Ejections (CMEs): These are **large expulsions of plasma** and magnetic fields from the Sun's corona. CMEs can eject billions of tons of coronal material and carry an embedded magnetic field that is stronger than the background solar wind interplanetary magnetic field. When directed towards Earth, CMEs can cause **geomagnetic storms**, potentially affecting satellite operations, power grids, and radio communications.

Lagrange Points

Lagrange points are positions in space where objects tend to stay still due to **gravitational equilibrium** between two large bodies (like the Sun and Earth). There are five such points (L1 to L5) in any two-body system.



Importance of Lagrange points:

L1 (Earth-Sun system):

1. Located between Earth and Sun, about **1.5 million km** from Earth.
2. Ideal for solar observation missions like **SOHO**, DSCOVR and India's **Aditya L1.**

L2 (Earth-Sun system):

1. Located on the **far side** of Earth from the Sun, about 1.5 million km away.
2. Hosts **space telescopes** like James Webb, providing a **stable, cold environment for deep space observation**.

L3 (Earth-Sun system):

1. Located on the **opposite side** of the Sun from Earth.
2. **Rarely used** due to communication difficulties, but could potentially host future missions.

L4 and L5 (Earth-Sun system):

1. Located 60 degrees ahead (L4) and behind (L5) Earth in its orbit around the Sun.
2. **Stable points** that could host **future space colonies** or serve as locations for studying gravitational effects.

The Moon

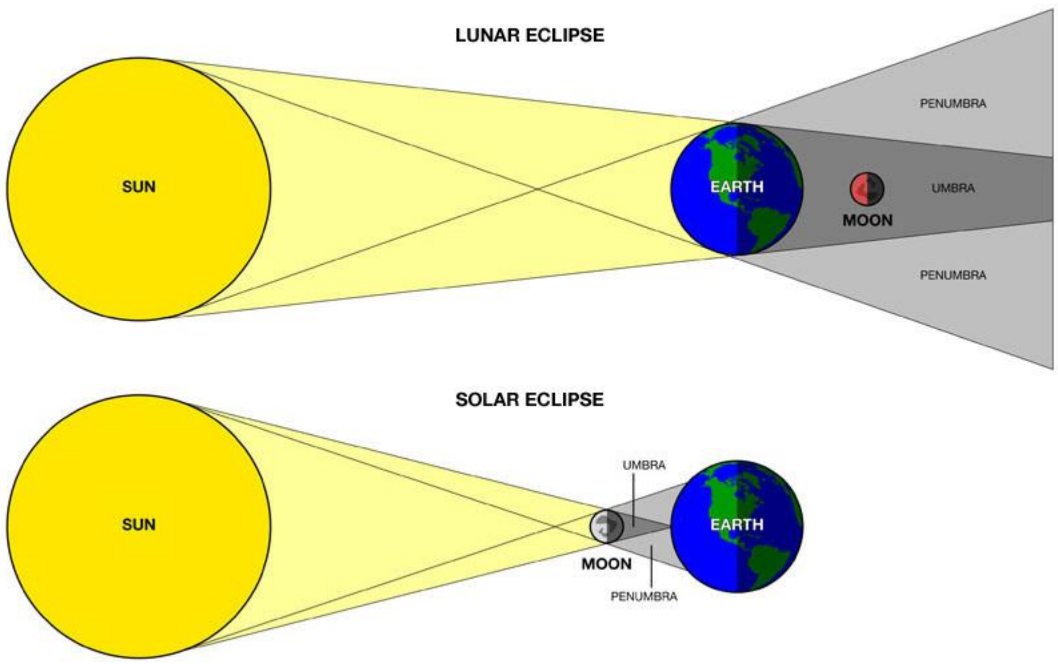
The Moon, Earth's **only natural satellite**, has a diameter of about one-quarter of Earth's diameter. It orbits at an average distance of 384,400 km from Earth. Due to **synchronous rotation**, the Moon always presents the **same face towards Earth**. The Moon's phases, visible from Earth, are caused by the changing angles between the Sun, Moon, and Earth as the Moon orbits our planet.

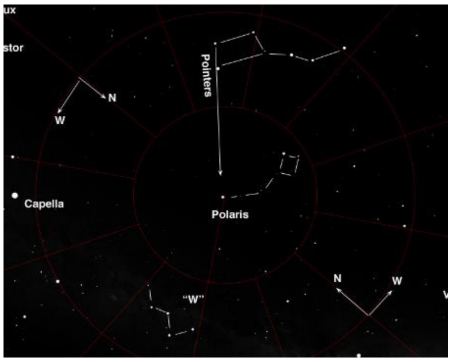
The Moon **rotates on its axis** and **revolves around Earth** in the same **27.32-day period**, resulting in synchronous rotation that keeps one face always towards Earth. Its elliptical orbit maintains an average distance of 384,000 km from Earth, with the sidereal month matching its rotational period.

The Moon's phases result from its changing position relative to Earth and the Sun, with a complete cycle taking 29.5 days (synodic month). These phases range from **New Moon** (dark side facing Earth) to **Full Moon** (entire lit surface visible), with waxing and waning stages in between. While the phases are **consistent globally**, they appear inverted when viewed from the Southern Hemisphere compared to the Northern Hemisphere.

Solar and Lunar Eclipses

Characteristic	Solar Eclipse	Lunar Eclipse
Definition	The Moon passes between the Earth and the Sun	The Earth passes between the Sun and the Moon
When it occurs	During a new moon	During a full moon
Celestial arrangement	Sun, Moon, Earth in alignment	Sun, Earth, Moon in alignment
Shadow cast by	Moon casts shadow on Earth	Earth casts shadow on Moon
Visibility on Earth	Visible only from a small area on Earth	Visible from anywhere on the night side of Earth
Duration	A few minutes to several hours	A few hours
Effect on celestial body	The Sun gets obscured from Earth's view	The Moon gets darkened
Types	Total, Partial, Annular, Hybrid	Total, Partial
Safety for direct viewing	Unsafe to view directly without proper eye protection	Safe to view directly with naked eye
Frequency	Up to 5 per year	Up to 3 per year
Time of day	Occurs during daytime	Occurs at night
Impact on light on Earth	Can cause temporary darkness in affected areas	Minimal impact on Earth's illumination





Polaris:

Polaris is a star located almost **directly above the Earth's northern axis** of rotation. It **appears stationary** in the night sky while other stars seem to rotate around it. Polaris is important for navigation, as its position indicates true north. It's visible year-round in the Northern Hemisphere.

Auroras:

Auroras are **natural light displays** that occur in the Earth's sky, primarily in the polar regions. They are also known as:

- **Aurora borealis** or "northern lights" in the Northern Hemisphere
- **Aurora australis** or "southern lights" in the Southern Hemisphere

Causes of Auroras

- **Solar wind**: Electrically charged particles (ions) from the Sun.
- **Earth's magnetic field**: Traps some of these particles.
- **Collisions**: The trapped particles collide with atoms and molecules in Earth's upper atmosphere.

Auroras have been **observed on other planets** with magnetic fields and atmospheres, including Jupiter, Saturn, Uranus, Neptune, and Mars.

Planets

The eight planets are divided into two groups:

1. **Inner/Terrestrial planets**: Mercury, Venus, Earth, Mars
- Composed mainly of rock and metal
- Relatively small with solid surfaces.
2. **Outer/Jovian planets**: Jupiter, Saturn, Uranus, Neptune
- Primarily composed of hydrogen and helium
- Large with gaseous composition.

Planet	Distinct Characteristics	Atmosphere Composition	Significant Natural Satellites
Mercury	Smallest planet in the solar system, high density with a large metallic core, surface features marked by craters, experiences extreme temperature variations, completes an orbit in 88 Earth days, one rotation takes 176 Earth days.	Hydrogen, helium, oxygen, sodium, calcium, potassium, water vapour.	0
Venus	Rotates clockwise; a day on Venus (243 Earth days) is longer than a year (225 Earth days); hottest planet with an average surface temperature of 462°C due to greenhouse effect; known as Earth's 'sister planet' due to similar size and mass.	96.5% Carbon Dioxide, 3.5% Nitrogen, with trace amounts of sulphur dioxide and water vapour.	0

Earth	Only planet known to harbour life, vast oceans covering 70% of its surface, and has plate tectonics.	Nitrogen (78%), Oxygen (21%), Argon (0.9%), Carbon Dioxide (0.04%), and trace gases.	The Moon.
Mars	Known as the Red Planet due to its iron oxide surface; features include Olympus Mons (the tallest volcano) and Valles Marineris (one of the largest canyons).	Carbon Dioxide (95%), Nitrogen (2.7%), Argon (1.6%).	Phobos and Deimos.
Jupiter	Largest planet in the solar system, diameter of about 142,984 km (11 times that of Earth).	About 90% hydrogen, 10% helium, with traces of methane, ammonia, and other gases.	79 known moons, including Ganymede, Io, Europa, and Callisto.
Saturn	Low density allows it to float in water, and has prominent rings made of ice and rock.	96.3% hydrogen, 3.25% helium with trace amounts of methane and ammonia.	145 moons, including Titan.
Uranus	Has the coldest planetary atmosphere in the Solar System, tilted on its side, experiences extreme seasons lasting about 20 years.	Hydrogen (82%), Helium (15%), Methane (2%), with traces of ammonia, water, and hydrocarbons.	At least 27 moons, including Miranda, Ariel, Umbriel, Titania, and Oberon.
Neptune	Vivid blue colour due to methane; extreme weather patterns with the strongest winds in the solar system; classified as an ice giant.	Hydrogen (80%), Helium (19%), Methane (1.5%).	14 moons total, with Triton as the most significant.

Other solar system objects

Asteroids

Asteroids are primarily **rocky bodies** orbiting the Sun, mostly concentrated in the **asteroid belt between Mars and Jupiter**. While **Ceres** is the largest at about 940 km in diameter, most asteroids are much smaller. They are divided into different types based on their composition. Some asteroids, like the **Trojans**, share Jupiter's orbit. **Near-Earth asteroids** have orbits that bring them close to Earth's orbit.

Comets

Comets are **icy bodies** composed of **dust, rock, and frozen gases**. When they approach the Sun, the heat causes the ice to sublimate, creating a coma (a fuzzy atmosphere) and often a tail. Famous comets include **Halley's Comet** and **Hale-Bopp**.

Kuiper Belt

The Kuiper Belt is a region **beyond Neptune's orbit,** extending from about 30 to 50 AU from the Sun. It contains numerous icy bodies, including:

- **Dwarf planets**: Pluto, Haumea, and Makemake
- Kuiper Belt Objects (KBOs): Smaller icy bodies, some of which are binary systems.

The Kuiper Belt is thought to be the source of short-period comets and provides valuable information about the early Solar System.

Oort Cloud

The Oort Cloud is a theoretical **spherical cloud of icy objects** surrounding the Solar System, extending from about 2,000 to 100,000 AU from the Sun. It's believed to be the source of long-period comets. It contains **trillions of icy bodies,** remnants from the formation of the Solar System. Occasionally, passing stars or galactic tides may disturb Oort Cloud objects, sending them towards the inner Solar System.

The study of these objects helps astronomers **understand the formation and evolution of our Solar System.**

The Goldilocks Zone

The "Goldilocks Zone" or **habitable zone** is the region around a star where **conditions might allow liquid water** on a planet's surface. This concept is crucial in the search for potentially habitable exoplanets.
Factors affecting the location of the habitable zone:

- Star's size and temperature
- Planet's atmospheric composition
- Planet's albedo (reflectivity)

Earth is located within the Sun's habitable zone, while Venus is too close (too hot) and Mars is near the outer edge (too cold).

Kepler's Laws of Planetary Motion

1. Planets orbit in ellipses with the Sun at one focus.
2. A line connecting a planet to the Sun sweeps out equal areas in equal times.
3. The square of a planet's orbital period is proportional to the cube of its semi-major axis.

Rotation of Earth

'Rotation' refers to an object's **spinning motion about its own axis**. Earth also spins around a central line called an axis. Earth rotates along its axis **from west to east**. It takes approximately **24 hrs** to complete one rotation. **Days and nights occur due to rotation** of the earth. The circle that divides the day from night on the globe is called the **circle of illumination.** Earth rotates on a **tilted axis** that makes an angle of 23.5° with the orbital plane. Rotation Movement of the earth on its axis for 24 hours is called **Earth day.**

Effects of Rotation

Rotation creates a **diurnal cycle** of light and darkness, temperature, and humidity changes. Rotation causes the **tides**- the twice daily rise and fall of sea level. Rotation requires the creation of **standardised time zones**. There are **24,** one for each hour of the earth's rotation.
The Coriolis Force- When the Earth rotates on its axis, it prevents air currents from moving in a straight line north and south from the equator. Instead, it results in one of the effects of rotation of the Earth: the Coriolis Effect. This deflects winds to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.

What happens If Earth didn't rotate?

The portion of the earth facing the sun would always experience day, thus bringing continuous warmth to the region. The other half would remain in darkness and be freezing cold all the time. Life would not have been possible in such extreme conditions.

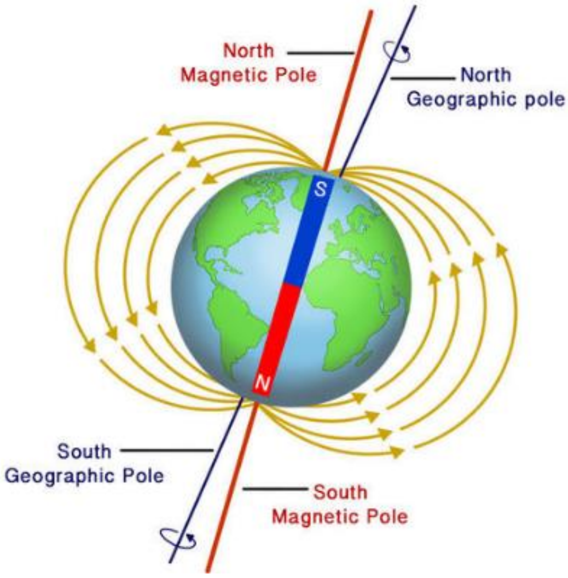
Because one rotation takes 24 hours, one might think that each side of Earth spends approximately 12 hours facing the Sun and 12 hours in darkness. This is true of places located on or near the equator. However, as one moves towards the North and South Poles, the length of daytime and nighttime varies. The closer a city is to the North or South Pole, the more extreme the difference in daylight hours and night time hours are. This is due to the tilt of the axis and Earth's revolution around the Sun.

Revolution

The motion of the **earth around the sun** in its orbit is called revolution. It takes 365¼ days (one year) to revolve around the sun. Six hours saved every year are added to make one day (24 hours) over a span of four years. This surplus day is added to the month of February. Thus, every fourth year, February is 29 days instead of 28 days. Such a year with 366 days is called a leap year. Revolution leads to **change in Seasons**. During one revolution around the Sun, Earth travels at an average distance of about **150 million km**. Earth revolves around the Sun at an average speed of about 27 km (17 mi) per second, but the speed is **not constant**. The planet moves slower when it is at **aphelion** and faster when it is at **perihelion**. During the Northern Hemisphere summer the North Pole points toward the Sun, and in the Northern Hemisphere winter the North Pole is tilted away from the Sun.

Effects of Revolution

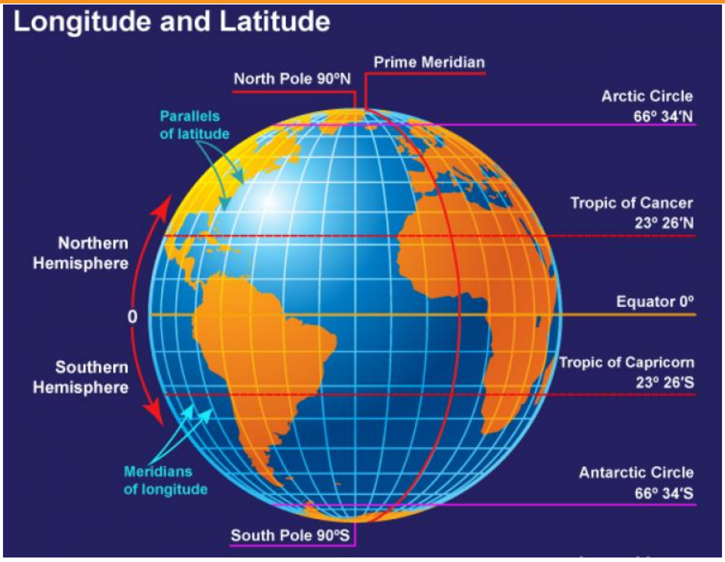
Revolution along with the earth's tilted axis leads to **changing seasons** across the hemispheres. The speed of the Earth's revolution has influenced the state of the Earth. On account of the speed of pivot, a diffusive power is made which prompts the straightening of the Earth at shafts and protruding at the middle. The Earth's revolution influences the development of water in the seas. The speed of revolution additionally influences the development of the **breeze**. Because of revolution, winds and the sea flow redirect to one side in the Northern Hemisphere and to one side in the Southern Hemisphere.



Earth's Magnetic Axis: Apart from the various axis mentioned above, the earth also has a magnetic axis. It is represented by a field of a **magnetic dipole** currently tilted at an angle of about **11° with respect to Earth's rotational axis**, as if there were an enormous bar magnet placed at that angle through the centre of Earth. The North geomagnetic pole actually represents the South Pole of Earth's magnetic field, and conversely the South geomagnetic pole corresponds to the north pole of Earth's magnetic field.

Latitude and Longitude

Latitude:

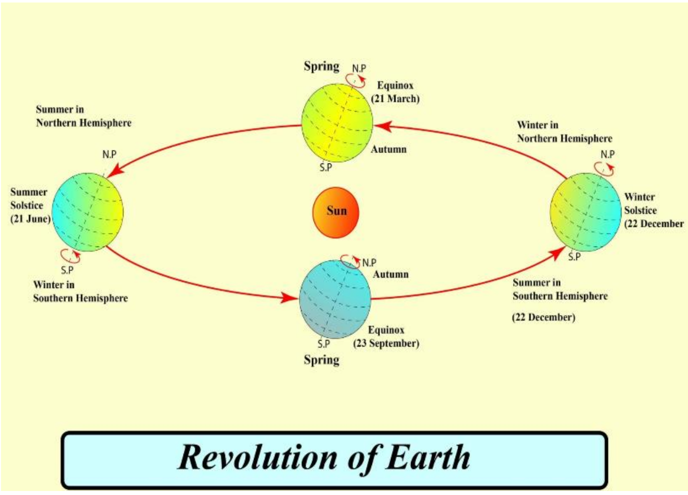


- Imaginary lines running east-west parallel to the Equator
- Measures **north-south position** on Earth's surface
- Ranges from 0° at the Equator to 90° at the poles
- North of Equator: 1° to 89° N
- South of Equator: 1° to 89° S
- The distance between two successive lines of latitude **remain constant (111km)** because latitudes run **parallel to each other** and never meets the other latitude
- Key latitudes: Equator (0°), Tropic of Cancer (23°26' N), Tropic of Capricorn (23°26' S), Arctic Circle (66°34' N), Antarctic Circle (66°34' S)

Longitude:

- Imaginary lines running north-south between the poles
- Measures **east-west position** on Earth's surface
- Ranges from 0° to 180° east or west of the Prime Meridian
- **Prime Meridian (0°)** passes through Greenwich, England
- **180° meridian** is opposite the Prime Meridian

Key points:



- Latitude and longitude together form a **coordinate system** to describe any location on Earth
- Measured in degrees, minutes, and seconds
- Latitude lines are parallel, while longitude lines converge at the poles
- Distance between latitude degrees is relatively constant (about 111 km)
- Distance between longitude degrees varies, largest at Equator (111.32 km) and converges to 0 at poles

This system allows for **precise location identification** and is crucial for navigation, mapping, and understanding global geography.

Summer Solstice:

- Occurs around **June 20 or 21** in the Northern Hemisphere
- Marks the **longest day** and **shortest night** of the year
- The Sun's path is farthest north in the Northern Hemisphere
- The North Pole is tilted about 23.4° toward the Sun

- Marks the beginning of summer in the astronomical definition of seasons

Winter Solstice:

- Occurs around **December 21 or 22** in the Northern Hemisphere
- Marks the **shortest day** and **longest night** of the year
- The Sun's path is farthest south in the Northern Hemisphere
- The North Pole is tilted about 23.5° away from the Sun
- Marks the beginning of winter in the astronomical definition of seasons

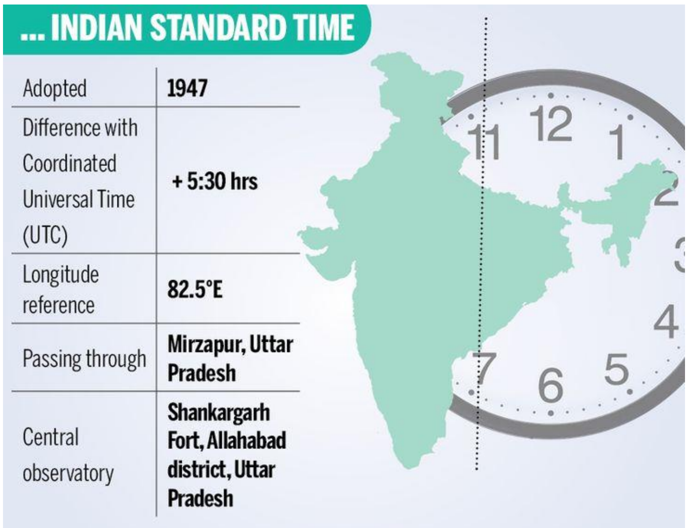
Equinox:

- Occurs **twice a year**, around March 20 (**spring equinox**) and September 22 (**autumn equinox**)
- Day and night are approximately **equal** in length
- The Sun crosses the celestial equator
- Marks the beginning of spring and autumn respectively
- The Sun appears to rise due east and set due west

Key points:

1. Solstices and equinoxes are caused by **Earth's axial tilt** of 23.5°
2. These events mark the **changing of seasons** in the astronomical calendar
3. The dates can vary slightly due to Earth's elliptical orbit and other factors
4. The experiences of solstices and equinoxes are **reversed in the Southern Hemisphere**
5. These events have been culturally significant throughout human history, often associated with festivals and agricultural practices

Local and Standard Time

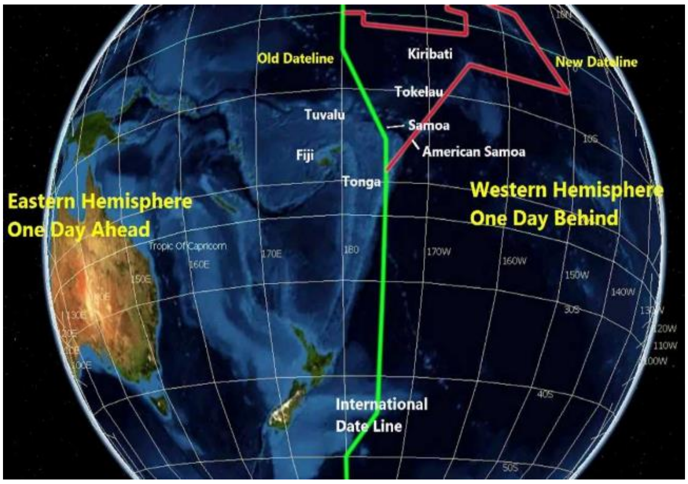


Local time and standard time are two distinct concepts in timekeeping. Local time is determined by the **sun's position** and varies with longitude, changing by **4 minutes for every 1 degree of longitude.** This natural time-reckoning method, based on the sun's shadow, was historically used but proved impractical for modern needs. Standard time, on the other hand, is set by countries **based on a central meridian and remains constant within a time zone**, addressing the complications arising from varying local times. Standard time was first adopted by British railways in 1847 and later by U.S. railroads in 1883, revolutionising transportation and communication. Today, the **world is divided into 24 time zones**, each covering approximately 15 degrees of longitude, facilitating global coordination and timekeeping.

In India, the concept of standard time was adopted to unify timekeeping across the vast country. India follows Indian Standard Time (IST), which is **5 hours and 30 minutes ahead** of Greenwich Meridian Time (GMT+5:30). This is based on the longitude of **82.5°E**, which passes through **Mirzapur in Uttar Pradesh**. Despite spanning about 30 degrees of longitude, India uses a **single time zone** for practical and administrative purposes. However, some **northeastern states unofficially follow a different local time** due to significant time differences with IST. The adoption of standard time in India has been crucial for coordinating transportation, communication, and various national activities across the country's diverse geographical expanse.

International Date Line

The International Date Line (IDL) is an **imaginary line** running approximately **along the 180° longitude from the North Pole to the South Pole**, serving as a demarcation between calendar dates. It's not a straight line but zigzags to accommodate political borders and island groups. When crossing the IDL **from east to west, a day is added**, and when crossing **from west to east, a day is subtracted**. This line was established to ensure a consistent global date and time structure, crucial for international navigation, trade, and communication.



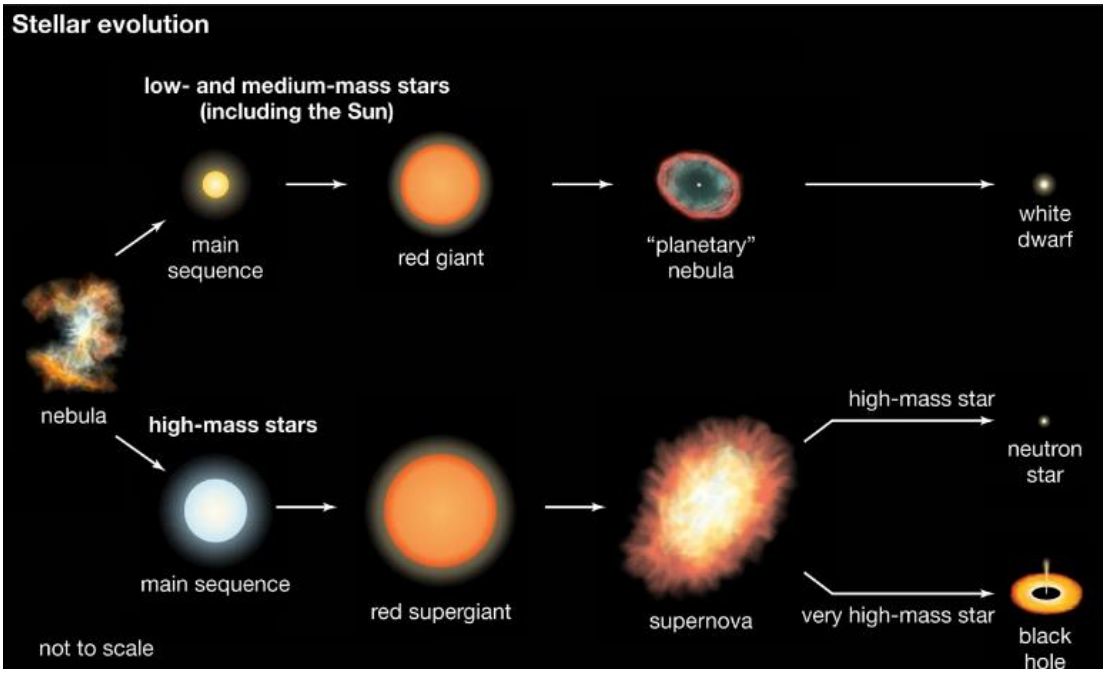
While India is not directly affected by the IDL due to its geographical location, the concept is relevant to India's global interactions. Although India spans about 30 degrees of longitude, it uses a single time zone for practical and administrative purposes. The IDL becomes significant for India in terms of international trade, communication with countries across the Pacific, and coordinating with global partners.

Life Cycle of Stars

Main stages in a star's life cycle:

1. **Nebula**: Star forms from a collapsing cloud of gas and dust
2. **Protostar:** Contracting cloud heats up but nuclear fusion hasn't begun
3. **Main Sequence**: Star fuses hydrogen into helium in its core
4. **Red Giant**: Outer layers expand as core hydrogen is depleted
5. Final Stages: Depend on the star's mass

- Low/medium mass stars: Planetary Nebula → **White Dwarf**
- High mass stars: Supernova → **Neutron Star or Black Hole**



Black Hole

Black holes are regions of spacetime where **gravitational forces are so intense that they warp the fabric of space-time itself.** These cosmic phenomena come in **various sizes**, from stellar-mass black holes formed by collapsing stars to supermassive black holes found at the centres of galaxies, and their study has revolutionised our understanding of gravity, space, and time. Key features include:

Event Horizon:

The event horizon is the **point of no return** around a black hole. It's the boundary beyond which the gravitational pull becomes so strong that escape is impossible, even for light. The **size of the event horizon depends on the black hole's mass** - larger black holes have larger event horizons.

Singularity:

At the centre of a black hole lies the singularity, a **point of infinite density** where the laws of physics as we know them break down. All the mass of the black hole is compressed into this **dimensionless point**, creating **extreme spacetime curvature**. The nature of the singularity remains one of the biggest mysteries in physics.

Accretion Disk:

The accretion disk is a **flattened ring of gas, dust, and other matter spiralling into the black hole.** As this material falls inward, it heats up due to friction and compression, causing it to glow brightly across multiple wavelengths. The accretion disk is often the primary way astronomers can detect and study black holes indirectly.