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Coverage of Important Facts from NCERT Books (Class 6-12)

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Arihant Publications (India) Ltd.

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ARIHANT PUBLICATIONS (India) LTD.

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'Ramchhaya' 4577/15, Agarwal Road, Darya Ganj, New Delhi -110002
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SALES & SUPPORT OFFICES
Agra, Ahmedabad, Bengaluru, Bareilly, Chennai, Delhi, Guwahati, Hyderabad, Jaipur, Jhansi, Kolkata, Lucknow, Nagpur & Pune.

ISBN 978-93-25798-04-5

PO No : TXT-XX-XXXXXXX-X-XX

PRODUCTION TEAM

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Published By Arihant Publications (India) Ltd.

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INDIA & WORLD GEOGRAPHY

ENVIRONMENT, ECOLOGY & BIODIVERSITY

TOPICS FOCUS & TREND OF QUESTIONS

The Universe and Solar System

Some of the important topics from examination perspective are various theories regarding the origin and evolution of the universe. After in-depth analysis of the previous year's question paper. This topic is very much important for the basic understanding of cosmology and Space technology.

The Earth

This is one of the important sections of the geography and questions relates this chapter to another chapter that consists of Earth's interior, drainage pattern and landforms. This topic also concern of the mostly asked topics like-question of international date line and distribution of time and date.

Geomorphology

This chapter cover important aspects that is Earth file, landforms history, tectonic uplift which is very important from examination point of view. If we analyse the pattern of question in previous years, most of them are related Earth movements, land forms produced by different processes, constituents of Earth and also geomorphic processes.

Climatology

This chapter cover important points that help student to discover and explain the impacts of climate, so that society can plan its activities, design its builidings and infrastructure and anticipate the effects of adverse condition. In the past the questions have been asked regarding the important atmospheric pressure and circulations, Air Masses, fronts and cyclone. Most of the competitive examination give special weightage to this chapter and question will asked by relating other topics of geography, so it is very important topics on the examination point.

Oceanography

This chapter consist of diverse topics reflect multiple blend of knowledge of the ocean world such as salinity and temperature, ocean ridge, currents, the living oceans and coral reefs that will help student to tackle multidisciplinary questionnaires. This topic provides information to the very common asked question related to ocean tides, coral reefs and ocean current.

Biogeography

In this chapter, the components of biosphere, ecosystem and ecology explained that will help student to cope up the questions of evaluative perspective. Although, majority of questions inclined towards this chapter.

Human Geography

This chapter is major sub-fields of the discipline of geography that covers the world, its people, communities and cultures.

Economic Geography

This chapter covers the location, distribution and spatial organisation of economic activities across the world. It helps students to understand the economic aspect of geography. Economy is the bases of all the discipline and this topic broaden the student's horizon to understand the economic aspects of the geography.

Continents

This is one of the important chapter from examination point of view, in which the large landmass on Earth is explain according to their characteristics, features and extent.

India : Physical Aspects

This is one of the important topic from examination point of view. It covers India's frontier, relief features, i.e., mountains, plateaus, plains, islands. Apart from this, Indian geography should be given move emphasis because it is common for both prelim and mains while Indian geography is important for prelims, but the nature of question earlier it used to be mapped based or location based Indian geography, but current trends is mostly related with agriculture, environment angles.

Indian States And Union Territories

This topic deals with important aspects of States and UTs about their location, features and extent. Questions are frequently asked almost all exams about Jharkhand, Andhra Pradesh, Maharashtra and Madhya Pradesh.

Resources
The topic deals with the resources distribution about minerals, industry, energy which very much important for examination.

Indian Agriculture
This topic deals with the India's agriculture patterns, distribution and contribution in GDP.

Industrial Features of India
This topic deals with industrial development, pattern of industries, agro-based industries and major industrial cluster from examination point of view.

Transport, Trade and Communication in India
This topic consisted the major topics from which questions are frequently asked such as trends in transports, major ports trade regions and network of communication.

India-Cultural Settings
This topic deals how regional variation formed India's distinct cultural setting. Chapter 18 (Demographic Features of India) This chapter is sub-part of human geography, which deals with the distribution of India's population.

Settlement Geography of India
This topic deals with rural settlement, urbanisation and urban agglomeration.

Ecology; Environment; Biodiversity
This is the major important topic from examination point of view. It covers some important topics such as importance of environment, affect of climate on environment, global warming, tropic, food chain, species variation and biome or planet. This topic is given special weightage by the UPSC and other competitive examination. The level of question had asked was pro-concept and current based. Hence, the topic is master trivial compilation of every aspects related ecology, environment and biodiversity like other topics, environment and biodiversity can be classify into two heads.

Statis
Basic theoretical and static stuff such as biomes, in-situ, ex-situ modes of wildlife conservation.

Current Based
IPCC report, kyotoprotcol supreme court order on xyz issue, cleaning of yamuna, Ban on minning etc.

Climate Change
This topic deals with significant and lasting change in statistical distribution of weather patterns over period ranging from decades to millions of years. It is become international topic of discussion then how can examination would be destituted. It is one of impudent topic after environment and biodiversity which has given special weight age because it is the only regulating factor of the sub-field of the geography. Every competitive examination asked question by the factor of the climate change relate with other topics through affects.

Disaster Management
This topic deals with environmental impacts on using resources, disaster prevention, disaster preparedness, relief, recovery.

Sustainable Development
This is very important topic from examination point of view. This topic covers the various facets of sustain ability and also describe an economy in equilibrium with basic ecological support system. As far as the new syllabus, a significant number of questions are being asked from on these topic every year and also in creases the number of question day by day. Apart from examination, this topic became world wide agenda. Hence, it became prominent and important for any examination point of View.

Chapter one

The Universe *and* the Solar System

Universe is the sum total of all the potentially knowable objects. The study of universe on a grand scale is called ***cosmology****. The universe includes planets, stars, galaxies, the contents of intergalactic space, the smallest sub-atomic particles and all matter and energy.*

Universe

- All the heavenly bodies i.e. stars, planets, satellites, asteroids, meteors comets, dust and gases are called **celestial bodies**, which together form the universe. The science of studying these heavenly bodies is known as ***astronomy*** and the scientists who practice astronomy are called **astronomers**.

Theories about Universe

- Universe has been fascinating since ancient times. Various scholars have presented their views on universe. *These theories can be put into two categories:*

(i) Early Theories

- **Geocentric Theory** The theory is proposed by Ptolemy in AD 140, which states that the Earth is the centre of the universe.
- **Heliocentric Theory** The theory is proposed by Copernicus in AD 1543, according to which the Sun is the centre of the universe.
- In 1805, British astronomer Hershel studied universe with the help of telescope and stated that the solar system is merely a small part of a galaxy.
- An American astronomer, Edwin P Hubble in 1925 said that the universe has a diameter of 2.5 billion light years and is composed of several galaxies.

(ii) Modern Theories

There are four main modern theories put forward to explain the origin and evolution of the universe:

The Big Bang Theory

- It is the most acclaimed theory proposed by Georges Lemaitre in 1930s and later strongly evidenced by George Gamow, which explained the modern Big Bang theory.
- Theory states that, at the beginning, all matter forming the universe existed in one place in the form of a *tiny ball* (singular or primeval atom) with an unimaginably small volume, infinite temperature and indefinite density.
- Around 15 billion years ago, a vast explosion occurred and the primeval atom disintegrated giving rise to space and time and the expansion of the universe that still continues till today and will continue further.
- The expansion of matters further formed galaxies and these galaxies are continuously expanding and moving away from each other in an accelerated velocity and in the process cooling the universe.
- The Big Bang or the expanding universe is now proven by the discovery of the Cosmic Microwave Background Radiation (CMBR) and Wilkinson Microwave Anisotropy Probe (WMAP).
- Another important astronomic observation called **red shift** also proved the expansion of universe.
- The recent experiments at the Large Hadron Collider (LHC), built by the European Organisation for Nuclear Research beneath the Franco-Swiss border near Geneva, Switzerland, aims to recreate conditions just after big bang to have a better understanding of the phenomenon.

Red Shift Theory

- Light is formed of a band of colours called **spectrum**. Violet colour has the shortest wavelength and lies at one end of the spectrum and red light has longest wavelength and lies at another end.
- The movement of a star or galaxy affects its light as seen by the observer. When the star is approaching the observer the light shifts to the blue end of the spectrum and the light shifts to the red end when the star recedes away.
- This is known as the **doppler effect** or **doppler shift**. The doppler shift of the galaxies show that they are receding and that the universe is in a state of rapid and accelerated rate of expansion. This astronomical observation is known as **red shift**.

Steady State Theory

- Bondi, Gold and Fred Hoyle developed this theory. According to this theory, the number of galaxies in the observable universe is constant and new galaxies are continuously being created out of empty space, which fill up the gaps caused by those galaxies, which have crossed the boundary of the observable universe. As a result of it, the overall size of mass of the observable universe remains constant. Thus, a steady state of the universe is not disturbed at all.

Pulsating Theory

- According to this theory, the universe is supposed to be expanding and contracting alternately i.e. pulsating. At present, the universe is expanding.
- According to Pulsating theory, it is possible that at a certain time, the expansion of the universe may be stopped by the gravitational pull and it may contract again. After it has been contracted to a certain size, explosion again occurs and the universe will start expanding. The alternate expansion and contraction of the universe give rise to pulsating universe.

Age of the Universe

- Astronomers estimated that the Big Bang occurred between 12 and 14 billion years ago and the age of the universe is now accepted to be 13.7 billion years on the basis of measurements made on the Cosmic Microwave Background Radiation (CMBR). Our solar system is thought to be 4.5 billion years old.

  Astronomers estimate the age of the universe in two ways:

  (i) By observations made on globular clusters which are a dense collection of roughly a million stars having many old stars.

  (ii) By measuring the rate of expansion of the universe called **Hubble Constant** (Ho) and extrapolating back to the Big Bang.

- The fate of the universe is determined by a struggle between the momentum of expansion and the pull of gravity. The rate of expansion is expressed by the Hubble Constant (Ho) while the strength of gravity depends on the density and pressure of the matter in the universe.
- If the pressure of the matter is low then the fate of the universe is governed by the density. If the density of the universe is less than the 'critical density', which is proportional to the square of the Hubble Constant, then the universe will expand forever.
- If the density of the universe is greater than the 'critical density', then gravity will eventually win and the universe will collapse back on itself, which is called **big crunch**.
- This strange form of matter is now referred as dark energy. If the dark energy infact plays a significant role in the evolution of the universe, then in all likelihood the universe will continue to expand forever.

Components of the Universe

- Our universe has a foamy structure. Considering only the largest structures the visible universe is made up of filaments, superclusters and galaxy groups and clusters. The galaxy groups and clusters in combined form are called **superclusters**, which are on turn form part of walls, which are also parts of filaments.
- The visible part of universe is concentrated in certain parts in a complex scaffold that surrounds a network of enormous cosmic voids or vast empty spaces.
- In addition to the 'normal' matter that makes up the visible parts of the universe, scientists have discovered that there are vast amounts of unseen matters called **dark matters**. *In proportion*

—Dark energy	:	68%
—Dark matter	:	27%
—Visible matter	:	5%

The visible matter of the universe are composed of:

Hydrogen	:	(72-75%)
Helium	:	(23-26%)
Other elements	:	<2%

- The process of nuclear fusion has very slightly increased the quantities of helium, but the proportional composition is practically unchanged since, the earliest years of our universe.
- Dark matters cannot be seen by any of the electromagnetic spectrum such as radiowaves, x-ray etc, but certain phenomena such as gravitational lensing, temperature distributions, orbital velocities and rotational speeds of galaxies etc, evidence of a missing mass and justify the probable existence of dark matter. Another invisible entity known as **dark energy**, is believed to be the reason why galaxies are speeding away at an accelerated rate.

Galaxy

- A large group of stars is called **galaxy**. There are billions of galaxies having different sizes, regular and irregular shape. *Galaxies can be divided into two categories:*

(i) Normal Galaxies

- These galaxies emit comparatively small amount of radio radiations as compared to the total radiations emitted.
- These galaxies are bright from the centre and gradually dim towards the edges. Each normal galaxy contains billions of stars in the form of a band, travelling together in the universe. *Depending upon their shapes, the normal galaxies may be divided into three groups namely:*
  - —Elliptical galaxies
  - —Spiral galaxies
  - —Irregular galaxies
- About 18% of the galaxies are elliptical, 80% of the galaxies are spiral and only 2% of the galaxies are irregular galaxies. The irregular galaxies are youngest, spiral galaxies are middle aged and elliptical galaxies are quite old.

(ii) Radio Galaxies

- These galaxies emit million times more radio radiations than normal galaxies. The radio radiations do not come from the galaxy itself, but are believed to be coming from two large radio sources.
- There are 170 billion galaxies in the observable universe. The largest galaxies have nearly 400 billion stars and our galaxy 'Milky Way' has about 100 billion stars.

Milky Way

It is the name of the galaxy to which our Earth belongs. If one looks at the sky on a clear night, a hazy band of white light stretching across a great circle is seen, which is called the **Milky Way** or **Akash Ganga**. It is a spiral galaxy.

Recently a super massive black hole known as **sagittarius** 'A' found in the core of the Milky Way.

Stars

- A star is a fiery luminous heavenly body that has own light and heat energy. Sun is the nearest star to our planet Earth and it takes 8.3 minute (500 second) for light to reach Earth from Sun. Proxima centauri is the nearest star beyond our solar system that is at a distance of 4.3 light years from the Earth.
- Stars may exist as single star, but are very few in the universe (only 25%). They may also occur in pairs called **binary stars** (about 33%) and the rest are multiple stars. Alpha centauri consists of three stars.
- Variable stars are stars that show varying degrees of luminosity. Luminosity fluctuates between periods. Delta cephei is an example. Stars of fluctuating luminosity are called **cepheid variables**.
- Pulsars are variable stars which emit regular pulses of electro-magnetic waves of very short duration whereas quasars are powerful quasi-stellar sources of radio radiations.
- Stars form when enough dust and gas clump together because of gravitational forces. Nuclear reactions release energy to keep the star hot. Planets form when smaller amounts of dust and gas clump together because of gravitational forces.
- Stars like the Sun change their form into other forms of stars, such as red giants, white dwarfs, neutron stars and black holes during their lifetime. The fate of a star depends upon how much matter it contains.
- High mass stars are much brighter than low mass stars, thus, they rapidly burn through their supply of hydrogen fuel. A star has enough fuel in its core to burn which makes it bright. e.g. the Sun has enough fuel to keep it bright for approximately 9 billion years.
- A star that is twice as massive as the Sun will burn through its fuel supply in only 800 million years. A 10 solar mass star, a star that is 10 times more massive than the Sun, burns nearly a thousand times brighter and has only a 20 million year fuel supply. Conversely, a star that is half as massive as the Sun burns slowly enough for its fuel to last more than 20 billion years.
- **Life Cycle of a Star** Stars are born in nebulae. A **nebula** is a cloud of gas (hydrogen) and dust in space. Huge clouds of dust and gas collapse under gravitational forces, forming protostars. These young stars undergo further collapse, forming main sequence stars.
- Stars expand as they grow old. As the core runs out of hydrogen and then helium, the core contracts and the outer layers expand, cool and become less bright. This is a red giant or a red super giant (depending on the initial mass of the star). It will eventually, collapse and explode, then becomes either a black dwarf, neutron star or black hole.
- (Transformation of stars) → Red giant → White dwarf → Black dwarf.
- (Transformation of stars) → Red supergiant → Supernova → Neutron star or Black hole.
- **White Dwarf** This is very small, hot star, the last stage in the life cycle of a star like the Sun. White dwarfs have a mass similar to that of the Sun, but only 1% of the Sun's diameter; approximately the diameter of the Earth.
- **Supernova** This is the explosive death of a star and often results in the star obtaining the brightness of 100 million Suns for a short time.

There are two general types of supernova:

(i) **Types I** These occur in binary star systems in which gas from one star falls on to a white dwarf, causing it to explode.

(ii) **Types II** These occur in stars ten times or more as massive as the Sun, which suffer runaway internal nuclear reactions at the ends of their lives, leading to an explosion. They leave behind neutron stars and black holes. Supernova are thought to be main source of elements heavier than hydrogen and helium.

- **Neutron Stars** These stars are composed mainly of neutrons and are produced when a supernova explodes, forcing the protons and electrons to combine to produce a neutron star.
- Typical stars having a mass of three times the Sun, but a diameter of only 20 km.
- If its mass is any greater, its gravity will be so strong that it will shrink further to become a black hole.
- Pulsars are believed to be neutron stars that are spinning very rapidly.
- **Black Holes** These are believed to form from massive stars at the end of their life times. The density of matter in a black hole cannot be measured.
- The gravitational pull in a black hole is so great that nothing can escape from it, not even light. It can often engulf neighbouring matters including stars and planets etc.

Black Hole and Gravitational Waves

When two black holes orbit each other and merge, it could cause ripples in space. These ripples would spread out like the ripples in a pond when a stone is tossed in. Scientists call these ripples of space, gravitational waves. Gravitational waves are invisible. They travel at the speed of light (186,000 miles per second).

The first direct observation of gravitational waves was made September 14, 2015 at LIGO.

The Chandrasekhar Limit

It is an upper bound on the mass of bodies made from electron-degenerate matter such as white dwarf. The calculation of the maximum mass of 1.44 solar masses for a white dwarf was done by *Subrahmanyan Chandrasekhar*. This implied that for masses above 1.44 solar masses there could be no balance between electron degeneracy and the crushing gravitational force and that the star would continue to collapse.

The collapse will continue until it is stopped by neutron degeneracy with the formation of a neutron star. But even that is not the ultimate limit, since neutron degeneracy can also be overcome by masses greater than three solar masses and the ultimate collapse is toward a black hole.

Some Facts of Universe

- Universe was very hot when young. Within minutes of expansion the temperature was billions Kelvin whereas the average temperature of the universe is now only 2.725 kelvin.
- As time grows the universe is cooling and marching towards a big freeze also known as **Heat Death**, when the universe will be devoid of any usable heat energy. Such prediction is supported by the measurements made by the Wilkinson Microwave Anisotropy Probe (WMAP) on the current geometry and density of the universe.
- The universe spans a diameter of over 150 billion light years and is flat not spherical. The universe is ever expanding and having no centre as each galaxy is away from one another.
- Some scientists predict that such expansion may fate with a radically catastrophic ending in a Big Rip, that everything would be forced to be ripped apart.

Our Changing View about the Universe

- 2000 years ago, the Greek astronomers thought that the Earth was at the centre of the universe and the Moon, the planets, the Sun and stars were orbiting around it. In the 6th century, it was Aryabhatta who stated that the rotation of the heavenly bodies as observed by us is due to the rotation of the Earth around its axis.
- Aryabhatta discovered that the day and night occur due to the rotation of the Earth. He also established that the lunar and solar eclipses were caused due to the shadows of the Earth and the Moon respectively. In the 15th century Nicholas Copernicus, the polish scientist showed that the Sun was at the centre of the Solar System and planets revolve around it. So, the Sun became the centre of the universe.
- In the 16th century, Johannes Kepler discovered the laws of planetary orbits, but the Sun still remained at the centre of the universe.It was only in the beginning of the 20th century, that a picture of our own galaxy became clear. The Sun was found to be located in a corner of the galaxy.

Discovery of Gravitational Waves

In February 2016, scientists from Laser Interferometer Gravitational– wave Observatory (LIGO) revealed that they had detected gravitational waves. Previously gravitational waves had only been understood indirectly, via their effect on the timing of pulsars in binary star systems.

First proposed in 1916 by Albert Einstein, gravitational waves are ripples in space and time that are produced when whole black holes collide and stars explode. Through these waves scientists hope to gain valuable insight into the universe because these waves experience no barriers, unlike electromagnetic waves such as radio waves, visible light, infrared light, X-rays and gamma rays.

Laser Interferometer Gravitational-wave Observator (LIGO)-India

- LIGO-India is planned as a collaborative project between a consortium of Indian research institution and LIGO laboratory in the USA, along with its international partner Australia, Germany and UK.
- The LIGO project operates three gravitational wave detectors. Two are at Hanford and one at Livingston in USA. The proposed project aims to move one advanced LIGO detector from Hanford (USA) to Hingoli in Maharashtra, India.
- Gravitational waves are distortions or 'ripples' in the fabric of space-time caused by some of the most violent energetic processes in the universe.

The Solar System

- The Solar System is dominated by the Sun, which accounts for almost 99.9% of the matter of the whole system. It is the source of light and heat to us. Scientists believe that the Sun has been formed from a moving cloud of gases, which is called **nebula**. The Sun and the planets were born out of this cloud. The force of gravity has created them.
- For over millions of years, these balls of dust and gas are moving around the Sun. The Sun by virtue of its mass and weight, controls the movement of the planets. This force is called the **force of gravity**.
- Sun is at the centre of the Solar System with eight planets (i.e. Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune) and their satellites, dwarf planets, asteroids, meteors and comets that move around the Sun.
- Till 2006, there were nine planets in the Solar System. Pluto was the farthest planet from the Sun. In 2006, the International Astronomical Union (IAU) adopted a new definition of a planet. Pluto and other celestial bodies like Ceres, 2003 UB_{313} does not fit this definition. It is no longer considered as a planet of the Solar System.

The Sun

- It is believed that the Sun was born about 5 billion years ago. Since that time, it is continuously emitting huge amount of heat and light and it is expected to glow in a similar manner for the next 5 billion years or so on. The Sun is the nearest star from us.
- The Sun is the source of almost all energy on the Earth. In fact, the Sun is the main source of heat and light for all the planets.The radius of the Sun is almost 100 times of the radius of the Earth and its mass is about a million times the mass of the Earth.
- The Sun is essentially a sphere of hot gases. The disc is also called the **photosphere**. The layers of gas above the photosphere are extremely hot, but their densities are extremely low. These layers are very faint and are not visible in the presence of strong light from the disc of the Sun.
- At the time of the total solar eclipse, when the light of the Sun's disc is completely cut off, the outermost layer becomes visible. It appears like a crown round the Sun. This layer is called **Corona**.
- Solar flares are charged particles overcome from Sun's gravity and comes into the outer space. When these solar flares reach the Earth atmosphere they collide with the gaseous particles and produces a colourful effect. In South pole region, these effects are known as **Aurora Australis and in North pole Aurora Borealis.**
- The temperature of the bright disc is about 6000 K. At the centre of the Sun, the temperature is about 15 million K. The pressure is also extremely high. All these conditions are right for fusion reactions. In the Sun, four protons (nuclei of hydrogen atoms) combine to form a helium nucleus.
- The mass of the helium nucleus is slightly smaller than the combined mass of four protons. So, there is a loss of mass in the process. This loss of mass is the source of Sun's energy.
- The Sun is about 150 million km away from the Earth. Light travels at a speed of 300000 km/s. So, the light of the Sun takes about 8.3 light minutes to reach us. The light of the nearest star (Proxima or Alpha centuari) to the Sun reach Earth in about 4.3 light years.
- In August, 2018 NASA has launched first planned robotic spacecraft to study outer corona of Sun. The goal of the probe is to determine structure and dynamics of magnetic fields at sources of solar wind. It will also trace flow of energy that heats corona and accelerates solar wind.

Process of Fusion

According to Einstein's equation $E = mc^2$, E is the energy produced when a mass (m), is lost. The quantity (c) is the velocity of light. Most stars produce their energy by the process of fusion.

The Planets

- Planets are actually revolving around the Sun. They have their own elliptical path of movement known as the **orbits**. Movement around its own axis is called **rotation** and around the Sun is **revolution**. They have their own speed also.
- Planets, unlike stars, have no light or heat of their own. They are lit by the light of the stars. Stars twinkle whereas planets do not. The word *planet* comes from the Greek word *Planetai*, which means *wanderers*. Planets keep changing their positions with respect to the stars.

Inner and Outer Planets

- The first four planets namely Mercury, Venus, Earth and Mars are much nearer to the Sun than the other four planets. They are called the **inner planets**. The inner planets have very few Moons.The planets outside the orbit of Mars namely Jupiter, Saturn, Uranus and Neptune are much farther off than the inner planets. They are called the **outer planets**. They have a ring system around them. The outer planets have more number of Moons.

Terrestrial and Jovian Planets

- Mercury, Venus, Earth and Mars are also called the **terrestrial planets** because their structure is similar to the Earth. *The common features of these planets are as follows:*
  —a thin rocky crust
  —a mantle rich in iron and magnesium
  —a core of molten metals
  —have thin atmospheres.
  —the planets outside the orbit of the Mars are called **Jovian planets** because their structure is similar to that of Jupiter.
  The common features of these planets are as follows:
  —these are all gaseous bodies.
  —they have rings, which are belts of small debris around them and
  —have large number of satellites.

Mercury (Buddha)

- It is nearest to the Sun. It is the smallest planet of the Solar System, nearly of the same size and mass as the Moon. Mercury takes 88 days for one orbit around the Sun and 59 days for one spin on its axis. It has no satellite.
- There is no atmosphere on mercury. The surface of mercury is rocky and mountainous. One side of the surface facing the Sun receives maximum heat and light. The surface of this planet does not receive sunlight or heat on its other side. One part of Mercury, therefore, is very hot while the other part is very cold.
- As Mercury is very close to the Sun, it is difficult to observe it, as most of the time it is hidden in the glare of the Sun. However, it can be observed in September and October just before sunrise in the Eastern sky as a morning star. It is also seen in the Western region of the sky immediately after sunset in March and April as an evening star.

Venus (Shukra)

- Venus has no Moon or satellite of its own. Its rotation on its axis is somewhat unusual i.e. from East to West. Its size is nearly the same as that of the Earth. The mass of Venus is nearly 4/5 times that of the Earth. It takes 224.7 days for one orbit around the Sun and 243 days for one spin on its axis.
- Venus has an atmosphere that consists of mainly carbon dioxide. Minute quantities of water vapour and oxygen have also been found on Venus. The cloudy atmosphere of Venus sends back almost 3/4th of the sunlight that falls on it. Because of its thick, toxic atmosphere which is made up of Sulfuric acid clouds, it is an example of extreme greenhouse effect. It is hottest planet in Solar System.
- Sometimes, Venus appears in the Eastern sky before sunrise and sometimes it appears in the Western sky just after sunset. Therefore, it is often called a **morning** or an **evening star**.

Goldilock Zone

The Goldilocks zones an area of space in which a planet is just the right distance from its home star so that its surface is neither too hot nor too cold. The Earth occupies what scientists sometimes call the Goldilocks zone. Its distance from our star means it is neither too hot, nor too cold to support liquid water–thought to be a key ingredient for life.

Just because a planet or moon is in the Goldilocks zone of a star, it doesn't mean it's going to have life or even liquid water. Venus and Mars are also in this habitable zone, but aren't habitable because of lack of atmosphere and solidified core.

The Earth (Prithvi)

- Our Earth rotates from West to East. Our Earth is more or less like a sphere, which is slightly flattened in the North and South. The Earth is best to be described as geoid which means Earth like shape.
- Earth is the third nearest planet to the Sun. In size it ranks fifth. In size and make up the Earth is almost identical to Venus. Due to presence of water and landmasses, the Earth appears blue-green in colour from the space. Therefore, it is called **blue planet**.
- The Earth is the only planet where some special environment conditions are responsible for the existence and continuation of life.

Our Only Natural Satellite-the Moon

A small body revolving around a bigger body is called its **satellite**. The Moon is a satellite of the Earth. Planets are the satellites of the Sun. These are natural satellites. Like planets, satellites also have no light or heat of their own.

As the Moon revolve around the Earth and also around the Sun its position changes daily in relation with the Sun. As a result, the relative positions of the Moon keep on changing everyday. i.e. Moon appears different each night. The various shapes of the bright part of the Moon as seen during a month are called **phases of the Moon**.

The Moon takes almost the same time, 27 days and 7 hours to complete both the movements i.e. *rotation and revolution. Thus, it always presents the same side towards our Earth. The Moon has no atmosphere.*

The diameter of the Moon is only 1/4th of that of the Earth. The Moon is about 384400 km away from the Earth. The light reflected by the Moon reaches us in just one and a quarter seconds. Neil Armstrong, Edwin Aldrin and Collins set foot on the Moon for the first time on 21st July, 1969. They found that the Moon's surface is dusty and barren. There are many craters of different sizes. It also has a large number of steep and high mountains. These cast shadows on the Moon's surface.

Mars (Mangal)

- It is almost half the size of the Earth. The diameter of Mars is slightly more than half of that of the Earth, but its mass is only 1/10th of that of the Earth. It takes 687 days for one orbit around the Sun and 1 day for one spin on its axis.The atmosphere of Mars is much thinner than that of the Earth.
- It perhaps consists mainly nitrogen and argon. Traces of oxygen have also been found. It appears slightly reddish and therefore, it is also called the **red planet**. Mars has two small natural satellites named Phobos and Deimos.
- In July, 2018, scientist revealed that they had found evidence of a liquid lake beneath the surface of its's Southern pole's ice cap.
- The Mars is visible from the Earth for most part of the year. However, it is best situated for observation, when it is opposite the Sun's position in the sky with respect to the Earth. On these days, it is closer to the Earth as well.

Jupiter (Brihaspati)

- It is the largest planet of the Solar System. It takes 11 years and 11 months for one orbit around the Sun and 9 hours, 56 minutes for one spin on its axis. It has 67 satellites. It also has faint rings around it. Its most distinguishing feature is the great red spot. It is believed that it is a complex storm in the atmosphere of the planet ranging for a few hundred years.
- Its mass is more than the combined mass of all other planets. Because of its large mass, Jupiter exerts a strong gravitational pull on other objects which pass by it. A comet passing close to it is likely to experience this pull and stray from its original path. In 1994, the comet, shoemaker-levy, actually broke up into several pieces when it came too near this planet. The pieces then collided with the planet.
- Jupiter's bright appearance in the sky after Venus and occasionally Mars is due to its thick atmosphere that reflects most of the sunlight falling on it. It is believed that Jupiter mainly consists of hydrogen and helium in gaseous form. Its cloud like outer regions consists of methane in gaseous form while ammonia is present in crystalline form.

Saturn (Shani)

- Beyond Jupiter is Saturn which appears yellowish in colour. What make it unique in the Solar System are its three beautiful rings. It takes 29 years, 5 months for one orbit around the Sun and 10 hours, 40 minutes for one spin on its axis. It has 82 satellites. Saturn is the least dense among all the planets. Its density is less than that of water. It is similar in mass and composition to Jupiter. It is however, cooler than the Jupiter.

Uranus (Arun)

- It was the first planet to be discovered with the help of a telescope. William Herschel discovered the planet in 1781. Hydrogen and methane have been detected in the atmosphere of Uranus. Except Venus and Uranus, all other planets rotate in the same direction in which they revolve.
- Like Venus, Uranus also rotates from East to West. The most remarkable feature of Uranus is that it has highly tilted rotational axis. As a result, in its orbital motion it appears to roll on its side. It takes 84 years for one orbit around the Sun and 17 hours, 14 minutes for one spin on its axis. It has 27 satellites.

Neptune (Varun)

- It was discovered by Sir William Herschel on the basis of the law of gravitation given by Sir Issac Newton which he gave almost 180 years before it. It takes 164 years for one orbit around the Sun and 16 hours 7 minutes for one spin on its axis. Uranus and Neptune are quite faint and cannot be seen with the naked eye. That is why only 6 planets were known in ancient times. These two planets have been discovered only after telescopes came into use in astronomy. It has 8 satellites.

Pluto

Discovered in 1930 by Clyde Tombaugh, Pluto was long considered our solar system's ninth planet. But after the discovery of similar fascinating planets deeper in the distant Kuiper Belt, Pluto was reclassified as a dwarf planet in 2006.

It takes 248 years in revolution and 155 hours in rotation. Pluto has five known moons. *Charon* (the largest), *Styx, Nix, Kerberos* and *Hydra*. Pluto and Charon are sometimes considered as a binary star system.

New Horizons is a NASA's spacecraft that was the first to visit dwarf planet Pluto in July 2015. Its flyby images of the dwarf planet's icy surface, as well as observations of Pluto's moon Charon, are revolutionizing our understanding of solar system objects far from the sun.

The mission is now enroute to an object deeper in the Kuiper Belt, called 2014 MU69. It reached this object on 1st Jan, 2019.

Boundary of the Solar System

- The orbit of Pluto does not mark the boundary of the Solar System. It extends much beyond it. Its size has been estimated to be about 105 AU (Astronomical Unit which is equal to the mean distance between the Earth and the Sun i.e. 150 million km). At the edge of the Solar System, there exist billions of very small objects.
- These objects were formed very early in the gas cloud from which the Solar System evolved. Occasionally, paths of these bodies are disturbed by accidents, such as a star passing nearby, causing some of them to move towards the Sun, which appears as comets. Comets are of great interest to scientists. This is because the material of comet presents a sample of the original material from, which the Solar System was formed.

Asteroids
(Starlike heavenly bodies)

- There are numerous tiny heavenly bodies found between the orbits of Mars and Jupiter, which revolve around the Sun. These bodies are called **asteroids**. Each asteroid has its own orbit and the orbits of all of them are spread over a large distance forming a band. A few asteroids have elongated orbits going beyond the orbit of Jupiter.
- The size of asteroids varies from barely a pebble to a few 100 km. The largest asteroid is Ceres, has a diameter of about 1000 km. Scientists believe that asteroids are the pieces of matter that somehow could not get assembled in the form of a planet. The asteroids are small rocky bodies.
- While making their rounds the asteroids often collide and break into smaller pieces. These smaller pieces or meteorites sometime fall on to the Earth. They crash to the ground and create craters. Meteor crater in Arizona, USA and Lonar lake in the State of Maharashtra, India are good examples of craters.

Comets

- It revolves around the Sun in highly elliptical orbits. However, their period of revolution round the Sun is usually very long. They become visible from the Earth only when they come close to the Sun. A comet appears generally as a bright head with a long tail. The length of the tail grows in size as it approaches the Sun. The tail disappears again, when the comet move away from the Sun. The tail of a comet is always directed away from the Sun.
- Many comets are known to appear periodically. One such comet is Halley's comet, which appears after nearly every 76 years. It was last seen in 1986.The study of comet tails has shown the existence of molecules of carbon, nitrogen and hydrogen.
- Since, these molecules can help to form complex molecules necessary for the origin of life, some scientists have suggested that the seeds of life on the Earth were brought by comets from the outer space.

Meteors, Meteorites and Meteor Showers

- Meteors are very small stone-like objects that are revolving around the Sun. Their existence becomes known only, when some of them occasionally enter the Earth's atmosphere. At that time, it has a very high speed. Due to the friction in the atmosphere it heats up. It glows and evaporates quickly.
- The path of the meteor, therefore, appears as bright streaks of light in the sky. The bright steak lasts for a very short-time. These are commonly known as **shooting stars,** although they are not stars.
- Some meteors are large and, so they can reach the Earth before they evaporate completely. The body that reaches the Earth is called a **meteorite**. They can be examined in the laboratory. They give us an idea of the composition of the material from which the Solar System was formed.When the Earth crosses the tail of a comet, swarms of meteors are seen. These are known as **meteor showers**. Some meteor showers occur at regular intervals each year.
- **New Discovery of Exoplanets** Exoplanets are planets located outside the Solar System. NASA's Spitzer Space Telescope has revealed the first known system of seven Earth-size planets around a single star. Three of these planets are firmly located in the habitable zone, the area around the parent star where a rocky planet is most likely to have liquid water. This exoplanet system is called TRAPPIST-1, named for the Transiting Planets and Planetesimals Small Telescope (TRAPPIST) in Chile.
- On 7th June, 2018 scientist working for Physical Research Laboratory (PRL) of ISRO, using the PRL Advance Radial-Velocity Abu Sky Search (PARAS) Spectograph integrated with telescope at the Mount Abu, announced the discovery of host star EPIC 211945201 and expolanet EPIC 211945201 b located at a distance of 600 light years from the Earth.
- In September, 2020 scientists discovered a planet of the size of Jupiter named WD 1586b by NASA's Transiting Exoplanet Survey Satellite (TESS).

Self Check

Build Your Confidence

1. Which of the following statements are helpful in probing the Big Bang theory?

1. Study of Cosmic Microwave Background Radiation (CMBR).
2. Measurement by Wilkinson Microwave Anisotropy Probe (WMAP).
3. Red shift observation.
4. Informations of large Hadron Collider.

Select the correct answer using the codes given below

(a) 1 and 3 *(b)* 1, 2 and 3 *(c)* 3 and 4 *(d)* All of these

2. Consider the following statements regarding Solar System

1. All the planets constitute less than 2% of the total matter of Solar System.
2. All the Jovian planets have rings.
3. At the edge of the Solar System, there are numerous small celestial bodies.

Which of the above statements are correct?

(a) 1 and 2 *(b)* 2 and 3
(c) 1 and 3 *(d)* All of these

3. Consider the following statements

1. Our galaxy 'Milky way' is a spiral galaxy.
2. Our Solar System is located in approximate centre of the Milky way.

Which of the statement(s) given above is/are correct?

(a) Only 1 *(b)* Only 2
(c) Both 1 and 2 *(d)* Neither 1 nor 2

4. Which of the following statements are correct?

1. Most of the stars in our universe exist single.
2. High mass stars has shorter duration of life span.
3. In future, 'Sun' may become a black dwarf not a black hole.
4. Chandrasekhar limit deals with the finding of black holes.

Select the correct answer using the codes given below

(a) 1 and 4 *(b)* 1, 2 and 3 *(c)* 2 and 3 *(d)* All of these

5. Consider the following statements regarding Mercury

1. One part of the planet is very hot while other is very cold.
2. Its surface is rocky and mountainous.
3. It can be seen in sky in September and October 'just after sunset'.

Which of the above statements are correct?

(a) 1 and 2 *(b)* 2 and 3
(c) 1 and 3 *(d)* All of these

6. Consider the following statements about the Pluto

1. Pluto is largest dwarf planet in our Solar System.
2. Pluto is located in Kuiper belt.
3. Pluto has no natural satellites.

Which of the above statement(s) is/are correct?

(a) Only 2 *(b)* Only 3
(c) 1 and 2 *(d)* All of these

7. Consider the following statements

1. Pulsars emit regular pulses of electromagnetic waves.
2. Quasars emit radio radiations.
3. Origin of stars are traced back to nebulae.
4. It is predicted that after 5 billion years the Sun may expand enough to engulf all its planets and collapse itself.

Which of the statements given above is/are correct?

(a) 3 and 4 *(b)* 1 and 2
(c) 1, 2 and 3 *(d)* All of these

8. Which of the following is/are the measures of astronomical distances?

1. Light year
2. Astronomical unit
3. Per second
4. Orbital length

Select the correct answer using the codes given below

(a) 1 and 2 *(b)* 1, 2 and 3
(c) Only 2 *(d)* All of these

9. Consider the following statements regarding Moon of Earth

1. In terms of size Moon is similar to planet Mercury.
2. In terms of mass, Moon is about 2/3 of the planet Mercury.

Which of the statement(s) given above is/are correct?

(a) Only 1 *(b)* Only 2
(c) Both 1 and 2 *(d)* Neither 1 nor 2

10. Consider the following statements

1. When a star moving away from the observer then the light coming from it looks red gradually shifting from white.
2. This observation is useful to explain the origin of the universe.

Which of the statement(s) given above is/are correct?

(a) Only 1 *(b)* Only 2
(c) Both 1 and 2 *(d)* Neither 1 nor 2

11. Which of the following statements is/are correct?

1. Supernova is a stage when star explode and cost its characteristics.
2. Stars having similar mass like our Sun have similar rotational speed.
3. Stars having mass lower than the Sun never explode.
4. Once a star turns to white dwarf, it is rapidly converted to black hole.

Select the correct answer using the codes given below

(a) Only 1 *(b)* 1 and 2 *(c)* 1, 2 and 3 *(d)* All of these

1. (d) **2.** (d) **3.** (a) **4.** (c) **5.** (a) **6.** (a) **7.** (d) **8.** (b) **9.** (a) **10.** (a) **11.** (a)

Chapter two
The Earth

The Earth was formed approximately 4.54 billion years ago and is the only known planet to support life. In ancient culture, Earth was considered flat. The paradigm of a spherical Earth was developed in Greek astronomy, beginning with Pythagoras (6th century BC). Aristotle accepted the spherical shape of the Earth on empirical grounds around 330 BC.

Shape and Size of the Earth

- The Earth is an oblate spheroid, bulges at the equator and is flattened at the poles. For such shape, the Earth is called as **geoid**. Geodesy is a branch of science that deals with measuring the Earth's size and shape.
- Due to rotation of Earth, centrifugal force is generated which is greatest at the equator that causes a slight outward bulge there, so the equatorial circumference is larger than polar circumference.
- Gravitational pull is strongest at the flattened poles and gradually weaken towards the equator. So, our weight is lowest at the equator and highest at the pole. Earth is the third nearest planet to the Sun and in size, it is the fifth largest planet and largest among the 4 inner planets.
- The equatorial circumference is 83 miles more than polar circumference and equatorial diameter is 26 miles (~ 42 km) greater than its polar diameter.
- The spherical shape of the Earth is also marked by the intervening highlands and oceans on its surface.
- The surface area of the Earth is approximate 510 million km^2 in which water is 361 million km^2 (70.8%) and land is about 149 million km^2. Water is more concentrated in Southern hemisphere and the landmass is more concentrated in Northern hemisphere of the Earth considering equator as the boundary line.
- Of all the planets in our solar system, the Earth has the greatest density approximately 5.52 grams cm^3, second in line is Mercury.
- There is an antipodal arrangement of land and water on directly opposite side of the Earth, means land is opposite to water and *vice-versa* on the globe.
- Even, the North Arctic ocean is opposite to the Antarctic landmass. Only a few landmass has antipodal to landmass, such pairs are like New Zealand-Spain, Bermuda-Perth, Jakarta-Bogota, China-Argentina, Lima-Bankok etc.
- Antipodal points on Earth of a location can be calculated by converting North latitude to South latitude and subtracting longitude value from 180° and reversing East to West or *vice-versa*.

Facts about Earth

- **Mass** 5.97×10^{24} kg
- **Equatorial Diameter** 12756 km
- **Polar Diameter** 12714 km
- **Equatorial Circumference** 40030 km
- **Known Satellites** 1, the Moon
- **Orbit Distance** 149598262 km (1 AU)
- **Orbit Period** 365.26 Earth days
- **Surface Temperature** -88°C to 58°C
- **Average Atmospheric Temperature** 14.2°C
- **Earth's Atmosphere** Nitrogen (78%), Oxygen (21%), Argon (0.93%) and Carbon dioxide (0.03%)
- **Earth's Orbital Speed** 29.8 km/sec
- **Density** 5.52 g/cm^3

Measurement of Earth's Age

Several methods to determine the age of the Earth are:

Erosion

- Scientific observation shows that erosion takes place at about 1 ft in every 5000 years. Knowing this method, we can estimate the age of rock formations like the Grand Canyon.

Sedimentation

- Another method used is to measure the rate at which sediment is deposited. Scientists think it takes between 500 and 10000 years to deposit 1 foot of sediment. This method is not as accurate as the erosion method.

Salinity of the Oceans

- Some geologists try to measure the age of the Earth by the amount of salt in the ocean.
- First, they need to find out how much salt is in the oceans. Then, they find out how much salt rivers pour into the oceans each year.
- By comparing how much salt there is in the oceans now to how much is carried in by rivers each year, scientists can estimate the age of the oceans.

Radioactive Method

- It is the method to study the uranium in igneous and metamorphic rocks. Uranium is a mildly radioactive substance that breaks down very slowly to form other elements and eventually into lead and cannot be influenced by temperature and pressure.
- Scientists calculate that it takes about 5 billion years for a half of a piece of uranium to become lead. By looking at different rocks and comparing the amount of uranium still in the rock to the amount of lead that has been formed, they have measured the age of the Earth about 4.5 billion years.

Carbon-14 Dating

- All organic life forms have some amount of carbon-14 in them. When they die, no more carbon-14 is produced, but instead the carbon-14 begins to slowly break down. Scientists think it takes 5600 years for half of a piece of carbon-14 to break down.
- The fossil remains of creatures that had carbon-14 in them are found in sedimentary rock. By comparing the amount of carbon-14 in a rock to the amount of other substances that have been formed, as a result of the breaking down of the carbon-14, scientists can date the rock.
- **Carbon-14** dating is used to find the age of rocks upto 15000 years old and the radioactive method is used for older rocks.

Motions of the Earth

- As a celestial body, Earth has different varieties of spatial motions. It may include rotation, revolution, axial precession, change in tiltation of axis, changes in the ellipticity of the orbit (spin motion).

Rotation

- Rotation is the motion of the Earth along its axis, around the imaginary line passes through North pole and South pole. Earth rotates from West to East i.e. anti-clockwise. So, Sun, Moon and other stars rises in the East and set on the West.
- Rotational motion causes day and night, so, called **daily motion**. Speed of the rotation decreases from equator to poleward i.e. the speed is about 1670 km/h at equator and about 1120 km/h at 45° latitude.
- **Solar Day** It is found when the duration of Earth's revolution around the Sun is calculated in terms of days, while taking Sun as stationary. Duration of a solar day is exactly 24 hours. It is the average interval between two successive midnights. It is also called **synodic day**.
- **Sideral Day** The duration between the passage of a particular star over a meridian twice is called **sideral day**. Its duration is of about 23 hours and 56 minutes. It is smaller than Solar day.
- Rotation causes deflation of ocean currents and winds differently in different hemisphere, popularly known as **coriolis force**. It also causes alternate rise and fall in ocean waves twice daily. Rotation of Earth creates a centrifugal force that causes a bulge at the equator and reduces the gravitational pull there.

Revolution

- Revolution is the motion of the Earth on its elliptical orbit around the Sun. Earth revolves at about 18.5 miles per second or 29.6 km per second. It is responsible for experience of seasons on Earth. One complete revolution is called a year and can be called synodic/solar year/tropical year or sideral year as per the relative calculation.
- The sideral year is defined to be the time for the Sun to return to the same position with respect to the stars. Whereas, the tropical year is the time for the Sun to return to the same position relative to the Earth's axis, which is normally calculated from one vernal equinox (summer solstice) to another. The solar year is shorter than the sideral year by about 20 minutes and 23 seconds because of the precession.
- Hipparchus was the first man to take exact observations of the length of the year and later Ptolemy also made the similar one.

- The average distance between Earth and Sun is approximately 93 million miles or 150 million km, but it varies as the orbit of Earth is elliptical not circular.
- The position at which Earth is closest to the Sun is called **perihelion** (about 147 million km) likely occur about 3rd January, every year. Similarly, the farthest position of the Earth from the Sun is called **apehelion,** likely occur about 4th July every year (152 million km).

Axial Precession

- The rotational axis of the Earth is tilted with respect to the normal to the plane of the ecliptic, presently at an angle of about 23.5°. Because of the oblate shape of the Earth and the tilt, the Sun exerts a gravitational pull that differs in force at the two poles. The effect is to attempt to set the Earth up straight i.e. to try to right the axis to be normal to the ecliptic.
- However, instead of straightening, the Earth's rotation axis precesses, i.e. it exhibits a slow, conical motion around the orbital axis. Infact, the 'righting force' has the effect of causing the rotational axis to execute a circular, wobbling motion, like a spinning top. The precession of the equinoxes is responsible for the difference between the Julian and Gregorian calendars.

Changes in Tilt

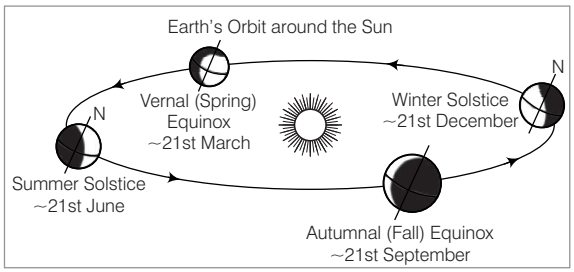
- While the inclination of the Earth's rotational axis is presently 23.5°, it has moved a little in the past. Like the precession of the equinoxes that reflects the circular motion of the rotational axis, the tilt changes periodically also from about 24.5° to 21.5° over a period of about 40000 years. So, as the rotational axis wobbles, it also tilts back and forth.
- This motion provides no insight into the Earth's internal properties, but it turns out to be very important as an influence on the Earth's climatic changes.

Changes in the Earth's Orbit

- The Earth revolves around the Sun in an elliptical orbit every 365 days with the Sun at one focus. This orbital state too is not static. The ellipticity of the orbit, changes, also in a periodic way, with this period being the longest at around 100000 years, the ellipticity changes from 0.01 to 0.007.
- In summary, these three motions can be thought of as a 100000 years stretch of the orbital ellipse, a 40000 years tilt of the rotational axis, together with a 26000 years wobble of the rotational axis. Wobble and stretch are actually coupled, if one changes the other is also forced to change alongwith it.

Seasons

- The imaginary surface on which Earth orbits around the Sun is called as the **plane of the ecliptic**. The Earth's axis is inclined at 66.5° to the plane of the ecliptic (or 23.5° from the perpendicular to the plane of the ecliptic). The Earth maintains its orientation with respect to the stars. Thus, the North pole points in the same direction to Polaris, the North star, as it revolves around the Sun. Consequently, the Northern hemisphere tilts away from the Sun during one-half of Earth's orbit and towards the Sun through the other half.
- If the Earth would not have been tilted on its axis, the days and nights would have been of same duration, always. Moreover, if the Earth would not have been revolving around the Sun, one of the hemispheres would have long days and short nights, whereas the other one would have short days and long nights.



Revolution of Earth

- The Earth moves not only on its axis, but also in its orbit around the Sun. Therefore, the Earth changes its position continuously with respect to the Sun. *There are four major positions of the Earth, while it revolves around the Sun and these positions bring different seasons on the Earth:*

(i) **Position on 21st June** In this position, the Sun shines perpendicularly over the Tropic of Cancer. This position is called the **summer solstice**. Infact, from 21st March, the Sun starts shifting towards the North, gradually. It is the time of summer season in the Northern hemisphere, while in the Southern hemisphere, it is winter season. The day in the Northern hemisphere is longest on 21st June. From 21st June, the Sun starts retreating towards the equator and hence, the heat of summer gradually decreases. On this date Sun does not set below the horizon at the arctic circle.

(ii) **Position on 22nd December** In this position, the Sun shines perpendicularly over the Tropic of Capricorn. This position is called **winter solstice**. During this period, days are long and nights are short in the Southern hemisphere and *vice-versa* in Northern hemisphere.

(iii) **Position on 21st March** The Sun starts shifting towards North gradually from 21st March. This position marks the summer in the Northern hemisphere and winter in the Southern hemisphere. On this day, the Sun also shines directly overhead the equator. It is called **spring equinox**.

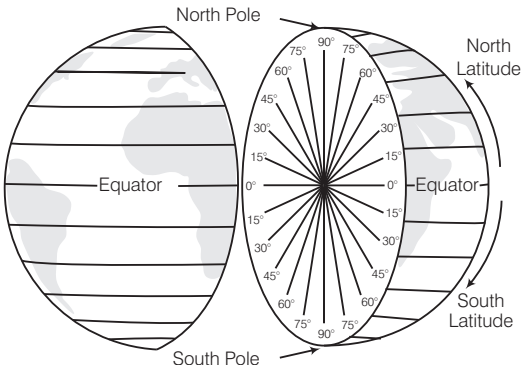
(iv) **Position on 23rd September** The Sun shines directly overhead the equator. Therefore, half part of all latitudes receives the sunlight at these times. Hence, everywhere the duration of the day and night is equal. Seasons are also similar in both the hemispheres. It is called **autumn equinox**.

Effects of Earth's Motion

- Alongwith creating day-night and seasons, the motions also create spatial temperature variations on the Earth.
- Sun oscillates overhead regions within the tropics. Sunlight is concentrated time-to-time over these regions, but it becomes gradually oblique and faint towards the poles. So, tropical regions are net gainers of heat during respective summer seasons and beyond these regions are permanent net loser of heat on Earth. Whereas the equatorial region is always net gainer of heat on Earth.

Latitudes

- The points at which the rotational axis intersects the Earth's surface are called **North pole** and **South pole**. Latitude which divides the Earth into two equal halves is called **equator**. Its value is 0°. The position of all the latitudes is either to North or to South of the equator. The Northern half of the Earth from the equator is known as the **Northern hemisphere** and the Southern half is known as the **Southern hemisphere**.
- The latitude of a place is the angular distance of a place North or South of the equator, as measured in degrees from the center of the Earth.
- The line of latitude are drawn parallel to the equator in circles, so called **parallels** and grow smaller towards the poles. Thus, latitude of the great circle or equator is the largest and nearly a point at the poles.
- Total number of latitudes are 181 and the most important lines of latitude are the Equator (0°), the Tropic of Cancer ($23\frac{1}{2}^{0}$ N), the Tropic of Capricorn ($23\frac{1}{2}^{0}$ S), the Arctic Circle ($66\frac{1}{2}^{\circ}$ N) and the Antarctic Circle ($66\frac{1}{2}^{\circ}$S), North Pole (90° N) and South Pole (90° S).
- The average latitudinal distance of 1° is about 69 miles or 111 km. As the Earth is slightly flattened at the poles, the linear distance of a degree of latitude at the pole is little longer than that at the equator.

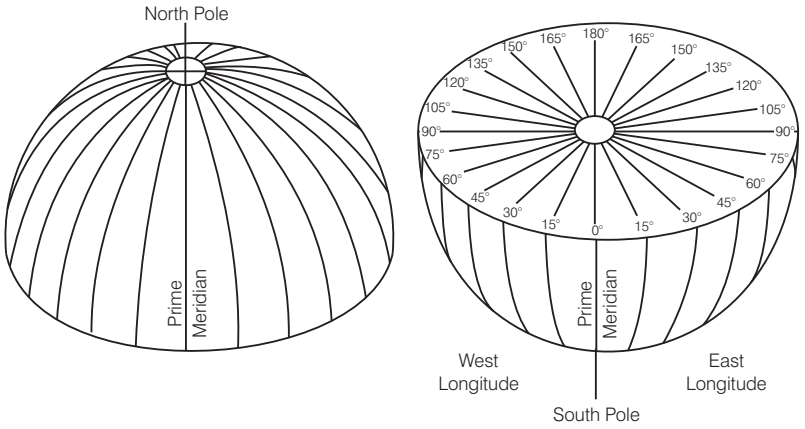


Latitudes on Earth

- During the winter and summer solstices, the area on the Earth between the Arctic circle (at 66.5° N latitude) and the North pole has 24 hours of darkness and daylight, respectively.
- The same phenomena occurs for the area between the Antarctic circle (at 66.5° S latitude) and the South pole, except that the seasons are reversed in the Southern hemisphere. At the poles, the Sun is below the horizon for 6 months of the year.
- For those living outside the tropics (poleward of 23.5° North and South latitude), the noon Sun will never shine directly overhead.

Longitudes

- Since, the equator is a circle, it can be divided into 360 divisions and the imaginary line joining both the poles passing through such divisional points on the equator are like semi-circles and called **meridians**.
- Unlike the equator, which is centrally placed between the poles, any meridian could have been taken to begin the numbering. It was finally decided in 1884, to choose as the zero meridian, the one which passes through the Royal Astronomical Observatory at Greenwich, near London.
- This is the Prime Meridian (0°) from which all other meridians radiate Eastwards and Westwards upto 180°.
- Less conventionally, the part of the Earth on the Eastern side of the Prime Meridian is called **Eastern hemisphere** and that on the Western side of it is called **Western hemisphere**.
- These meridians shows the longitude of a place on the globe at its angular distance, East or West of the Prime Meridian.
- The Prime Meridian and the 180° longitude that lies just opposite to the Prime Meridian together form one complete circle. From Prime Meridian, Eastward longitudes are marked as 'E' upto 179°E and Westward longitudes are marked as 'W' upto 179°W, but 180° is left unlabelled. So, there are total 360 longitudes.
- Like latitudes, longitudes also can be sub-divided into minutes (′) or seconds (″) for precise locational analysis. As the parallels of latitude become shorter polewards, so the meridians of longitude which converge at the poles, enclose a narrower space. The degree of longitude therefore decrease in length towards pole. For this reason, they are not used for calculating distances.



Longitudes on Earth

Great Circles and Small Circles

- A **great circle** is a circle, which divides the Earth into two equal parts or hemispheres.
- A great circle is the longest circle that can be drawn on the globe. Conversely, a circle on the surface of the Earth, that does not pass through the center of the Earth and thus, divides the Earth into two unequal parts is called a **small circle**.
- Among the parallels of latitude, only the equator is a great circle and all other parallels are small circles. However, among the meridians of longitude, all are semi-circles and form great circle alongwith meridian running opposite side. Apparently, an infinite number of great circles can be drawn on the surface of Earth.

Important Facts on Longitude and Latitudes

The Equator passes through 13 countries: Ecuador, Colombia, Brazil, Sao Tome and Principe, Gabon and Republic of the Congo, Democratic Republic of the Congo, Uganda, Kenya, Somalia, Maldives, Indonesia and Kiribati. Among physical features, the equator passes through Andes, Mouth of Amazon, Congo basin, Lake Victoria, Mouth of R Juba (Somalia), Sumatra, Borneo.

The Tropic of Cancer at 23½° N runs through Mexico, Egypt, Saudi Arabia, India, Bangladesh, Myanmar, South China and Taiwan. Among physical features, it passes through Gulf of Mexico, Mexican plateau, Saharan desert, river Nile, Red sea, Arabian peninsula, Arabian sea, Ganga-Brahmaputra-Meghna confluence, Indo-China peninsula and Red river in China.

Tropic of Capricorn at 23½ S runs through Chile, Northern Argentina, Paraguay, Southern Brazil, Botswana, Northern South Africa, Madagascar, Australia etc among major countries. Among major physical features, it passes through Andes, Granchaco, Brazilian highlands, Namib desert, Kalahari desert, Mozambia channel, Great Dividing range etc.

Antarctic Circle (66½ N) passes through entirely over ocean except some part of Antarctica Arctic circle (66½ N) passes through Bejing strait, Alaska, Davis strait, Greenland, Scandinavia and Siberian plateau.

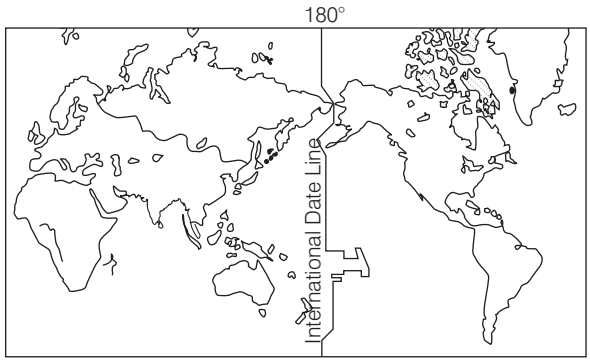
Prime Meridian passes through United Kingdom, Paris, Spain, Algeria, Mali, Ghana etc.

Distribution of Date and Time

- To eliminate the confusion of time and date at local and international level, the world is divided into standard time belts. Prime Meridian is used as the basis for reckoning of international time, which is the reference of local time or noon of Greenwich Meridian.
- Earth rotates from West to East, hence, places situated in the East of Prime Meridian experience Sun rise earlier than the places in the West.
- Earth takes 24 hours for one complete rotation of 360°, it implies the Sun appears to move at the rate of 15° in 1 hour or 1° in 4 minutes. Sun is overhead each meridian after 4 minutes, such position can be taken for calculation of local time.
- Taking Greenwich Meridian as standard time zone (GMT), the whole world has been divided into 24 standard time zones, each of which differs from the next by 15° in longitude or 1 hour in time.
- Every 15° we go Eastwards, local time is advanced by 1 hour and conversely if we go Westward, local time is retarded by 1 hour. Places East of Prime Meridian see the Sun earlier and gain time, whereas places West of it see the Sun later and lose time. A simple memory technique may be East Gain Add (EGA) and West Lose Subtract (WLS) for finding the local time of a region if GMT is known.
- Indian Government has accepted the meridian of $82\frac{1}{2}$ E for the standard time, which is 5 hours 30 minutes ahead of GMT. Nepal and Sri Lanka also follow the same standard time.
- Some larger countries adopt several time zones for practical purposes i.e. Russia has 11 time zones, USA and Canada has 5 time zones, Australia has 3 time zones, but China has only 1 time zone.

International Date Line (IDL)

- The Prime Meridian also helps in establishment of the International Date Line, which is congruent with 180° longitude.
- When we count the time of the 180° longitude from Eastern side of GMT, it will be 12 hours ahead and when it is counted Westward, it is 12 hours behind the GMT. That means, difference of 24 hours or a complete day occur on the either side of the meridian. When the longitude is crossed from one side to another, the date is changed exactly 1 day. So, it is called **International Date Line**.
- A traveller crossing the date line from East to West losses a day (the time he made) and gains a day when travels West to East (the gain of time he encountered).
- 180° meridian was chosen as IDL because it passes through the middle of Pacific ocean and there is practically no landmass and wherever there is landmass, a deviation has been taken to avoid confusion of time and date.
- Samoa was previously located East of the IDL, but in 2011 it moved the IDL to the East of the country, so that Samoa would lie to the West of the date line for better trading with its neighbours.
- The IDL curves 8 times from the normal 180° meridian at *Bering strait*, Fiji, Tonga and other islands to prevent confusion of day and date. Some of them keep Asiatic or New Zealand standard time, others follow the American date and time.



International Date Line

Daylight Saving Time (DST)

In summer time in several countries, there is a practice of advancing clocks, so that, evenings have more daylight and mornings have less. Typically, clocks are adjusted forward 1 hour near the start of spring and are adjusted backward in autumn.

Although, an early goal of DST was to reduce evening usage of incandescent lighting, formerly a primary use of electricity, modern heating and cooling usage patterns differ greatly.

Daylight Saving Time begins in the Northern hemisphere between March-April and ends between September-November. Daylight Saving Time begins in the Southern hemisphere between September-November and ends between March-April.

The Earth and the Moon

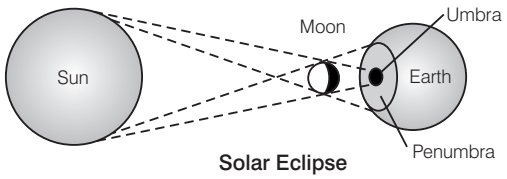
- The Moon has size about 27% of the Earth. Its diameter is about 3474 km in comparison to Earth's 12742 km. The surface area of Moon is 37.9 million km^2 and that is about only 7.4% of Earth and less than Asia. The volume of Moon is only 2% of Earth's volume and mass of the Moon is only 1.2% of the mass of the Earth.
- The Moon orbits the Earth in an elliptical path and the closest position of Moon to Earth is called **perigee** and the farthest distance is called the **apogee**. Its average distance from the Earth is about 3.844×10^5 km or 0.00243 AU.
- Highest point on the Moon's surface is **Mount Leibnitz** (35000 ft) situated on the South pole of the Moon. Moon's orbital velocity is about 3680.5 km/h or 1.02 km/sec. Its orbital eccentricity is about 0.0554 and orbital inclination is about 5.16°. Its density is about 3.344 g/cm^3 (about 0.607 of Earth) and surface gravity is about $\frac{1}{8}$th of Earth, so has lower escape velocity of about 2.376 km/sec (about 0.2% of Earth).
- Moon's sideral rotation period is synchronous with its orbital period and about 27.322 Earth days, so observers on Earth only see one side of the Moon.

Phases of the Moon

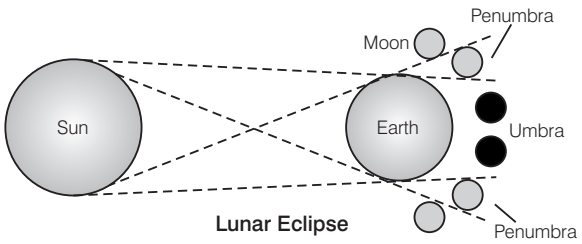
- The changing angles between Earth, the Sun and the Moon determine how much of the Moon's illuminated surface can be seen from Earth and cause the phases of the Moon. As the Moon orbits the Sun and we see different amounts of its sunlit side, its shape seems to change, which is called **phases of the Moon**.
- Phases of Moon starts from the New Moon every month when Moon does not look at all because the complete dark past of the Moon faces the Earth. Then only a small part of the Moon is seen bright which is called (recent and it gradually becomes half Moon when half of the Moon lit, then when the increasing brighter portion match upto 3/4th of the Moon it is called *Gibbous* and then it converted to full Moon.)
- After Full Moon or the complete brightness, the Moon lit starts receeding through the stages of gibbous, half Moon, Crescent and finally becomes invisible as new Moon.
- Nearly, 59% of the Moon's surface permanently seen from the Earth as its rotational period is synchronous with its orbital period. Such surface is called the near side of the Moon whereas other 41% are called the far side of the Moon. Moon's apparent size in our sky varies by 13% as its distance from Earth varies.

Eclipse

- An eclipse is a complete or partial obscuration of light from a celestial body as it passes through the shadow of another celestial body.



Solar Eclipse



Lunar Eclipse

- **Solar eclipse** occurs near the New Moon position, when the Moon is between the Sun and Earth, thus, obscuring a part of whole of the Sun as viewed from the Earth.
- **Lunar eclipse** occurs near the Full Moon position, when the Earth is between the Sun and the Moon and Earth's shadow obscure the Moon as viewed from the Earth.
- Moon's orbital plane inclined 5° to the orbital plane of the Earth, so eclipses do not occur every Full Moon or New Moon positions.
- **Syzygy** is the position of alignment when Earth comes in between Sun and Moon on a straight line; in such position, lunar eclipse occurs and conjunction is the position when Sun and Moon lie on one side of the Earth and then solar eclipse occurs.
- The portion of the Sun or Moon covered by the vertical shadow of any celestial body like Earth or Moon is called **Umbra** and it is deep dark whereas the faint shadow region is called **Penumbra**.
- During a total eclipse, as the Moon's shadow is short enough to cover the whole of the Sun then the outer region of the Sun still glow and looks bright as a ring as observed from the Earth. Such phenomena is called **diamond ring**.
- Unlike a solar eclipse, which can only be viewed from a certain relatively small area of the world, a lunar eclipse may be viewed from anywhere on the night side of the Earth.
- A lunar eclipse lasts for a few hours, whereas a total solar eclipse lasts for only a few minutes at any given place, due to the smaller size of the Moon's shadow.
- Lunar eclipses are more frequent than solar eclipses.

The Earth's Magnetic Field

- The Earth has a substantial magnetic field quite similar to a simple bar magnet. The axis of the magnetic field is tipped with respect to the rotation axis of the Earth. The axis of Earth's magnet and the geographical axis do not coincide. The axis of the Earth's magnetic field is inclined at an angle of about $11\frac{1^\circ}{2}$ with the geographical axis.

  Thus, true North (defined by the direction to the North rotational pole) does not coincide with magnetic North (defined by the direction to the North magnetic pole).
- The South pole of the Earth's magnet is in the geographical North because it attracts the North pole of the suspended magnet and *vice-versa*. Thus, there is a magnetic S-pole near the geographical North and a magnetic N-pole near the geographical South. The positions of the Earth's magnetic poles are not well defined on the globe; they are spread over an area. The magnetic field is strongest near the magnetic poles and is weakest near the equator.
- The magnetic poles of the Earth are defined as the location of the strongest vertical magnetic field. This places the magnetic North pole just West of Northern Greenland (about N80° W70°) and the magnetic South pole near the coast of Antarctica South of Australia (about S75° E150°). The magnetic equator does not circle the Earth as a smooth line like the geographic equator, but instead it meanders North and South.
- The magnetic field lines usually dip towards or come out of the Earth's surface at some angle. This angle is called the **magnetic inclination** or the **magnetic dip** at that place. At the magnetic poles, the angle of dip is 90°.
- The line on the Earth's surface passing through the places having angle of dip 0° is called the **magnetic equator**, it passes through Thumba in South India, where the space research centre is located.

Origin of the Magnetic Field

- Magnetic fields are produced by the motion of electrical charges. The origin of the Earth's magnetic field is not completely understood, but is thought to be associated with electrical currents produced by the coupling of convective effects and rotation in the spinning liquid

metallic outer core of iron and nickel. This mechanism is termed the dynamo effect, but it is not constant in direction.

- Rocks that are formed from the molten state contain indicators of the magnetic field at the time of their solidification.
- The study of such 'magnetic fossils' indicates that the Earth's magnetic field reverses itself every million years or so the North and South magnetic poles switch.

The Earth's Magnetosphere

- The solar wind is a stream of ionised gases that blows outward from the Sun at about 400 km/sec and that varies in intensity with the amount of surface activity on the Sun. The Earth's magnetic field shields it from much of the solar wind. When the solar wind encounters Earth's magnetic field, it is deflected like water around the bow of a ship.
- The imaginary surface at which the solar wind is first deflected is called the **bow shock**. The corresponding region of space lying behind the bow shock and surrounding the Earth is termed the magnetosphere. It represents a region of space dominated by the Earth's magnetic field in the sense that it largely prevents the solar wind from entering. However, some high energy charged particles from the solar wind leak into the magnetosphere and are the source of the charged particles trapped in the Van Allen belts.

Van Allen Radiation Belts

- A fundamental property of magnetic fields is that they exert forces on moving electrical charges. Thus, a magnetic field can trap charged particles such as electrons and protons as they are forced to execute a spiraling motion back and forth along the field lines. It was discovery in the late 1950s that the Earth is surrounded by two regions of particularly high concentration of charged particles called the ***Van Allen Radiation belts***.
- The radiation belt has inner and outer belts. The primary source of these charged particles is the stream of particles emanating from the Sun known as solar wind. The charged particles trapped in the Earth's magnetic field are responsible for the Aurora (Northern and Southern lights).
- The belts are extending from 650 km to 65000 km above the Earth. The inner belt is mainly protons with some electrons whereas a outer one mainly has electrons. A part of a belt dips into the upper region of the atmosphere over the South Atlantic to form the Southern Atlantic anomaly. This can present a dangerous hazard to satellites orbiting the Earth.

Self Check

Build Your Confidence

1. Consider the following statements **[IAS 2005]**

1. The axis of the Earth's magnetic field is inclined at 23rd and half to the geographic axis of the Earth.
2. The Earth's magnetic pole in the Northern hemisphere is located on a Peninsula in Northern Canada.
3. Earth's magnetic equator passes through Thumba in South India.

Which of the statement(s) given above is/are correct?

(a) Only 3 *(b)* 2 and 3
(c) Only 2 *(d)* All of these

2. Who amongst the following was the first to state that the Earth was spherical? **[IAS 2005]**

(a) Aristotle *(b)* Copernicus
(c) Ptolemy *(d)* Strabo

3. If the stars are seen to rise perpendicular to the horizon by an observer, he is located on the **[IAS 2001]**

(a) Equator *(b)* Tropic of Cancer
(c) South pole *(d)* North pole

4. Consider the following statements **[IAS 2005]**

1. Total land area of Earth is approximately 1475 lakh km^2.
2. Ratio of land area to water area of Earth is approximately 1:4.
3. Maximum percentage of Earth's water is in the Pacific ocean.

Which of the statement(s) given above is/are correct?

(a) 1 and 3 *(b)* 2 and 3
(c) Only 1 *(d)* Only 3

5. Variations in the length of day time and night time from season to season are due to **[IAS 2013]**

(a) the Earth's rotation on its axis
(b) the Earth's revolution around the Sun in an eliptical manner
(c) latitudinal position of the place
(d) revolution of the Earth on a tilted axis

6. Find the effects of rotation of Earth

1. Formation of day and night.
2. Deflation of ocean currents.
3. Deflation of cyclones in temperate regions.
4. Bulging shape of Earth at equator.

Which of the statement(s) given above is/are correct?

(a) Only 1
(b) 1 and 4
(c) 1, 2 and 4
(d) All of the above

7. Earth's axis is now focusing towards the Polar axis or Pole star. What are the benefits we draw from such celestial phenomena?

1. It helps us finding the direction in our travel route even in vast oceans.
2. It helps us finding our apparent location on the globe.
3. It acts as a counter force to the combined gravitational force of Sun and Moon, so that our atmosphere still exist without escaping away.

Select the correct answer using the codes given below

(a) Only 1 *(b)* 1 and 2
(c) All of these *(d)* None of these

8. Through which one of the following groups of countries, does the equator pass? **[IAS 2006]**

(a) Brazil, Zambia and Malaysia
(b) Colombia, Kenya and Indonesia
(c) Brazil, Sudan and Malaysia
(d) Venezuela, Ethiopia and Indonesia

9. Which of the following statement does not explain the difference between solar eclipse and lunar eclipse?

1. Solar eclipse occur during the New Moon position whereas lunar eclipse occur during Full Moon position.
2. A lunar eclipse lasts for a few hours whereas a total solar eclipse lasts for only a few minutes.
3. Lunar eclipses are less frequent than solar eclipses.
4. Solar eclipse may be viewed from everywhere, but lunar eclipse can be seen from a particular relative place.

Select the correct answer using the codes given below

(a) 1 and 3 *(b)* 2 and 4 *(c)* 3 and 4 *(d)* 1 and 2

10. Consider the following statements

1. Normally, the antipodal places of land surfaces on Earth are water bodies.
2. Sideral day is smaller than the solar day and simultaneously Sideral year also smaller than the Solar year.
3. The precession of the equinoxes is responsible for the difference between the Julian and Gregorian calendars.
4. Earth's climate change may be correlated with the changes in the axial tiltation of Earth.

Which of the statement(s) given above is/are correct?

(a) Only 2 *(b)* 1 and 4 *(c)* 1, 3 and 4 *(d)* All of these

11. Which of the following country decided to change the position of International Dateline for better trading with its neighbours?

(a) Fiji (b) New Zealand
(c) Tonga (d) Samoa

1. (b) **2.** (a) **3.** (a) **4.** (a) **5.** (d) **6.** (d) **7.** (b) **8.** (b) **9.** (c)
10. (c) **11.** (d)

Chapter three
Geomorphology

Geomorphology is a tangle of physics, chemistry, biology and history. It is also geometry, as the geomorphology plays out in a complex geographic. Topographic setting in which both the tectonic and climate processes responsible for driving evolution of the topography change in style and intensity.

Introduction

- Geomorphology may be defined as the scientific study of surface features of the Earth's surface involving interpretative description of landforms, their origin, development, nature and mechanism of geomorphological processes which evolve the landforms. An understanding of geomorphology and its process are essential to the understanding of physical geography.

Evolution of Earth

- The approximate age of the Earth is around 4.578 billion years. The very first logical hypothesis for the origin of the Earth was given by the French scientist, **Caste-de-Buffon** in AD 1749.
- The planet Earth initially was a barren, rocky and hot object with a thin atmosphere of hydrogen and helium and lacks oxygen which emerges markebly after emergences of floral species that make out oxygen through photosynthesis. Gradually, the Earth turns into a beautiful planet with abundance of water and conducive atmosphere suitable for existence of life.
- The Earth has a layered structure from the center to the upper atmosphere. Materials that exist (inside and on the Earth) are not uniform and their density go on decreasing, so the atmosphere has least density and core of the Earth has more density.
- The land portion of Earth is lithosphere, the water portion of Earth is hydrosphere and the air portion of Earth is atmosphere.

Evolution of Life

- It is now assumed that life evolved on Earth around 3800 million years ago and mostly confined to the oceans.
- Microscopic living organisms closely similar to blue green algae have been evolved at first phase.
- Then fishes are developed followed by amphibians, reptiles, flowering plants and at last, mammals and later *homo sapiens* developed.

Geological Time Scale (GTS)

- The GTS is a system of chronological measurement that relates stratigraphy to time and is used by geologists, paleontologists and other Earth scientists to describe the timing and relationships between events that have occurred throughout Earth's history.
- The estimation of the Earth's age, based on the study of radioactive elements, is believed to be the most authentic.
- The geological history of the Earth is divided into several eras. These eras are further divided into epochs, which are sub-divided into periods.

Pre-Palaeozoic Era

- The rocks of this era are completely devoid of fossils.
- Soft-skinned invertebrates originated in the warm seas.
- The land area remained lifeless.