CHAPTER 4 MOVEMENTS OF THE EARTH

Objectives

After studying this chapter, students should be able to:

(i) define the terms rotation and revolution of the earth.

(ii) state and describe the effects of each movement.

(iii) describe some concepts and terms associated with the movements.

4.1 Rotation and Revolution

Often times, man is conscious of the fact that the sun is always in motion. The Earth constantly moves in two ways, namely: (a) Rotation

(b) Revolution

Rotation

This is a movement that occurs when the Earth spins or turns on its axis in a west to east direction. The axis is an imaginary line that runs through the centre of the Earth. This movement occurs once every 24 hours which is called one day. As the Earth rotates from west to east, every part of the Earth is exposed to the sun at a particular time or the other. During rotation, the Earth is inclined at an angle of $23\frac{1}{2}^0$ along the axis.

Revolution

This is a movement where the Earth travels round the sun along its orbit (or elliptical orbit). One complete revolution takes 365¼ days or a year. Specifically, the earth is known to travel at a speed of 30km or 18.5 miles per second or 107,182 kilometres in an hour. During revolution, the earth is tilted or inclined at an angle of $66\frac{1}{2}^0$ to the plane of elliptic.

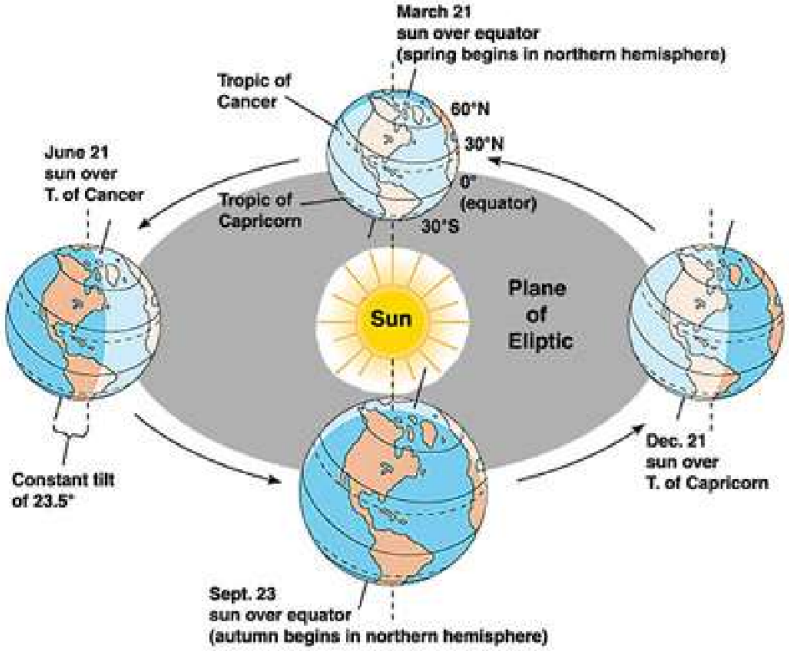


Fig. 4.1: Rotation and Revolution of the Earth

4.2 Effects of Rotation

The rotation of the earth is responsible for the following:

(i) Day and night: This situation occurs as the earth rotates, such that the part that faces the sun receives the rays which is thus regarded as experiencing daylight (day) while the other part not facing the sun will experience darkness (night).

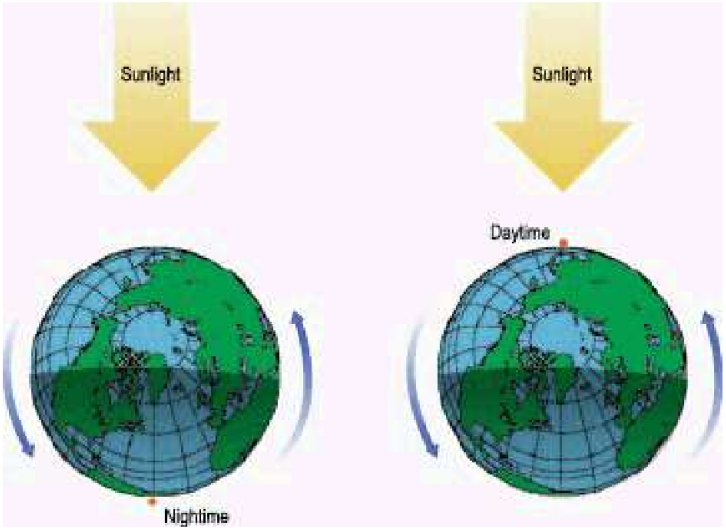


Fig. 4.2: Day and Night

(ii) Sunrise and sunset: Part of the Earth's surface that comes from darkness into the sun's rays experiences sunrise while that which is far from the sun's rays is said to be in sunset.

(iii) Deflection of winds and ocean currents: Owing to the process of the rotation of the Earth, wind and ocean currents are deflected in opposite directions in the northern and southern hemispheres. In the northern hemisphere, winds and ocean currents are deflected to the right while at the southern hemisphere they are deflected to the left. Winds and ocean currents are deflected from their original path as a result of the rotation of the earth. If there was no rotation, prevailing winds and ocean currents would have flown straight with no deflection whatsoever. The principle on which the idea of deflection of winds and ocean currents is based was propounded by a scientist known as Ferrel in the 19th century. The idea is called Ferrel's Law of Deflection. In strict terms, deflection is in a clockwise direction in the northern hemisphere while it is in an anticlockwise direction for an object in the southern hemisphere.

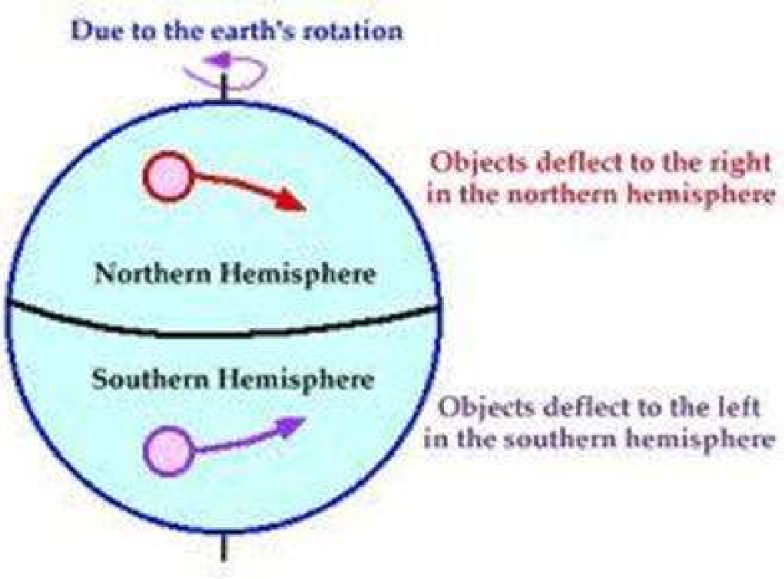


Fig. 4.3: Deflection of winds and ocean currents

(iv) Daily rise and fall of tides: Tides are formed from the rising and falling of ocean water surface. They occur due to the gravitational attraction or pull of the moon on the Earth which causes the rise and fall in the motion of ocean waters. The highest height attained is called HIGH TIDE while the lowest is called LOW TIDE. This phenomenon takes place everyday with two high tides, experienced at an interval of 12 hours 26 minutes. Within the high tides, two low tides occur also at an interval of 12 hours 26 minutes. In essence, the periodic rise and fall in the level of oceans and seas occurs within an interval of 24hours 52minutes which is roughly about a day. This situation is so because of the gravitational attraction or pull of the moon which also revolves round the earth in the same direction taken during the earth's rotation which is from west to east.

(v) Time difference from place to place: Due to rotation, the Earth spins round the sun in 24hours or one day. From this, it follows that for every hour, the Earth rotates exactly 15^0. Hence, there is a difference of 1hour for every 15^0 or 1^0 in 4 minutes. In essence, as the Earth moves from West to

East, it stands to reason that for every 15^0, one move towards the east, the local time is advanced by 1hour. On the other hand, moving westwards means that an hour is lost for every 15^0. The principle of local time is based on this reasoning.

Revolution

This is the movement of the Earth around the sun on its elliptical orbit. While the earth moves round the sun, the moon moves round the Earth. This occurs once in approximately 365¼ days that is, one year. During the process of revolution, the Earth's axis is inclined at an angle of $66\frac{1}{2}^0$ to the orbital plane. This affects the amount of sun's rays that is received at any part of the Earth. Much is received at the Equator while less is received as one move from the Equator.

4.3 Effects of the Earth's Revolution

1. **Length of the year:** A complete revolution of the earth around the sun takes exactly 365¼ days. In order to allow for accuracy in the compilation of the calendar, a year is taken as 365 days while the ¼ days is compensated for in every 4 years, where there is an additional day known as the LEAP DAY (February 29) in a leap year. For easy remembrance, on every leap year, there is an OLYMPIAD which is a festival of games and sports for which several nations of the world compete for laurels, the recent of which was held in London in 2012.
2. **The Seasons:** The revolution determines the seasons all over the world. Along the tropics, there are only two seasons, wet and dry season. This is simply because in the tropics, the sun is always overhead which explains why there is high temperature. The season is demarcated from each other by rainfall. During wet season rainfall is abundant, while during dry season there is a marked absence of rainfall. In the temperate belt, there are four marked seasons, caused by differential phases of temperature. The four seasons are summer, autumn, winter and spring. The seasons are very distinguished and unique. They follow themselves in a unique order. Winter leads to spring and after the spring comes the summer and then the autumn.

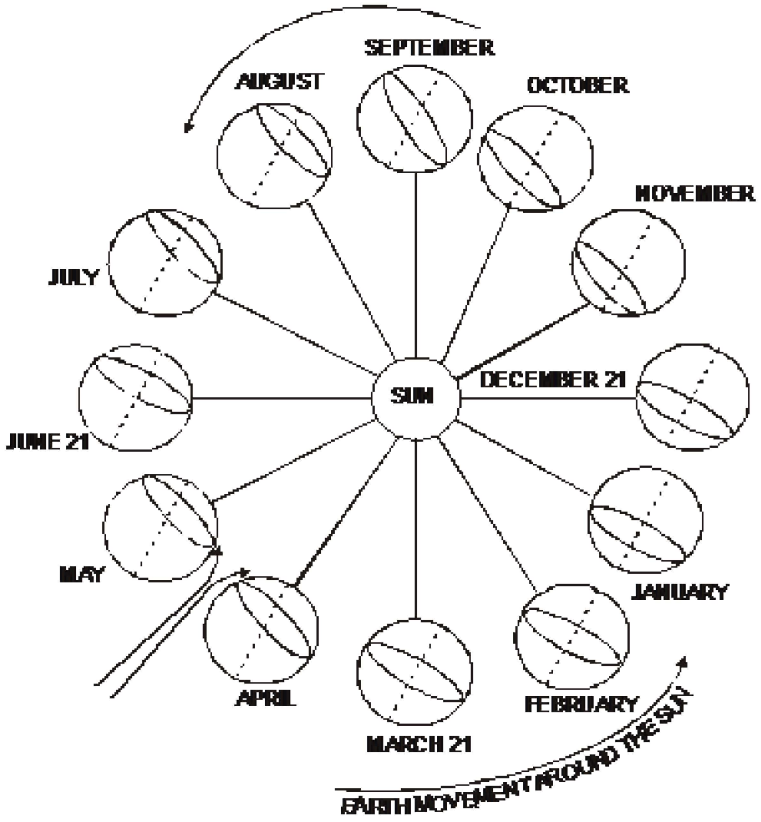


Fig. 4.4: The Seasons

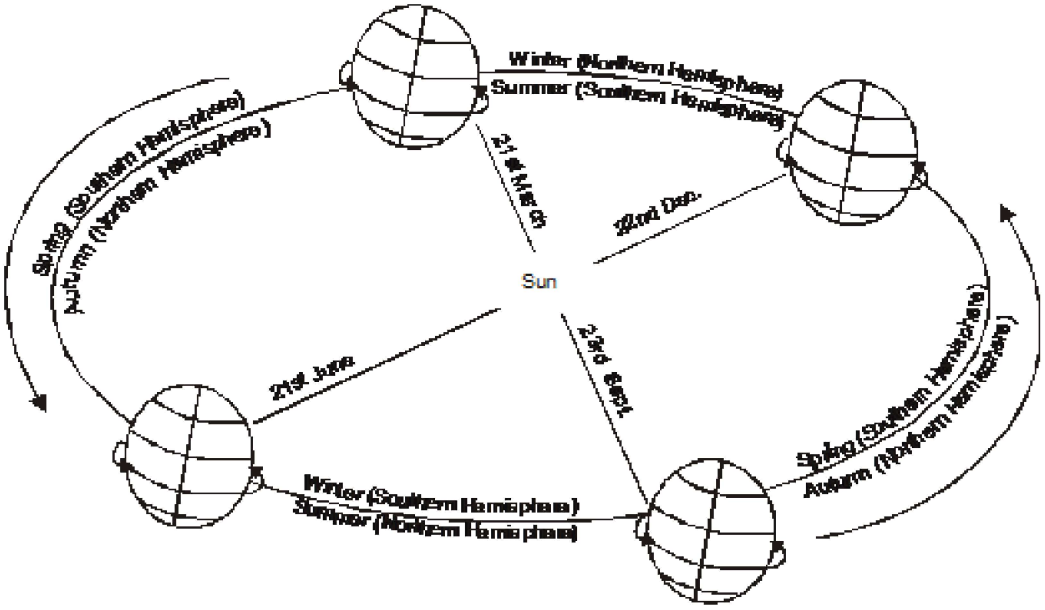
The periods of these seasons are different in the two hemispheres. For instance, in the northern hemisphere, summer is a period of three months during which the sun is located farthest into the hemisphere while winter is that period (three months) during which the sun is located far away from the hemisphere. During summer, temperatures are high while it is low during winter. June 21st is the height of summer in the northern hemisphere because the sun is located far away into the hemisphere on the Tropic of Cancer. Hence summer in this hemisphere falls into the months of June, July and August. At the same time December 21st is the height of winter season in the northern hemisphere because the sun is

located far away in the hemisphere. Thus, winter extends over the months of December, January and February.

In the southern hemisphere, opposite conditions prevail. The summer occurs in December, January and February while June, July and August are the winter months. Autumn also called Falls comes up three months that follows the summer while winter comes up on June, July and August in the southern hemisphere. The spring occurs in the three months which follow the winter (September, October and November). In this respect, autumn comes up in September, October and November in the northern hemisphere while these same months constitute the spring months in the southern hemisphere.

3. **Varying length of days and nights at different times of the year: Due to the fact that the earth's axis is inclined permanently at an angle of $66\frac{1}{2}^0$ to the plane of its orbit, the two hemispheres (the northern and southern hemispheres) are facing the sun more directly at different times of the year. During revolution, the earth is at four different positions. On 21st June, the inclination of the earth's axis brings the northern hemisphere to face the sun more directly than the southern hemisphere. As a matter of fact, the sun is overhead at mid-day on that day at the Tropic of Cancer ($23\frac{1}{2}^0$N).**

This creates a phenomenon called circle of illumination. By this, it is meant that all areas north of the Arctic Circle ($66\frac{1}{2}^0$N) experience a 24-hour daylight. These areas, in fact, enjoy six months of perpetual light and are often called the land of the midnight sun. This means that the sun does not rise or set, it simply goes round while remaining in the sky. From the 24-hour day at the North Pole, day length decreases southwards until at the Antarctic circle (Lat 66 $\frac{1}{2}^0$S), it is zero. Hence, all areas between it and South Pole are in perpetual darkness for six months



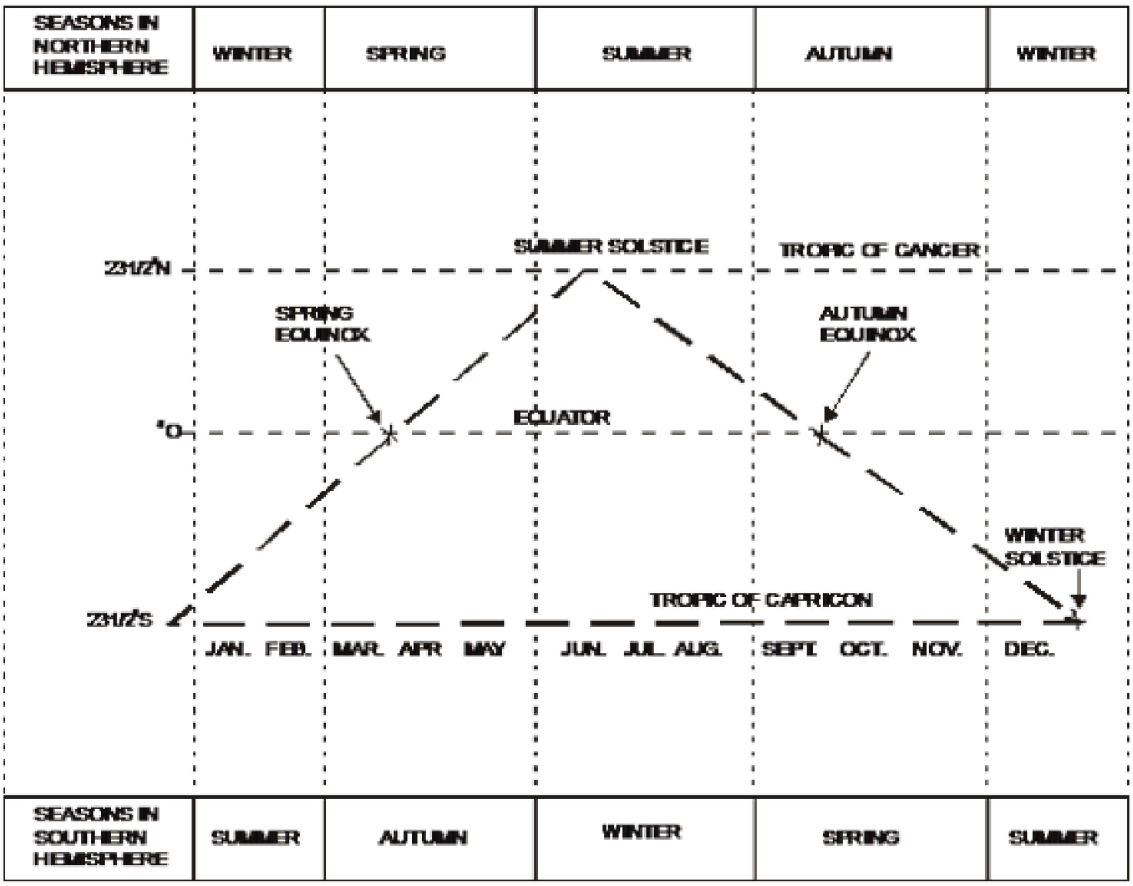


Fig. 4.5: Varying Length of Days and Nights

However, the reverse is the case on December 22 in the Southern hemisphere when the sun is located on the Tropic of Capricorn (23½^{0}S) and the circle of illumination is created such that all areas south of the Antarctic Circle experience a 24-hour daylight. Indeed al these areas enjoy perceptual daylight for six months. The sun does not set, it simply goes round and round while remaining low in the sky.

From the South Pole, the length of the day decreases northwards until at the Arctic Circle where it is zero and as a result, all areas between the Arctic Circle and the North Pole are in perpetual darkness.

4. Changes in the altitude of the mid-day sun at different times of the year: The inclination of the Earth's axis at 66½^0 to the plane of the ecliptic affects and changes the apparent altitude of the mid-day sun. It should be noted that the sun is vertically overhead at the Equator on two days each year. These are usually 21 March and 21 September even though the date changes because a year is not exactly 365 days. These two days are called *EQUINOXES*, that is equal nights, because on these two days, all parts of the world experience equal days and nights. March 21st is called *VERNAL* or *SPRING EQUINOX* while 23rd September is called *AUTUMN EQUINOX*. After the March equinox, the sun appears to move northwards and as such is vertically overhead at the Tropic of Cancer (23½^{0}N) on 21st June. This is known as *SUMMER SOLSTICE* when the northern hemisphere will have its longest day and shortest night. By December 22, the sun will be overhead at the Tropic of Capricorn (23½^{0}S). This is called the *WINTER SOLSTICE* when the southern hemisphere will have its longest day and shortest night. It should also be noted the tropics mark the limits of the overhead sun, beyond these, the sun is never overhead at any time of the year.

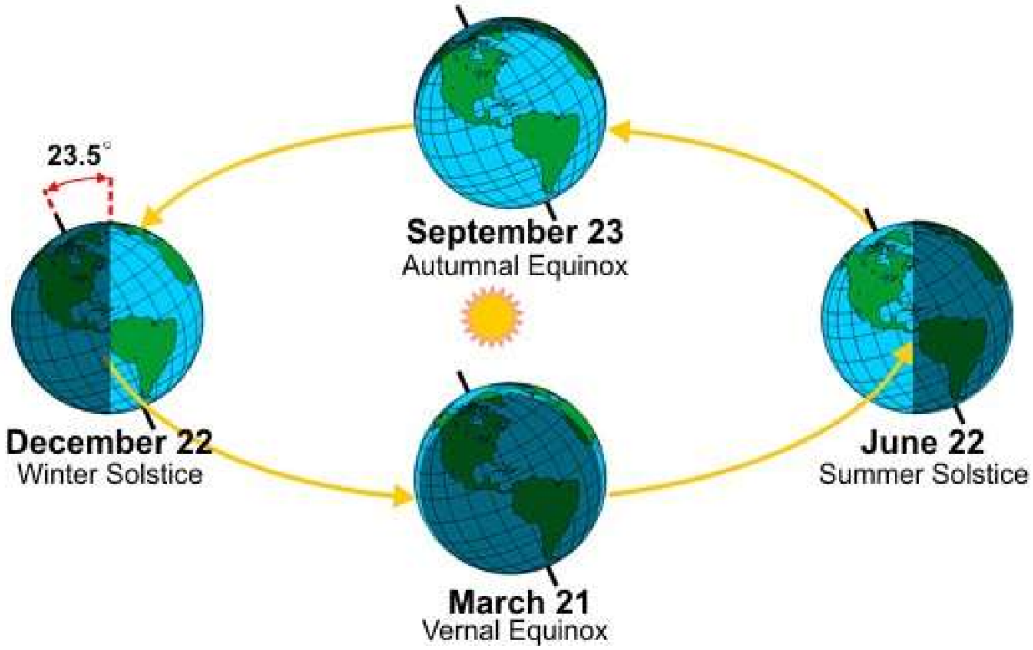


Fig. 4.6: Changing Altitude of the Midday Sun

Important Concepts Associated with the Movements of the Earth

1. Equinox: This means equal day and night. This phenomenon will have occurred all over the world throughout the year if the Earth's axis were perpendicular or overhead to the plane of its orbit. However, in reality this is not so. On the contrary, the earth's axis is inclined or tilted away at an angle of $66\frac{1}{2}^0$. Hence for most places all over the earth, there is usually variation in the length of days and nights. All over the world, there are only two days when places all over the earth experience equal length of day and night. They are March 21st which is called ***SPRING*** or ***VERNAL EQUINOX*** and September 23rd which is known as ***AUTUMN EQUINOX***. On these two days, the sun is directly overhead or perpendicular at an angle of 90^0 at the Equator at 12 noon.

2. Solstice: This is a time of the year (in summer and winter) when the sun reaches its maximum tilt from the Equator. Also, there are two of such days in a year: the winter solstice and the summer solstice. In the northern hemisphere, the summer solstice comes up around June 21st. This day, the mid-day sun is directly overhead at the Tropic of Cancer ($23\frac{1}{2}^0$N). The winter solstice occurs around December 22nd when the mid-day sun is directly overhead at the Tropic of Capricorn in the southern hemisphere. A solstice is a period or day when there is a longer day and shorter night.

3. Twilight and Dawn: A twilight is the brief period between sunset and the complete darkness of night. It is also known as ***Dusk***. The twilight is a state of partial darkness. The dawn is the brief period between sunrise and the full brightness of daytime and can be regarded as partial daylight. During these two periods (i.e. dawn and twilight), the earth receives diffused or refracted light from the sun while it is trying to appear or disappear in the horizon.

The period of twilight and dawn varies from places over the earth. Along the equator, the period is brief simply because the sun moves rapidly in an overhead or perpendicular angle after sunrise and also disappears rapidly after sunset. Since the sun rises and sets in the Equator in a vertical path, the period of twilight and dawn is rather short. However, this is not the case elsewhere especially in temperate (cold) regions where refracted rays received are much longer because the sun sets and rises in an oblique path. Twilight and dawn are rather prolonged and they take more time in polar regions since reflected rays from the sun takes a long time in duration.

4. Eclipses: These are shadows cast when three bodies – sun, earth and moon – are in straight line during the movement of the Earth such that rays from the sun is obscured from reaching either the moon or the Earth. The shadows are often cast on the Earth or the moon as the case may be. Eclipses are caused by blockage of sun's rays on the Earth. There are two types of eclipses: eclipse of the moon (lunar eclipse) and eclipse of the sun. Eclipse of the moon occurs when the earth comes in between the moon and the sun. Since the Earth is longer then the moon, it is capable of obstructing or blocking the rays and bigger so doing cast a showdown on the moon. This eclipse can lead to full darkness of the moon which is described as total or annular type of darkness. The shadows cast often result in darkness which lasts for some minutes.

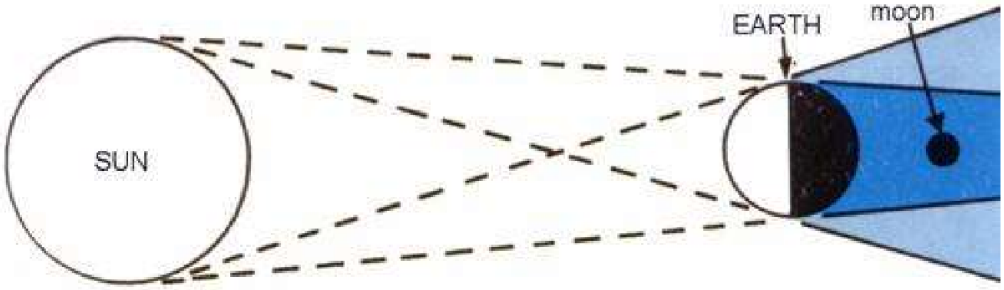


Fig. 4.7: Eclipse of the Moon

Eclipse of the sun or solar eclipse occurs when the moon comes in between the sun and the earth. In view of the fact that the sun, moon and earth are on a straight line and the moon is capable of blocking or obstructing the light from the sun. The moon then casts its shadow of darkness on the Earth. This is known as eclipse of the sun.

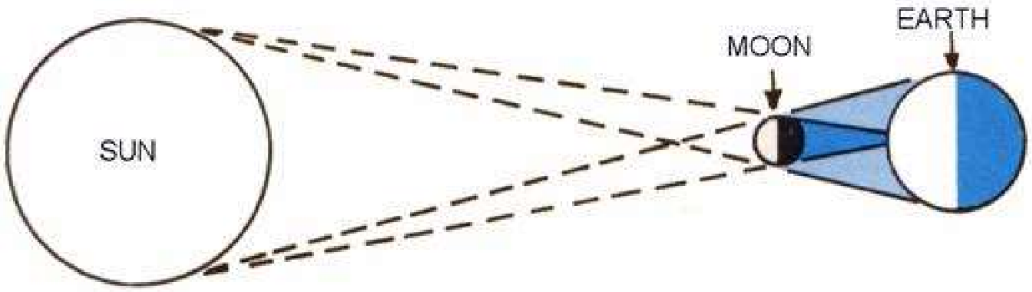


Fig. 4.8: Eclipse of the Sun

Eclipse can be total or partial depending on the amount or degree of obstruction. It is total where the moon or earth is completely covered or shielded from the sun. It is partial where the Earth or moon is half covered or shaded from the sun. Partial eclipse of the moon is a proof of the earth's spherical shape.

Fig. 4.9: Types of Eclipse

Eclipse can be described as annular if the body (that is, either the Earth or moon) is covered at centre with darkness while the other part is not.

Summary

- The Earth is always moving and the movements are rotation and revolution.
- The rotation of the Earth involves the Earth moving or spinning on its axis and the effects are: day and night, sunrise and sunset, daily rise and fall of tides, deflection of winds and objects and difference of 1hour between locations that are 15^0 apart.
- The revolution of the earth is the movement of the earth around the sun on its elliptical orbit. Its effects include: length of the year, changing altitude of the mid-day sun, varying length of days and nights and the seasons.
- There are periods when there are equal days and nights. This is known as equinox and there are two types: vernal or spring equinox and autumn equinox.
- There are also periods when there are longer days and shorter nights and are called solstices and there are two types: winter solstice and summer solstices.
- Equinox is a period when there are equal days and equal night. It occurs on March 21st and September 23rd.
- Solstice is a period where there are longer days and shorter nights and it occurs on June 21st and December 22nd.
- Eclipse are shadows cast when the sun, Earth and moon are in straight lines due to the blocking of sun's rays.
- Twilight is the period between sunset and night time.
- Dawn is the period between sunrise and day or daybreak.

Revision Questions

Objective Questions

1. The rotation of the Earth on its axis is
   A. faster in winter.
   B. faster in summer.
   C. from west to east.
   D. from east to west.
2. Each revolution of the Earth around the sun takes
   A. 24 hours.
   B. 365 days.
   C. one leap year.
   D. 365¼ days.
3. Which of the following phenomena is due entirely to the Earth rotating on its axis?

   A. The rising and setting of the sun B. The different angles of the sun's rays throughout the year C. The seasonal differences and changes D. The eclipse of the sun 4. The revolution of the Earth around the sun gives rise to A. different seasons.

   B. day and night.
   C. the earth's tilt on its axis.
   D. half of the earth being in darkness.

5. The tilt of the Earth's axis from the vertical is A. $23½^0$.

   B. $66½^0$.

   C. 90^0.

D. 156½^0.

6. On June 21st the sun is overhead at

A. the Equator.

B. the Tropic of Capricorn.

C. the North Pole.

D. the Tropic of Cancer.

7. The overhead sun is to be seen at the Tropic of Capricorn on A. March 21st

B. July 19th

C. August 17th

D. December 22nd

8. In the Northern hemisphere, the summer solstice occurs in A. June

B. July

C. September

D. December

9. Twilight is the period between

A. sunset and sunrise.

B. the setting of the sun and the rising of the moon.

C. the rising of the sun and daybreak.

D. daylight and midnight.

10. Mid-winters day in the northern hemisphere is A. December 21st.

B. March 21st.

C. September 21st.

D. June 21st.

Answers

1. C 2. D 3. A 4. A 5. A 6. D 7. D 8. A 9. D 10. A

Essay Questions

1a. Give two differences between rotation and revolution of the Earth.

b. Describe three effects of the rotation of the Earth.

2a. Using relevant diagrams, show the difference between (i) day and night (ii) twilight and sunrise b. Describe any two effects of the revolution of the Earth.

3a. Give two similarities between rotation and revolution of the Earth.

b. With the aid of a suitable diagram, describe the eclipse of the moon.

4a. Give two reasons why all areas north of Arctic Circle have 24hours of daylight on June 21st.

b. Give two reasons why summers are usually warm and bright while winters are cold and dark in the Arctic region.

5a. Using relevant diagrams, describe the four major positions of the earth during its revolution around the sun.

b. Suggest three effects of the revolution of the Earth.