General Knowledge Today

Prelims Geography-2: Earth Basics

Target 2016: Integrated IAS General Studies
Last Updated: April 3, 2016
Published by: GKTODAY.IN

Contents

Model Questions

Please check Prelims model questions and answers at the end of this module.

Motions of Earth , Seasons and Eclipse

There are four kinds of Earth's motions as follows:

1. Earth's rotation on its axis
2. Earth's precession movement which is very much similar to a spinning top.
3. Earth revolution around the Sun
4. Earth along with the entire solar system moves around the center of the Milky way Galaxy.

Earth's Rotation and Precession Movements

Earth rotates around its own axis from west to east. When seen from the North Star Polaris {Alpha Ursae Minoris}, Earth turns counter-clockwise. Rotation of Earth results in days and nights. Earth's rotation is mostly the *result of angular momentum left over during the formation process of Earth*. There are three distinct motions, the most noticeable being Earth's rotation. Earth rotates once every 23 hours, 56 minutes, causing our cycles of day and night. Earth also has precession (a wobble of the rotational axis) and nutation (a back-and-forth wiggle of Earth's axis), caused primarily by the gravitational pull of the Moon as it orbits Earth. Precession and nutation, over long periods of time, cause Earth's north and south poles to point toward different stars.

Solar Day

A Solar day refers to one complete rotation of Earth on its own axis relative to Sun. However, since Earth also revolves around the sun, there are three kinds of days recognized by astronomers viz. Apparent or True solar day; Mean solar day and sidereal day. These are discussed as follows:

Apparent {True} Solar Day

Apparent solar day is the interval between two successive returns of the Sun to the local meridian. A sundial can measure the apparent solar day with limited precision. The length of true solar day keeps changing throughout the year. There are two reasons for this. Firstly, Earth's orbit around sun is an ellipse. The second law of Kepler says that in elliptical orbits, the line joining the planet and sun sweeps out equal areas during equal intervals of time. Thus, earth moves faster when its is nearest to Sun (perihelion) and moves slower when it is farthest from Sun (Aphelion). Secondly, Earth currently has an axial tilt of about 23.5° and remains tilted in the same direction towards the stars throughout a year. This implies that when a hemisphere is pointing away from the Sun at one point in the orbit then half an orbit later (half a year later) this hemisphere will be pointing towards the Sun. This effect is the main cause of the seasons.

What is obliquity of the ecliptic?

Earth's orbital plane is known as the ecliptic plane, and so the Earth's axial tilt is called the obliquity of the ecliptic.

Due to Earth's tilt, Sun moves along a great circle (the ecliptic) that is tilted to Earth's celestial equator. When the Sun crosses the equator at both equinoxes, the Sun is moving at an angle to the equator, so the projection of this tilted motion onto the equator is slower than its mean motion; when the Sun is farthest from the equator at both solstices, the Sun moves parallel to the equator, so the projection of this parallel motion onto the equator is faster than its mean motion. The result is that apparent solar days are shorter in March (26–27) and September (12–13) than they are in June (18–19) or December (20–21).

The true solar day tends to be longer near perihelion taking about 10 seconds longer and is about 10 seconds shorter near aphelion. It is about 20 seconds longer near a solstice and shorter by 20 seconds near equinox.

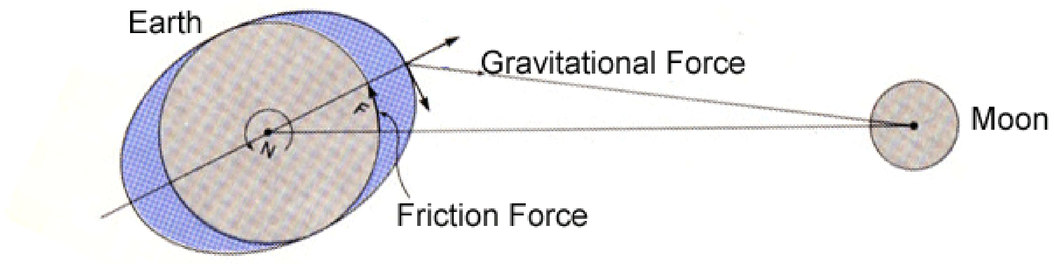
Mean Solar Day

The average of the true or apparent solar day over an entire year is called the mean solar day. It has 86400 seconds. Albeit, the amount of daylight varies significantly, the length of a mean solar day does not change on a seasonal basis. However, the length of the Mean Solar Day increases by 1.4 milliseconds per century. The astronomers have calculated that Mean Solar Day was exactly 86,400 (24 hours × 60 minutes × 60 seconds) SI seconds in approximately 1820 AD and now it is **86400.002** SI seconds. The reason behind this slow down is the net effect of **tidal acceleration** and global glacial rebound.

Tidal Acceleration

Tidal acceleration refers to the effect of the tidal forces between an orbiting natural satellite and the primary planet that it orbits.

We know that Moon's mass is a considerable fraction of that of the Earth. The Ratio of masses of moon and Earth is about 1:81. So these two bodies can be regarded as a double planet system, rather than as a planet with a satellite. The large mass of moon is sufficient to raise tides in the matter of earth. The water of the oceans bulges out along both ends of the axis, passing through the centers of Moon as well as Earth. This tidal bulge is shown below.



The average tidal bulge shown in above figure closely follows the Moon in its orbit. However, since earth also rotates, the rotation drags this bulge ahead of the position directly under the Moon. The arrow shown in the earth shows the direction of this drag. Due to the simultaneously forces of moon's gravitational force giving rise to the bulges in ocean water and substantial amount of mass in these bulges of water dragged by earth's rotation, this bulge is deviated from the line through the centers of Earth and Moon. This gives rise to a Torque which is perpendicular to the earth moon line. This torque boosts moon in its orbit and decelerates earth's rotation. The above phenomenon is responsible for the slowing Earth's rotation. Due to the tidal acceleration, Earth's mean solar day extends by 2.3 milliseconds every century. However, due to **glacial rebound**, this extension gets reduced by 0.6 seconds per century. So the net effect on mean solar day every century is 1.7 milliseconds.

Global Glacial Rebound

The average position of water is always nearer the equator. During glaciations water is taken from the oceans and deposited as ice over the higher latitudes closer to the poles. These poles are close to the polar axis or rotational axis of the Earth. The moment of inertia of Earth-water-ice system gets reduced which is very much similar to a rotating figure skater bringing her arms closer to her body, the earth should spin faster. This process leads to an increase in the rotation speed of the Earth and therefore to a decrease of the length of day.

Sidereal Day

The spinning of the earth on its polar axis is in fact takes 23 hours, 56 minutes and 4.09 seconds for rotation through the 360 degree. This is called sidereal day. During the time needed by the Earth to complete a rotation around its axis (a sidereal day), the Earth moves a short distance (approximately 1°) along its orbit around the sun. So, after a sidereal day, the Earth still needs to rotate a small additional angular distance before the sun reaches its highest point. A solar day is, therefore, nearly 4 minutes longer than a sidereal day.

Precession Movement of earth

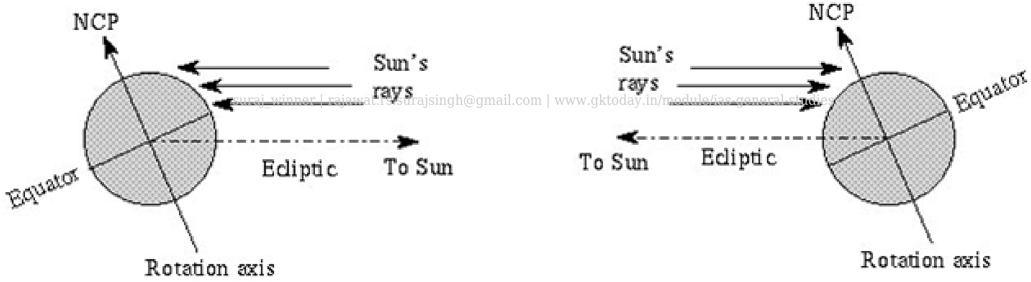
The Precession movement of Earth is very slow and proceeds in the direction of the opposite of Earth's Rotation. The one cycle completes in 28000 years. The reason of precession movement is gravitational attraction of Moon as well as Sun. The slightly irregular movement of earth's axis due to precession is called Nutation.

Earth's Revolution

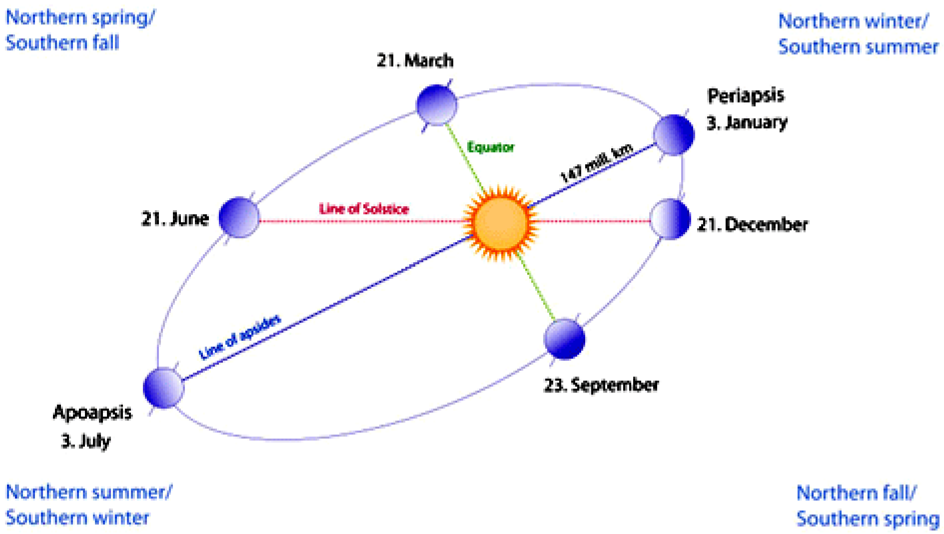
The orbit of the Earth is the motion of the Earth around the Sun every 365.242199 mean solar days. The orbital speed of Earth around the Sun averages about 30 kilometre per second or 108,000 kilometers per hour. This speed is equivalent to cover earth's orbit in 7 minutes and distance from moon to Sun in 4 hours.

Occurring of Seasons

The path of the Earth around the Sun is elliptical and slightly irregular due to gravitational attraction of moon and other celestial bodies. A constant angle is maintained between the earth's axis and its plane of elliptic, which is called *angle of inclination.* As we know that Earth's rotation axis is tilted by 23.44° with respect to the elliptic, and is always pointed towards the celestial poles when the earth moves around the Sun.



The above phenomenon gives rise to 4 seasons.



Solstice

The solstice refers to the events when the Sun's apparent position in sky reaches its northernmost or southernmost extremes. Solstice happens twice a year, and twice a year happen the equinoxes. Altogether, the four are considered to start 4 seasons.

- At the time of northern solstice, sun is perceived to be directly overhead the 23.44° north known as Tropic of Cancer.
- Likewise, at the southern solstice the same thing happens for latitude 23.44° south, known as the Tropic of Capricorn.
- The sub-solar point will cross every latitude between these two extremes exactly twice per year. The point where sun is perceived to be directly overhead is called subsolar point.
- The Northern solstice happens at 20-21 June and Southern solstice happens at 20-22 December.
- In 2010, Northern solstice happened at 21 June and Southern solstice will happen on 21 December.
- At Northern solstice, the places which are located at Arctic circle, posited at latitude 66.56° north will see the Sun just on the horizon during midnight. And all the places north of Arctic Circle will see Sun above horizon for 24 hours. This is called Midnight Sun or a Polar Day.
- At Northern solstice which are located at Antarctic circle, posited at latitude 66.56° south will see the Sun just on the horizon during midday. And all the places south of Antarctic Circle will NOT see at anytime of the day. This is called Polar Night.

- At Southern solstice, Polar day occurs at Southern Pole and Polar Night occurs at Northern Pole.

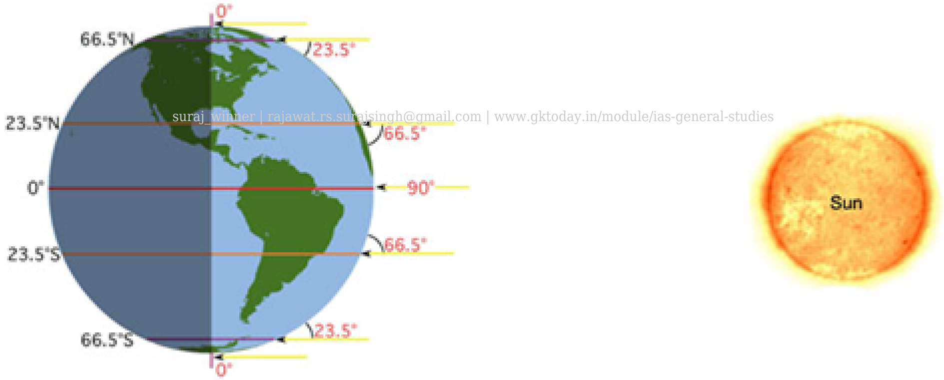
Uttarayan & Dakshinayan

For 6 months of the year, the Sun appears to be moving north. This Northward migration of Sun appears to begin after December 22 and is completed on June 21, when the Sun is directly overhead 23.44° North. Dute to this, In India we call this Uttarayan.

After June 21, for the next 6 months, Sun appears to be moving South and this southward migration appears to get finished , when Sun is directly overhead the 23.44° South. In India we call this apparent migration Dakshinayan.

Equinox

At equinox, Sun is at one of two opposite points where the celestial equator and ecliptic intersect. Sun can be observed to be vertically overhead the Equator. Equinox happens around March 20/21 and September 22/23 each year.



Longest Days & Nights

When Sun is direct overhead on 23.44° north, it is called Longest Day in Northern hemisphere. So Northern Solstice represents the longest day of the Northern hemisphere and smallest night of the Southern Hemisphere.

When Sun is direct overhead on 23.44° south, it is called Longest Day in Southern hemisphere. So Southern Solstice represents the longest day of the Southern hemisphere and smallest night of the Northern Hemisphere.

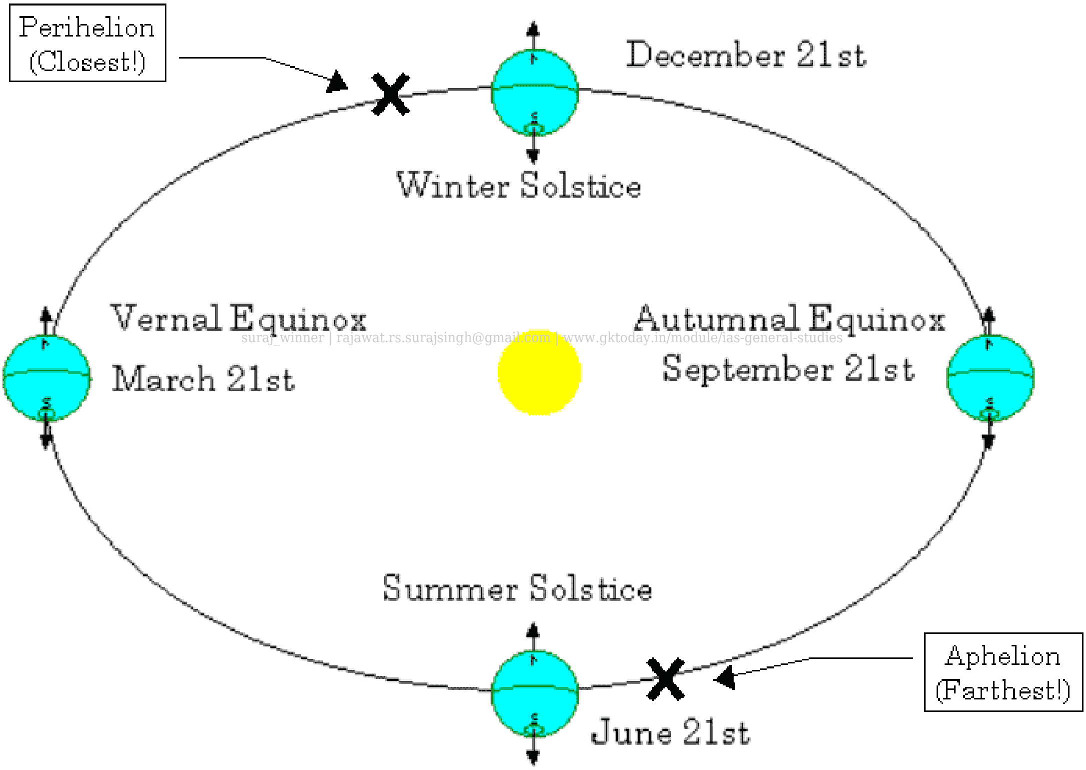
Perihelion and Aphelion

Earth travels 939,886,400 kms along its elliptical orbit in a single revolution. The average distance is 150 million kms, but the orbit is elliptical and there is the difference if 2.5 million kms. Perihelion is the point when Earth is closest to Sun and it occurs around 3rd January. The distance is 147.5 million kms.

Aphelion is the point when Earth is farthest from the Sun and it occurs on July 4. The distance is 152.5 million Kms,

- **Perihelion:** On around January 3rd, Earth is closest to sun and distance is around 147.5 million Kilometers. This is called Perihelion.
- **Aphelion:** On about July 4th earth is Farthest from Sun and this is called Aphelion.

Speed of Earth is fastest at Perihelion and slowest at Aphelion (Kepler's Second Law). The following Graphic shows the Solstice, Equinoxes and Helions altogether:



Eclipses

An eclipse is the partial or total blocking of the light of one object by another. In the solar system, relative positions of the Sun, Moon, and Earth create solar eclipses and lunar eclipses.

Frequency of Eclipses

Perfect alignments of the Sun, Moon, and Earth are relatively uncommon, because the plane of Earth's orbit around the Sun (ecliptic plane) is not the same as the plane of the Moon's orbit around Earth. Thus, during the new moon or full moon phases when an eclipse might be possible, the Moon is usually located just above or below the straight line that runs between Earth and the Sun, so no eclipse occurs. All three bodies viz. Earth, Moon, and Sun line up just right about twice a year.

Lunar Eclipse

A lunar eclipse occurs when Earth passes between the Sun and the Moon in such a way that the Moon moves into Earth's shadow. When a partial lunar eclipse is going on, the curved shadow of our planet is apparent on the Moon's face; the Moon looks kind of like it is in a crescent phase, but the terminator line (the line between light and dark) is not curved the same way. When a total lunar eclipse is happening, the entire Moon is in Earth's shadow, and the Moon looks full, but glows only faintly red. Why?

The reason is as follows: Earth's atmosphere is dense enough to act a little bit like a lens, so it refracts a small amount of sunlight shining through it toward the Moon. This small fraction of light, which is mostly red because that is the color of light that refracts best, bounces off the Moon's surface and comes back to Earth. Before and after totality, the direct sunlight reflected off the Moon is so strong by comparison that it drowns out this refracted light, so we normally cannot see it with our unaided eyes. During totality, however, the Earth-atmosphere-refracted light is quite visible as a soft reddish glow.

Solar Eclipse

A solar eclipse happens when the Moon is directly in line between Earth and the Sun. The Moon's shadow sweeps across Earth's surface; at those places where the shadow lands, an eclipse is seen.

Like Earth's shadow, the Moon's shadow consists of two parts: a dark, **central region called the umbra**, and a lighter region called the penumbra that surrounds the umbra. *Under the penumbra, a partial solar eclipse occurs. Under the umbra, a total eclipse or an annular eclipse is seen.*

Since the Moon travels in a slightly elliptical orbit around Earth, rather than in a perfectly circular path, its distance from Earth is not always the same. If the Moon's umbra falls on Earth's surface when the two bodies are at a closer point in the Moon's orbit, there is total solar eclipse. But if the Moon happens to be too far away from Earth at that time, the Moon does not cover enough of the sky to block the Sun's rays entirely. In that case, the Sun is seen as a ring, or annulus, of light glowing around the silhouette of the Moon.

During totality of a solar eclipse, the Sun looks like a perfectly black disk surrounded by glowing light. This light is actually the Sun's corona, which is invisible under normal circumstances because the Sun is so bright. Away from the corona, the sky is dark, so planets and stars that ordinarily could be seen only at night become visible.

Frequency of Solar Eclipse at a particular location on earth

The entire process of a solar eclipse, from the beginning of partial coverage until the end, usually takes about an hour. However, the totality of solar eclipse lasts at most only a few minutes. Most total solar eclipses last between 100 and 200 seconds— just about two to three minutes. Furthermore, total solar eclipses can be observed only from narrow bands on Earth's surface, and these bands change with each eclipse. In any given location on Earth, therefore, a total solar eclipse may appear only once every few centuries.

Why Moon blocks Sun so perfectly during solar eclipse?

The Moon's diameter is just under 400 times smaller than the diameter of the Sun. Coincidentally, the Moon's distance from Earth is also just under 400 times smaller than the Sun's distance from Earth. That is why the Moon covers almost exactly the same amount of sky, when viewed from Earth's surface, as the Sun. We are able to see only Corona during Total solar eclipse.

Geodesy: Latitudes and Longitudes

Eratosthenes was the first person to calculate the size of the earth. He realized that Earth could be located with a basic grid of lines called Longitudes and Latitudes.

Great Circle

When a sphere is divided exactly in half through its center, the circumference represents the largest circle that can be drawn on that sphere. The shortest distance between two points on a sphere is a great circle, or a circle whose plane passes through the centre of sphere. *In case of Earth, only equator is a great circle among latitudes and all longitudes are half great circles.*

Latitudes

Latitude is the angle between the equatorial plane and the axis. Lines joining points of the same latitude are called parallels. Equator {0° parallel} itself is largest parallel and only circle of latitude which also is a great circle. Equator is also used as fundamental plane of all geographic coordinate systems. It's worth note that geostationary satellites are over the equator at a specific point on Earth, so their position related to Earth is expressed in longitude degrees only. Their latitude is always zero. There are 180° of latitudes and *each degree of latitude spans around 111 kilometers or 69 miles or 60 Nautical miles*. But this distance varies because Earth is not a perfect sphere. From Equator to 40° towards both poles it is slightly less than 111 kilometers and from 41° towards both poles it is slightly more than 111 kilometers. The 90° North and 90° South are not circles but only reference points. Latitudes tell us the temperature and climatic position of a particular place.

Longitudes

Longitude is the angle east or west of a reference meridian between the two geographical poles to another meridian that passes through an arbitrary point. All meridians are halves of great circles, and are not parallel to each other. They converge only at the north and south poles. A line passing to the rear of the Royal Observatory, Greenwich (near London in the UK) has been chosen as the international zero-longitude reference line and is known as the Prime Meridian. Places to the east are in the eastern hemisphere, and places to the west are in the western hemisphere. The antipodal meridian of Greenwich serves as both 180°W and 180°E. There are 360° of the meridians and the longitude of prime meridian is 0°. Length of all meridians is equal. The distance between two meridians is farthest at the equator and it decreases as we move towards poles and becomes zero at poles.

Earth Structure

Earth Basic Information

Earth is located in the **Solar System**, which is located in the **Orion** (or local) **arm of Milky Way Galaxy**, which is a part of **Virgo Super cluster**. As a part of the Milky Way Galaxy, the Earth is accelerating outward toward the outer regions of the universe. The Earth and the other members of the solar system are orbiting the galaxy at about 225 kilometers per hour. Earth is third planet from the Sun and Fifth largest planet. It is largest among the Solar System's four terrestrial planets (Mercury, Venus, Earth, and Mars). Earth is also the *densest planet of the solar system*.

Radius and Circumference of Earth

The Mean radius of Earth is 6,371.0 km. Equatorial radius is 6,378.1 km, while polar radius is 6356.8 kilometers. This means that Earth is not perfectly spherical; no single value serves as its natural radius. Even calling it Radius is factually incorrect because "radius" normally is a characteristic of perfect spheres. Earth's rotation causes it to be like an oblate spheroid with a bulge at the equator and flattening at the North and South Poles. So the equatorial radius is larger than the polar radius.

The ***farthest point from Earth's centre is Chimborazo*** , an inactive volcano in the Andes mountains in Ecuador, in South America. Chimborazo is not the highest mountain by elevation above sea level, but its location along the **equatorial bulge** makes its summit the farthest point on the Earth's surface from the Earth's center.

The **Equatorial Circumference** of Earth is 40,075.16 km, while the **Meridional Circumference** is 40,008.00 km.

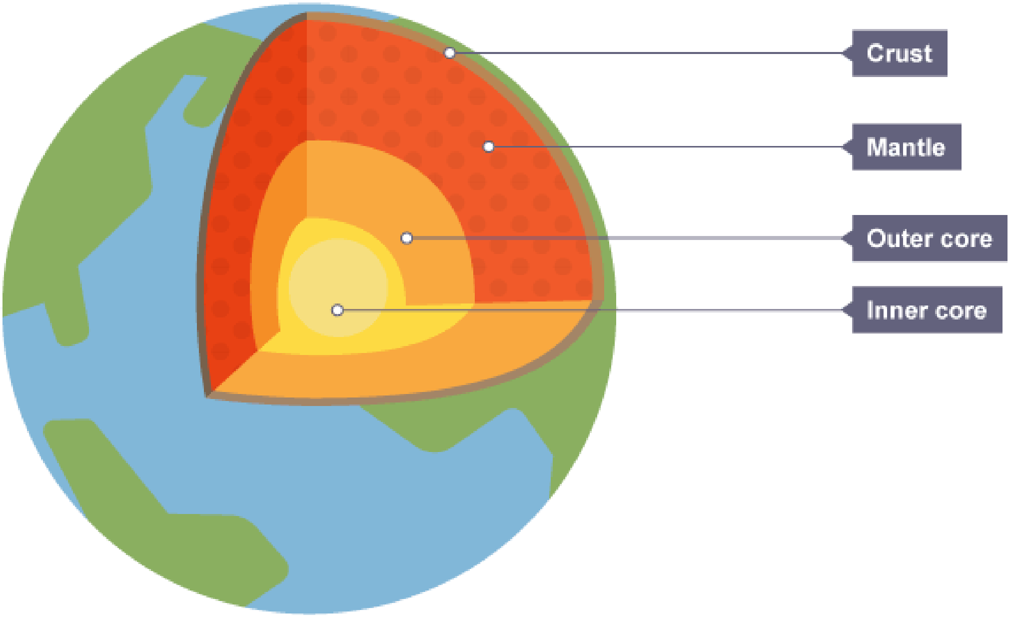
Other Basic Data

Variable	Information
Surface area	510,072,000 km^2
Land Area	148,940,000 km^2 (29.2 %)
Water Area	361,132,000 km^2 (70.8 %)
Volume	1.08321 × 10^{12} km3

Variable	Information
Mass	5.9736 × 10^{24} kg
Mean density	5.515 g/cm^3
Equatorial surface gravity	9.780327 m/s^2
Escape velocity	11.186 km/s
Sidereal rotation period	23h 56m 4.100s
Equatorial rotation velocity	1,674.4 km/h
Axial tilt	23°26’21”.4119
Albedo	0.36
Surface temp	Minimum −89.4 °C Median=14 °C Maximum =58 °C
Surface pressure	101.325 kPa
Composition	78.08% nitrogen, 20.95% oxygen, 0.93% argon, 0.038% carbon dioxide, approx. 1% water vapour

Structure of Earth

The internal structure of earth is layered. The Earth is generally divided into four major layers: the crust, mantle, inner core, and outer core.



The following defines each division.

Crust

The Earth's crust is the outermost layer and is the most familiar, since people live on the outer skin of the crust. It is rigid, brittle, and thin compared to the mantle, inner core, and outer core. Because of its varying characteristics, this outer layer is divided into the continental and oceanic crusts.

Mantle

Earth's mantle lies beneath the crust and above the outer core, averaging about 1,802 miles (2,900 kilometers) thick and representing ***68.3 percent of the Earth's mass*** and 84% of Earth's volume. A transition zone divides this layer into the upper and lower mantles.

Outer core

The **liquid outer core** is a layer between 2,885 and 5,155 kilometers deep in the Earth's interior. It is thought to move by convection (the transfer of heat through the circulating motion of materials), with the movement possibly contributing to the Earth's magnetic field. The outer core represents about 29.3 percent of the Earth's total mass.

Inner core

The inner core is thought to be roughly the size of the Earth's Moon. It lies at a depth 5,150 to 6,370 kilometers beneath the Earth's surface and generates heat close to temperatures on the sun's surface. It represents about 1.7 percent of the Earth's mass and is thought to be composed of a solid iron-nickel alloy suspended within the molten outer core.

Density of Various Earth Layers

The average density of Earth is 5,515 kg/m^3. Since the average density of surface material is only around 3,000 kg/m^3, it can be concluded that denser materials exist within Earth's core. When we move from earth's Crust to Core, the density increases. The following table shows the depth as well as the average density of various layers:

Depth (Sq. Kms)	Layer	Density gm per cubic cm.
0-60	Lithosphere	1.2-2.9
0-35	Crust	2.2-2.9
35-60	Upper mantle	3.4-4.4
35-2890	Mantle	3.4-5.6
100-700	Asthenosphere	NA
2890-5100	Outer core	9.9-12.2
5100-6378	Inner core	12.8-13.1

Earth's Crust

Earth's crust is the outermost layer composed of various types of rocks. *The boundary between the crust and mantle is generally called the Mohorovičić discontinuity*.

Thickness of Continental and Oceanic Crust

It varies in thickness from around 5 to 100 kilometers. The continental crust is thicker in comparison to oceanic crust. The oceanic crust ranges from 5 to 10 kilometers {average 7 km} while continental crust ranges from 25 to 100 kilometers {average 30-35 km}. *Thickest continental crust regions are under large mountain ranges.*

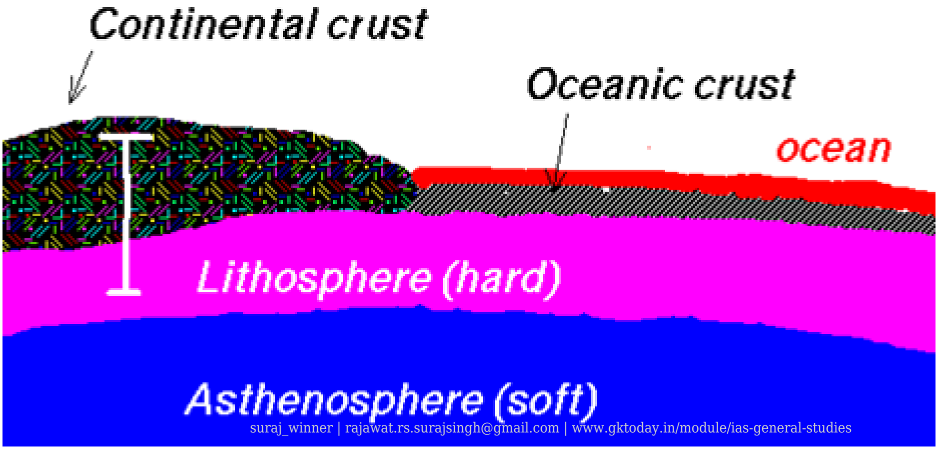
Difference in composition and density

Oceanic crust is made of dark rocks having more of Iron and Magnesium and are more basaltic. Continental crust is made of lighter rocks, having more of Silica and are more felsic. The below table shows the key differences between Oceanic and continental rocks.

Oceanic Crust	Continental Crust
Thinner (average 7 Km)	Thicker (Thickest where there are mountains) Average 30 Km.
Dark colored	Light colored
High in Silica and Magnesium (SIMA)	High in Silica and Aluminium (SIAL)
More Basaltic / Mafic	More Felsic
More Feldspar	More quartz
More dense (3000Kg/m^3)	Less dense (2500 Kg/m^3) due to increased amount of aluminium

Lithosphere, Asthenosphere and Pedosphere

Lithos means rock. Lithium is an alkali metal and its name is also derived from *Lithos*. *Lithosphere* is the upper 80 Kilometers layer composed of *both the crust and part of the upper mantle*. However, overall, it is cool enough to be tough and elastic than the molten mantle. The Oceanic lithosphere is associated with Oceanic crust and exists in the ocean basins, while the Continental lithosphere is associated with Continental crust. The Oceanic lithosphere is denser than the continental lithosphere.



Lithosphere is obviously thinner under the oceans and volcanically active continental regions than the other landmasses. The entire lithosphere is physically broken up into the brittle, moving plates containing the world's continents and oceans. These lithospheric plates appear to "float" and move around on the more ductile **asthenosphere**. The asthenosphere is the relatively **narrow, moving zone in the upper mantle** located between 72 to 250 kilometers beneath the Earth's surface. It is composed of a hot, semi-solid material that is soft and flowing after being subjected to high temperatures and pressures. The asthenosphere boundary is closer to the surface-within a few kilometers under oceans and near mid-ocean ridges than it is below the landmasses. The upper section of the asthenosphere is thought to be the area in which the lithospheric plates move, "carrying" the continental and oceanic plates also known as **Tectonic Plates**.

Further, the uppermost part of the Lithosphere that reacts with the atmosphere, biosphere and Hydrosphere is called as pedospehere. *Pedos* means soil. Pedospehere is composed of soil and it is the cradle of all the chemical and biogeochemical reactions which leads to soil development.

Composition of Earth Crust

Almost half of Earth's crust is made of oxygen, while a quarter of it is made of silicon. Since silicon and Oxygen react to make silica, around 48.6% of Earth's crust is made of silica.

Major elements in Earth's crust are Oxygen (47%), Silicon (28%), Aluminum (8%), Iron (5%), Calcium (3.5%), Sodium (2.5%), Potassium (2.5%), Magnesium (2.2%) and other elements such as

Hydrogen, Carbon, Phosphorus, Sulphur etc.

Major compounds in Earth's crust are shown in below table.

Compound	Formula	Continental	Oceanic
Silica	SiO_2	60.2%	48.6%
Alumina	Al_2O_3	15.2%	16.5%
Lime	CaO	5.5%	12.3%
Magnesia	MgO	3.1%	6.8%
Iron(II) Oxide	FeO	3.8%	6.2%
Sodium Oxide	Na_2O	3.0%	2.6%
Potassium Oxide	K_2O	2.8%	0.4%
Iron(III) Oxide	Fe_2O_3	2.5%	2.3%
Water	H_2O	1.4%	1.1%
Carbon Dioxide	CO_2	1.2%	1.4%
Titanium Dioxide	TiO_2	0.7%	1.4%
Phosphorus Pentoxide	P_2O_5	0.2%	0.3%
Total		99.6%	99.9%

Thus, most of the rocks in Earth's crust are all oxides. The principal oxides are silica, alumina, iron oxides, lime, magnesia & potash. There are not many iron loving compounds in Earth Crust because they were depleted and relocated deeper. Further, more meteoritic content is found in Earth's Crust.

Conrad Discontinuity

Conrad discontinuity (named after the seismologist Victor Conrad) is considered to be the border between the *upper continental crust and the lower one*. It is not as pronounced as the Mohorovičić discontinuity, and absent in some continental regions.

Earth's Mantle

The mantle is a **highly viscous** layer between the crust and the outer core. The boundary between crust and mantle is called Mohorovičić discontinuity after the name of Croatian geologist **Andrija Mohorovičić** who proposed this. No one has been able to physically drill into the mantle and there are no samples of the mantle with human beings as of now. Whatever information we have is based on indirect study, particularly of seismic waves.

Composition of the Earth's Mantle

Similar to earth's crust, Oxygen is most abundant element in Earth's Mantle. The following table shows the composition of earth's mantle.

Element	Amount	Compound	Amount
O	44.8		
Si	21.5	SiO_2	46
Mg	22.8	MgO	37.8
Fe	5.8	FeO	7.5
Al	2.2	Al_2O_3	4.2
Ca	2.3	CaO	3.2
Na	0.3	Na_2O	0.4
K	0.03	K_2O	0.04
Total	99.7	Total	99.1

Salient Features of Mantle

Earth's mantle is a rocky shell about 2,890 Kms thick that constitutes about 84 percent of Earth's volume. It is predominantly solid and encloses the iron-rich hot core, which occupies about 15 percent of Earth's volume. The mantle is divided into sections viz.

- The **Upper Mantle**, which starts from the Mohorovičić discontinuity around 7 to 35 km, downward to 410 km),
- The **transition zone** (410–660 km)
- The **Lower Mantle** (660–2891 km).

The upper and lower mantle differentiate on the basis of seismic and chemical changes in the layer. These changes create different kinds of *discontinuities* in the mantle. For example:

- Hales Discontinuity is found in the upper mantle at depths of about 60 to 90 kilometers, a region in which seismic velocities change.
- Gutenberg Discontinuity or the core–mantle boundary (CMB) lies between the Earth's silicate mantle and its *liquid iron-nickel outer core*. This boundary is located at approximately

2900 km depth beneath the Earth's surface. The boundary is observed via the discontinuity in seismic wave velocities at that depth.

Convective Material Circulation in Mantle

Due to the temperature difference between the Earth's surface and outer core and the ability of the crystalline rocks at high pressure and temperature to undergo slow, creeping, viscous-like deformation over millions of years, there is a convective material circulation in the mantle. Hot material upwells, while cooler (and heavier) material sinks downward. Downward motion of material occurs at convergent plate boundaries called subduction zones. The convection of the Earth's mantle is a chaotic process, which is thought to be an integral part of the motion of plates. Here, we have to note that the Plate motion is different from the continental drift which applies purely to the movement of the crustal components of the continents.

Earth's Core

Using the seismic data, the scientists had first postulated the existence of a fluid core. In 1915, Gutenberg published a measurement of the core's radius. In 1936, Danish seismologist **Inge Lehmann** (1888-1993) presented a paper titled, "P'" (or P -Prime, after the seismic waves), ***which announced the discovery of Earth's inner core.*** The division between the inner and outer core is now called the **Lehmann discontinuity.**

The size of this core was calculated later in 1960s when an underground nuclear test was conducted in Nevada. Because the precise location and time of the explosion was known, echoes from seismic waves bounced off the inner core provided an accurate means of determining its size. These data revealed a radius of Earth's Inner solid Core about 1,216 kilometers. *The seismic P-waves passing though the inner core move faster than those going through the outer core-good evidence that the inner core is solid*. The presence of high-density iron thought to make up the inner core also explains the high density of the Earth's interior, which is about 13.5 times that of water.

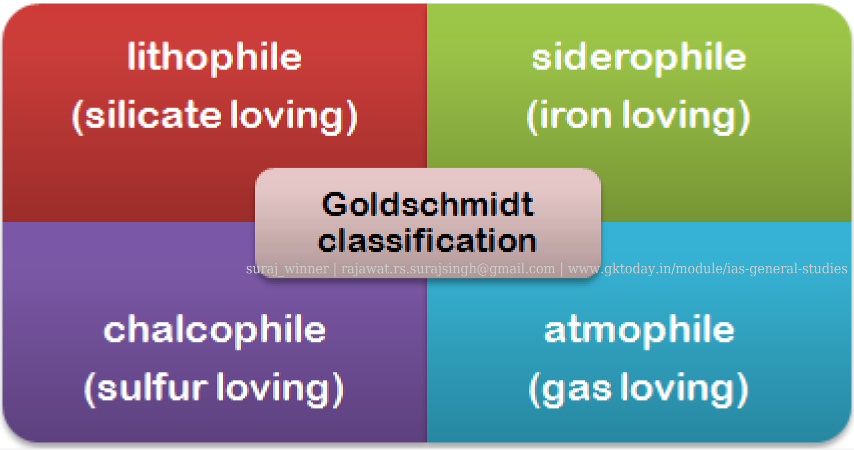
Outer Core versus Inner Core

Earth's core is divided into two parts viz. a solid inner core with a radius of =1,216 km and a liquid outer core extending beyond it to a radius of ~3,400 km. The solid inner core is generally believed to be composed primarily of iron and some nickel.

How it was formed?

The major event which led to the formation of core was **iron catastrophe**. Earth was formed approximately 4500 million years ago. After accumulation of the Earth's material into a spherical mass, the material was mostly uniform in composition. The collision of the material which formed the Earth was significant; heating from radioactive materials in this mass further increased the temperature until a critical condition was reached, when the material was molten enough to allow movement. At this point, the denser iron and nickel evenly distributed throughout the mass sank to the centre of the planet to form the core – an important process of planetary differentiation. The gravitational potential energy released by the sinking of the dense Ni-Fe globules increased the temperature of the protoplanet above the melting point resulting in a global silicate magma which accelerated the process. This event occurred at about 500 million years into the formation of the planet and is known as Iron catastrophe.

Recent researches show that the innermost part of the core is enriched in gold, platinum and other **Siderophile** elements (Siderophile elements are those 'Iron Loving" elements that tend to bond with metallic iron as per **Goldschmidt classification**).



Earth's Magnetic Field and Magnetosphere

Earth's Magnetic Field

The Magnetic Field of the Earth is generated by the *motion of molten iron alloys in the Earth's outer core*.

The solid inner core is too hot to hold a permanent magnetic field, but the outer core gives rise to Earth's magnetic field. The geomagnetic field extends from outer core to where it meets the solar wind. At the surface of Earth, the magnitude of Earth's magnetic field ranges from 25 to 65 microteslas (0.25 to 0.65 gauss).

How magnetic field protects life on Earth?

The magnetic field deflects most of the charged particles emanating from the Sun in the form of solar winds. If there were no magnetic field, the particles of the solar wind would strip away the ozone layer, which protects the Earth from harmful ultraviolet rays. One of the reasons that there is no atmosphere at Mars is that its magnetic field is turned off which led to the loss of carbon dioxide due to scavenging of ions by the solar wind.

How it is formed?

The Earth's magnetic field is believed to be caused by electric currents in the liquid outer core, which is composed of highly conductive molten iron. The motion of the fluid is sustained by convection, motion driven by buoyancy. At the core, the pressure is so great that the super hot iron crystallizes into a solid. The higher temperature of the fluid lower down makes it buoyant. This buoyancy is enhanced by chemical separation: As the core cools, some of the molten iron solidifies and is plated to the inner core. In the process, lighter elements are left behind in the fluid, making it lighter. This is called compositional convection.

> The mechanism of formation of Earth's Magnetic field has not yet been understood fully. The basic physics of electromagnetism can be used to somewhat explain the phenomena. Iron, whether liquid or solid, conducts electricity; when we move a flowing electric current, we generate a magnetic field at a right angle to the electric current direction (Ampère's law) . *The molten outer core of our planet releases heat by convection, which then displaces the flowing electrical currents. This generates the magnetic field that is oriented around the axis of rotation of the Earth, mainly due to the rotational effects on the moving fluid.* However, it has not been explained how the charges, necessary for creation of electric field originate, which in turn give rise to the magnetic field.

This convection caused by heat radiating from the core, along with the rotation of the Earth (Coriolis force), causes the liquid iron to move in a rotational pattern. It is believed that these rotational forces in the liquid iron layer lead to weak magnetic forces around the axis of spin. The role of the Coriolis Effect is that it causes overall planetary rotation, and tends to organize the flow into rolls aligned along the north-south polar axis.

Reversal of the fields

Based on data from ancient and new rocks, it has been observed that Earth's north and south magnetic fields have reversed polarity many times. *This is because the polarity of the Earth's magnetic field is recorded in sedimentary rocks*. The switching from north to south (an individual reversal event) seems to take around a couple thousand years to complete; once the reversal takes place, periods of stability seem to average about 200,000 years. No body has been able to explain why the poles reverse, but theories range from the changes in lower mantle temperatures to the imbalance of landmasses on our world (most of the continental landmass is in the Northern Hemisphere). The last magnetic reversal was 780,000 years ago, which gives us current northern and southern magnetic poles. It is believed that geomagnetic field is slowing weakening, so Earth might be heading for a long-overdue magnetic reversal. Reversals tend to occur when there is a wide divergence between the magnetic poles and their geographic equivalent (as it is now).

Intensity gradient of the Geomagnetic Field

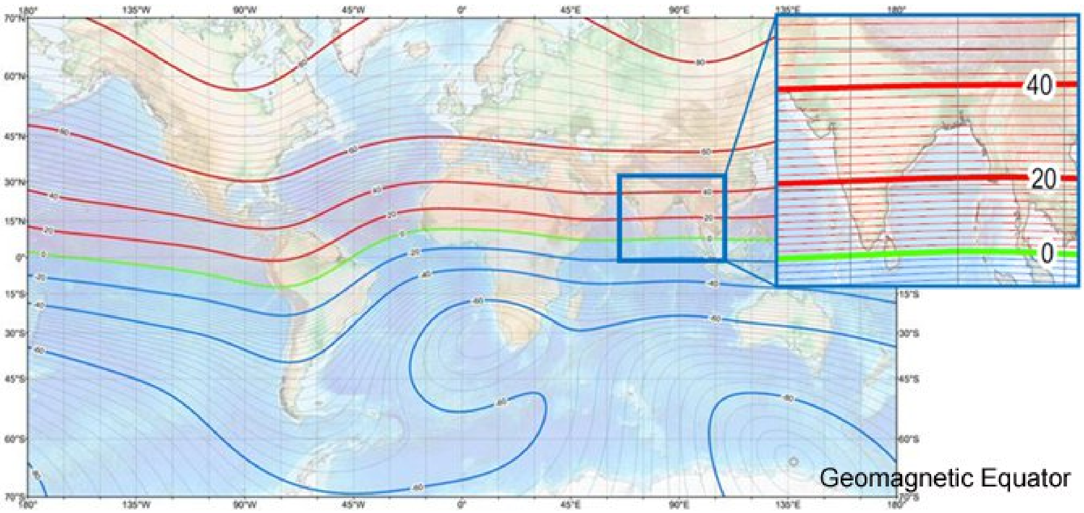
The intensity of the geomagnetic field is **greatest near the poles and weaker near the Equator**. A map of intensity contours of the geomagnetic field is called an isodynamic chart. Isodynamic chart for the Earth's magnetic field shows that *minimum intensity of the magnetic field is over South America* while maximum is over northern Canada, Siberia, and the coast of Antarctica south of Australia.

Magnetic Dip

Magnetic dip or magnetic inclination is the angle made with the horizontal by the compass needle of a vertically held compass. This angle varies at different points on the Earth's surface. ***In the northern hemisphere, the field points downwards.*** It is straight down at the North Magnetic Pole and rotates upwards as the latitude decreases until it is **horizontal (0°) at the magnetic equator.** It continues to rotate upwards until it is straight up at the South Magnetic Pole. North Magnetic Pole on the surface of Earth's Northern Hemisphere at which the planet's magnetic field points vertically downwards. In 2001, it was in Canada, but now, it has moved out of Canada's territory towards Russia. The south magnetic pole was off the coast of Wilkes Land — a part of Antarctica — about 2750 km from South Pole.

Geomagnetic Equator & Equatorial Electrojet

Contour lines along which the dip measured at the Earth's surface is equal are referred to as isoclinic lines. The locus of the points having zero dip is called the **magnetic equator or aclinic line**. In the following graphics, the green line shows the ***magnetic equator, which runs very close the southern tip of our country***. This is the important reason for the establishment of the Vikram Sarabhai Space Centre at Thumba, which is close to Geomagnetic Equator. The reason is that the magnetic equator differs significantly from the geographic equator. Directly above the magnetic equator, at altitudes of around 110 km in the atmosphere, a system of electric currents exists that flows from west to east along the magnetic equator. It is known as **Equatorial Electrojet.**



The closer we are to the magnetic equator, the better we are placed to study the Equatorial electrojet. In the early 1960s, there were very few places in the world close to the magnetic equator with adequate infrastructure to support research in this field. That is the reason that Thumba was chosen.

Thumba is located in the outskirts of Thiruvananthapuram. Here, Thumba Equatorial Rocket Launching Station (TERLS) was launched in 1963. Eventually, TERLS have given birth to the Vikram Sarabhai Space Centre (VSSC) and to the Indian Space Research Organisation (ISRO).

Earth's Magnetosphere

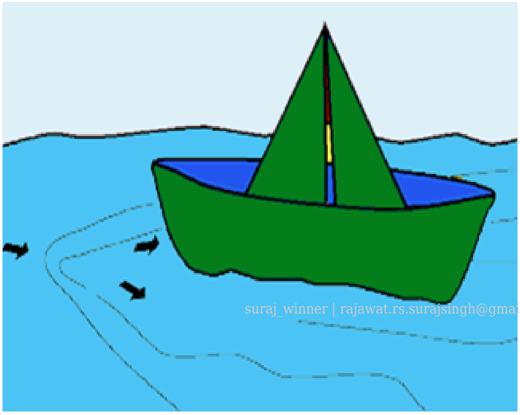
Earth is surrounded by a magnetosphere. The invisible geomagnetic lines stretch from one pole, curve far out into space, then go back to the opposite pole. The curved lines are further shaped by the electrically charged particles of the solar wind into a teardrop shape called the magnetosphere. The Magnetosphere is thus the magnetic field that prevents the solar winds, or highly energetic particles to reach Earth. Please note that the *shape of magnetosphere of Earth is determined by the Earth's internal magnetic field, the solar wind plasma, and the interplanetary magnetic field (IMF).* This shape is not static but is dynamic.

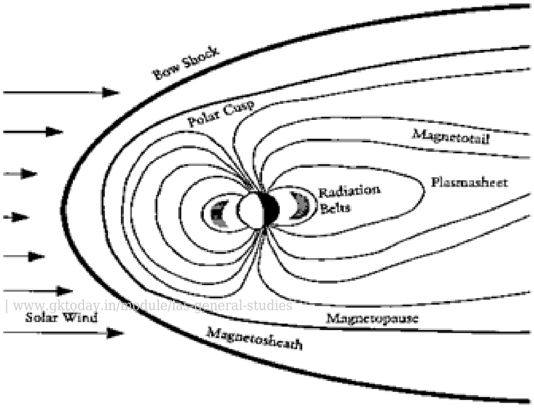
Structure of the Magnetosphere

The complex structure of Earth's magnetosphere is the result of the interplay between the charged particles originating in the upper layers of the terrestrial atmosphere, whose motion is guided by the Earth's magnetic field, and the solar wind particles carrying the interplanetary magnetic field. The magnetosphere is basically a space filled primarily with particles **from terrestrial origin**.

The shape of magnetosphere keeps changing throughout the day and night, with Earth's rotation, revolution and during solar storms and other such events which can affect it.

To understand its boundary, we take an example of a boat that moves through the sea. In front of the boat a bow wave is formed: that bow wave demarcates the region in which the boat disturbs the flow of the water. The water behind the bow wave is forced to flow smoothly around the boat's hull. Behind the boat a wake is formed. The similar kind of interaction is the solar wind -magnetosphere interaction. The solar wind consists of particles that are mainly of solar origin. It is pervaded by the interplanetary magnetic field. A bow shock is formed in front of the Earth's magnetosphere, which demarcates the region where the solar wind flow is impeded by the presence of the Earth. The solar wind in the magneto sheath, the region between the bow shock and the Earth's magnetosphere, is forced to flow around the Earth's magnetosphere and is compressed.





The impermeable outer surface of the magnetosphere, where the total pressure of the compressed solar wind precisely balances the total pressure inside the magnetosphere, is called the **magnetopause**. As shown in the accompanying figure, the magnetopause has a shape that is elongated and stretched out in the anti-solar direction, forming a long **magnetotail**, which is in a sense similar to the wake behind the boat.

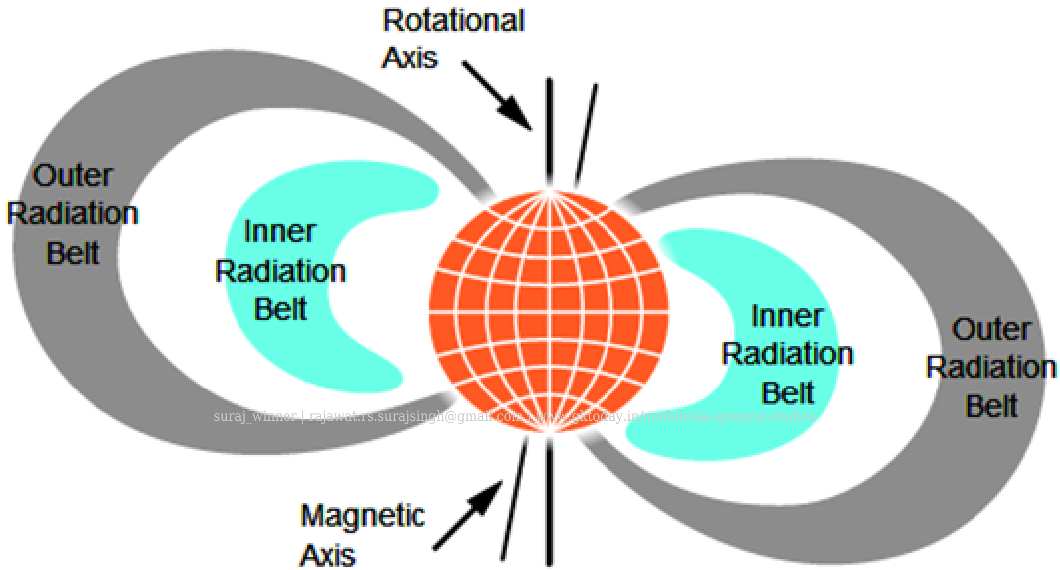
Due the complex interplay, the magnetosphere becomes roughly bullet shaped and extends on the **night side** in the "magnetotail" or "geotail" approaching a cylinder with a radius that is around 20-25 times of the Radius of Earth. The tail stretches to around 200 times the Radius of Earth. The day side tip or sub-solar point of the magnetopause is called "nose' of the magnetopause. It is normally located at 10 RE (Earth radii) towards the Sun.

There are two polar cusp regions above the "**Geomagnetic Poles**". These are regions where solar wind can enter relatively easily into the magnetosphere. The inner magnetosphere is strongly connected to the Earth's ionosphere. The inner region, called the plasmasphere, which consists of dense cold plasma largely of ionospheric origin, rotes more or less, along with the Earth.

Van Allen belts

In the inner region of the Earth's magnetosphere, there are **two distinct rings** of **electrically**

charged particles that encircle our planet. These are called Van Allen belts after their discover. *The particles in these belts originate from different sources; some come from the solar wind, some from the Earth's upper atmosphere, some from cosmic rays originating in the distant Universe*. The belts are shaped like fat doughnuts, ***widest above Earth's equator and curving downward toward Earth's surface near the Polar Regions.***



Van Allen Belts

These charged particles usually come toward Earth from outer space—often from the Sun—and are trapped within these two regions of Earth's magnetosphere. Since the particles are charged, they spiral around and along the magnetosphere's magnetic field lines. The lines lead away from Earth's equator, and the particles shuffle back and forth between the **two magnetic poles**. The closer ring is about 3,000 kilometers from Earth's surface, and the farther belt is about 15,000 kilometers away. The highly charged particles of the Van Allen belts pose a hazard to satellites, which must protect their sensitive components with adequate shielding if their orbit spends significant time in the radiation belts.

Van Allen Belts and Impact on Apollo Mission

There are several (conspiracy) theories on impact of the Van Allen Belts on its impact on astronauts who pass through them. It is said that there is deadly radiation in the Van Allen belts, which could have killed the Apollo astronauts (Thus, claiming that actually Apollo 11 was a fake mission). The NASA claims that the nature of that radiation was known to the Apollo engineers and they were able to make suitable preparations. The principle danger of the Van Allen belts is high-energy protons, which are not that difficult to shield against. And the Apollo navigators plotted a course through the thinnest parts of the belts and arranged for the spacecraft to pass through them quickly, limiting the exposure. The Van Allen belts span only about forty degrees of earth's latitude — twenty degrees above and below the magnetic equator. Further, The region between two to four earth radii lies between the two radiation belts and is sometimes referred to as the "safe zone".

The diagrams of Apollo's translunar trajectory printed in various press releases are not entirely accurate. They tend to show only a two-dimensional version of the actual trajectory. The actual trajectory was three-dimensional. The highly technical reports of Apollo, accessible to but not generally understood by the public, give the three-dimensional details of the translunar trajectory. {Source: http://www.clavius.org}

Please note that the inner belt consists mainly of **energetic protons**, while the outer belt consists mainly of **electrons.** As far as protective effects of Van Allen Belts are concerned, ***they have not much to credit for***. Van Allen belts *protect against charged particle radiation* but at the same time *don't not protect against electromagnetic radiation*. ***This protection is done by the atmosphere (Ionosphere).*** Thus, the statement that these belts protect earth is true in terms of particle radiation, false in terms of EM radiation. Van Allen Belts are regions of high concentrations of particle radiation. It is the Earth's magnetic field that does the protecting, forming the belts in the process.

Chapman Ferraro Cavity

On the sunward side, the Earth's Magnetosphere is compressed because of the solar wind, while on the other side it is elongated to around three earth radii. This creates a cavity called the Chapman Ferraro Cavity, in which the Van Allen radiation belt resides.

Magnetospheric storms

We have read above that the magnetosphere is not a static structure. Rather, it is constantly in motion, as the orientation of the Earth's magnetic dipole varies with the Earth's daily rotation and with its yearly revolution around the Sun, and as the solar wind is characterized by a strong time-variability on time scales ranging from seconds to years. As a consequence of this time-variability, the sizes and shapes of the regions may change with time. When material from a solar Coronal Mass Ejection travels through the interplanetary medium and hits the Earth, the dynamic pressure of the solar wind is strongly enhanced so that the ***bow shock and the magnetopause are pushed inward, producing a Magnetospheric storm***.

Geocorona

The magnetosphere is an almost completely ionized collision less plasma. Nevertheless, a large cloud of **neutral hydrogen** surrounds the Earth, which is called the Geocorona. Since collisions are so rare, this neutral cloud can co-exist with the plasma in the inner regions of the magnetosphere with relatively little interference.

Other plants with magnetosphere

Other planets with intrinsic magnetic fields viz. *Mercury, Jupiter, Saturn, Uranus, and Neptune. Jupiter's moon Ganymede also has a small magnetosphere, but it is situated entirely within the magnetosphere of Jupiter, leading to complex interactions.*

Model Questions and Answers for Prelims

Earth Basics Prelims Model Questions

1. In comparison to the Oceanic Crust, the Continental crust __:

1. is thicker
2. has more density
3. has more of quartz
4. called SIMA

Choose the correct option from the codes give below:

[A] 1 & 2

[B] 1, 2 & 3

[C] 1 & 3

[D] 1, 3 & 4

Answer: [C] 1 & 3

Oceanic Crust	Continental Crust
Thinner (average 7 Km)	Thicker (Thickest where there are mountains) Average 30 Km.
Dark colored	Light colored
High in Silica and Magnesium (SIMA)	High in Silica and Aluminium (SIAL)
More Basaltic / Mafic	More Felsic
More Feldspar	More quartz
More dense (3000Kg/m³)	Less dense (2500 Kg/m³) due to increased amount of aluminium

2. The shape of the Earth's Magnetosphere is defined by___?

1. Earth's internal magnetic field
2. Solar winds
3. Interplanetary magnetic field
4. Rotation of earth

Choose the correct option from the codes given below:

[A] Only 1 & 2

[B] Only 2

[C] Only 2, 3 & 4

[D] 1, 2, 3 & 4

Answer: [D] 1, 2, 3 & 4

3. Which among the following cause(s) the generation of the Van Allen belts?

1. Refraction of sunlight

2. Charged particles trapped in the earth's magnetic field.

3. Reflection of polar snow.

4. Precession of earth

Choose the correct option from the codes given below:

[A] Only 2 & 4

[B] Only 2

[C] Only 1 & 2

[D] 1, 2 & 4

Answer: [B] Only 2

4. Consider the following statements with respect to Earth's Lithosphere:

1. Lithosphere is a part of Earth&#146s Crust only

2. The Oceanic lithosphere is denser than the continental lithosphere

Which among the above statements is / are correct?

[A] Only 1 is correct

[B] Only 2 is correct

[C] Both 1 & 2 are correct

[D] Neither 1 nor 2 is correct

Answer: [B] Only 2 is correct

5. What benefits are provided by the Van Allen Belts ?

1. They protect the communication satellites

2. They protect life on earth against charged particle radiation

3. They protect life on earth from Electromagnetic radiation

Choose the correct option from the codes given below:

[A] Only 1 & 2

[B] Only 2

[C] Only 2 & 3

[D] 1 & 3

Answer: [B] Only 2

6. If the earth's axis changed from a 23.5 degree tilt to a 45 degree tilt, there would have been:
1. hotter summers and colder winters
2. longer days in summer and shorter days in winter
3. Shifting of equator towards north pole
Select the correct statements from the codes given below:
[A] Only 1
[B] Only 2 & 3
[C] Only 1 & 2
[D] 1, 2 & 3
Answer: [C] Only 1 & 2

Perhaps one of the most apparent factors contributing to Earth climate change is the angle at which the earth is tilted. This is the angle at which Earth's axis of rotation is from the vertical, also known as Earth's obliquity.
Earth's current tilt angle is approximately 23.5 degrees. The axial tilt angle affects climate largely by determining which parts of the earth get more sunlight during different stages of the year. This is the primary cause for the different seasons Earth experiences throughout the year, as well as the intensity of the seasons for higher latitudes. For example, in the Northern Hemisphere, if there were no axial tilt, i.e. Earth's obliquity would be zero degrees, then there would be no change in the seasons from year to year. This would be because there would be no difference in the amount of solar irradiation received, year-round, anywhere on Earth.

On the other hand, if Earth's axial tilt angle was great (45+ degrees), the seasonality of each hemisphere, individually, would be highly exaggerated. Summers would be extremely hot, with substantially more hours of daylight than night each day. Winters would be extremely cold, with substantially more hours of night than daylight each day. This is because, during summer for the northern hemisphere, if the earth is tilted more (pointed towards the sun more), there would be more available hours in which the suns rays can strike any certain place, thereby increasing the number of daylight hours at any given place, with more and more daylight hours at higher latitudes.
Also, because the northern hemisphere would be tilted much more towards the sun, it would be physically closer to the sun, thereby increasing the intensity of the sun's rays hitting the northern hemisphere, thereby causing the northern hemisphere to become hotter. Likewise, during winter for the northern hemisphere, there would be fewer hours of daylight because the northern hemisphere would essentially be pointed away from the sun. Fewer daylight hours means less solar radiation hitting the northern hemisphere, especially at higher latitudes, and therefore causing the

northern hemisphere to become colder.
The same things can also be said about the southern hemisphere, particularly at high latitudes. In either case, the climate around the equator is not affected nearly as much as the higher latitudes, thereby creating a sizable difference in how obliquity affects different latitudes. This is all, of course, dependent on what the actual tilt angle is at any given point in time.
The thing is, though, that Earth does in fact change obliquity over time in a cyclic pattern. Earth's obliquity does not change much, though, as obliquity has been determined to cycle between the small range of 22.2 degrees to 24.5 degrees, in a cycle that lasts approximately 41,000 years. Therefore with the small tilt variation over time, the Earth has always been thought to have had a seasonal climate, at least in the high latitudes due to the solar affect of changing Earth obliquity.

7. What do you call the phenomenon when Moon blocks the light coming from a star?

[A] Eclipse

[B] Occultation

[C] Transit

[D] Blockage

Answer: [B] Occultation

When two heavenly bodies apparently cross each other's path as seen from the Earth, there are 3 possibilities:
1.Eclipse: It occurs when two heavenly objects having apparently the same size cross each other. Eg: During the eclipse of sun, even though the Moon is much smaller, it appears to be of the same size as the Sun, because it is nearer to us. Therefore, it can completely hide the Sun behind it.
2.Occultation: It occurs when an apparently larger heavenly object covers an apparently smaller one. Eg: When Moon blocks the light coming from a star.
3.Transit: It occurs when an apparently smaller object traverses in front of an apparently larger one. Eg: Inferior planets Mercury and Venus can occasionally cross the Sun's disc when viewed from the Earth.

8. Consider the following differences between the Oceanic Crust and Continental Crust:
1.The Continental crust is denser in comparison to the Oceanic Crust
2.The Continental crust has more of quartz , while the Oceanic Crust has more of Feldspar
3.The Continental Crust is otherwise called SIMA, while the Oceanic Crust is otherwise called SIAL
4.The rocks that make the continental crust are little denser than those making Oceanic crust.
Which among the above statements is / are correct?

[A] Only 1 & 2

[B] Only 2 & 3

[C] Only 1 & 3

[D] Only 3 & 4

Answer: [A] Only 1 & 2

The oceanic crust is thinner than the Continental Crust. Oceanic Crust measures from 5 to 10 kilometers, averaging about 7 kilometers in thickness; the continental crust measures between 25 to 100 kilometers, averaging about 30 kilometers thick. Obviously, the thickest continental crust regions are under large mountain ranges.

Apart from the thickness, the oceanic and continental crusts also differ in composition and density. The oceanic crust is composed of dark, iron-rich rock similar to basalt. It is high in silica and magnesium, that is why called SIMA. It is often distinguished from the mantle by having more silica. This implies that Oceanic crust is more basaltic. Since Magnesium is denoted by Mg and Iron is denoted by Fe, these rocks have also been named Mafic Rocks. Most common rock-forming Mafic minerals in the oceanic crust are olivine, pyroxene, amphibole, and biotite.

The continental crust's composition is more complex. In general, continental rocks are light-colored, with an average composition between diorite (generally hornblende and plagioclase feldspar with a little quartz) and granodiorite (the same composition as diorite, but with more quartz present). These are rocks high in silica and aluminium and are often referred to as SIAL. This implies that Continental crust is more

felsic.

Then, there is a difference in density also. The oceanic crust has a density of 3,000 kilograms/m^3 while the continental crust has a lower density of 2,500 kilograms/m^3. This also implies that the rocks which make continental crust are slightly less dense than those making the Oceanic Crust. The less dense rocks such as granite is more common in continental crust than in oceanic crust. Density of Sial is lower than Sima primarily because of the increased amount of aluminium.

Please note that at a certain depth, the SIAL of the Continental Crest becomes close in its physical properties to SIMA. The temperature of the crust increases with depth, reaching values typically in th range from about 200-400°C at the boundary with the

9. Earth is at the closest distance from the Sun in January and farthest in July. Why the temperature of earth does not rise in January?

1. Distance of earth in its orbit from Sun does not affect the seasons
2. Earth is tilted on its axis which causes rise and fall in seasonal temperatures
3. At perihelion, southern hemisphere is more hot in comparison to northern hemisphere at

Aphelion

Choose the correct option from the codes given below:

[A] Only 1 & 2

[B] Only 2 & 3

[C] Only 1 & 3

[D] 1, 2 & 3

Answer: [A] Only 1 & 2

There are many reasons for it. Blame it on the tilt of the Earth's axis. Actually, our seasons are determined by the tilt of the Earth and not by how close the Earth is to the Sun. Sunlight raises the temperature of continents more than it does of the oceans.

10. The pointer or arrow of the magnetized needle of a compass indicates which among the following?

[A] Geographic North Pole

[B] Magnetic North Pole

[C] Geo-magnetic North Pole

[D] Magnetic South Pole

Answer: [D] Magnetic South Pole

The north pole of a magnet in a compass points north because it is attracted to the Earth's magnetic south pole, which is located near Earth's geographic north pole. The geographic north pole of earth corresponds to magnetic south pole and geographic south pole of earth corresponds to magnetic north pole. The direction in which a compass needle points is known as magnetic north. This is not exactly the direction of the North Magnetic Pole.

Instead, the compass aligns itself to the local geomagnetic field, which varies in a complex manner over the Earth's surface. The angular difference between magnetic north and true north (defined in reference to the Geographic North Pole), at any particular location on the Earth's surface, is called the magnetic declination. Most map coordinate systems are based on true north, and magnetic declination is often shown on map legends so that the direction of true north can be determined from north as indicated by a compass.

11. With reference to the structure of Earth, despite the hottest temperature at Inner Core, why the Earth has a solid inner core but liquid outer core?

1. Because the inner core is made of heavy metals

2. Because the inner core is under huge pressure

3. Because the inner core is actually getting cooled from inside

Choose the correct option from the codes given below:

[A] Only 1 & 2

[B] Only 2 & 3

[C] Only 2

[D] Only 1 & 3

Answer: [C] Only 2

The high pressures deep inside the Earth do have other interesting effects; for example, in the crust and mantle (which make up the outer 2900 km (1800 miles) of the Earth), you see different sorts of minerals at different depths because each is only stable over a certain range of pressures. Also, while the outer core of the Earth is made of liquid iron, the inner core is solid due to the high pressures at the center of the Earth.

12. Consider the following statements

1. A solar day is nearly 4 minutes smaller than a sidereal day
2. Approximately 1° is the distance covered by earth in its orbit everyday
3. The mean solar day at present is 86400 seconds

Which among the above statements is / are correct?

[A] 1 & 2 only

[B] 1 & 3 only

[C] 2 only

[D] 2 & 3 only

Answer: [C] 2 only

A solar day is nearly 4 minutes longer than a sidereal day. The mean solar day at present is 86400.002 seconds, It was 86400 in 1820