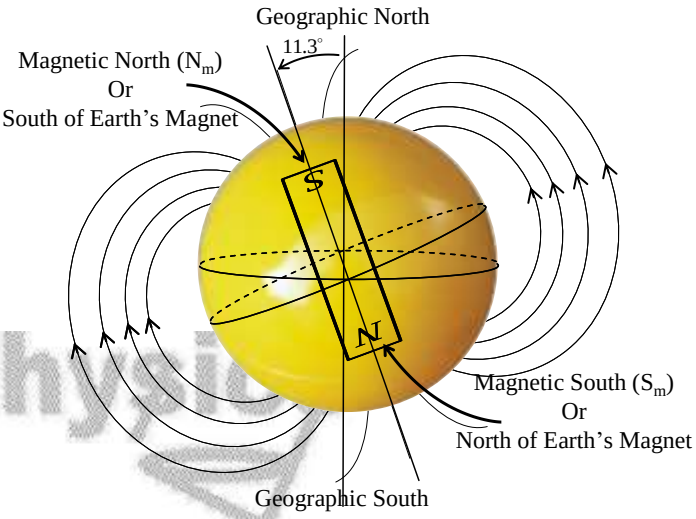
8. Earth's Magnetic Field

1.Earth's magnetic field:

▶ A weak magnetic field is found near the earth's surface whose value is of the order of 10^{-5}T[2]. The field pattern or magnetic field lines of the earth resembles that of a magnetic dipole embedded deep inside the earth with north pole of the magnet near the south geographic pole and south pole of the magnet near the north geographic pole. A freely suspended bar magnet aligns itself south – north, the north pole of the bar magnet pointing geographic north.

The pole of the earth's magnet near geographic north is called north magnetic pole (N_m) and that near the geographic south is called south magnetic pole (S_m).



2.Location of the Earth's magnetic poles?

▶ Magnetic and geographic meridians (axes) of Earth don't coincide. The magnetic meridian makes an angle approximately 11.3° with the geographical axis (westwards). Thus the poles of the geographical north and south and earth's magnetic north and south are not coinciding but are located at different points.

North Magnetic Pole is located at: latitude: 79.74° N and longitude 71.8°W (north Canada). South Magnetic Pole is located at: 79.74°S and 108.22°E in the Antarctica. Hence both the magnetic poles are diametrically opposite.[3]

3.Magnetic Declination and Dip?

▶ For any point on the surface of the earth the angle between earth's magnetic meridian and the geographic meridian is called *declination* at that point, denoted by θ or D. The compass needle orients itself in the plane of the magnetic meridian hence gives the exact declination.

Declination depends upon the latitude. At higher latitude it is greater and at the lower latitude it is lower. At the equator the declination is smaller.

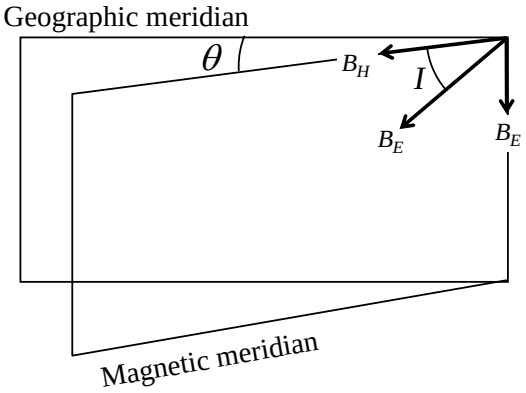
In India declination at Mumbai 58′ and at Delhi it is 41′ only. Thus at these two places magnetic compass almost points exactly towards north.

Magnetic field is not horizontal at every point on the surface of the earth. It points above the horizontal line in the southern hemisphere while below the horizontal in the northern hemisphere. The angle made by the earth's magnetic field B with horizontal line is called the angle of inclination or dip, I or δ.

If the intensity of magnetic field of earth at a place is B_E then its horizontal component is $B_H = B_E \cos I$ and vertical component is $B_V = B_E \sin I$. Therfeore $\tan I = B_V/B_H$.

[2] 0.25G to 0.65G

[3] South and North magnetic poles of the earth are the names of the real North and South poles of a bar magnet respectively. Hence the field lines terminate at the North magnetic pole of the earth while they emanate from the South magnetic pole of the earth.



4.Elements of earth's magnetic field?

▶ Earth's magnetic field has three elements: **Declination, Inclination or Dip and Horizontal component** (B_H) of the earth's magnetic field.

? How will the angle of dip vary when one goes from a place, where the acceleration due to gravity is maximum to a place where it is minimum, on the earth?

? At a place horizontal component of the earth's magnetic field is B and angle of dip at the place is 60°. What is the value of horizontal component of the earth's magnetic field? (i) at Equator; (ii) at a place where dip angle is 30°.

? A long straight horizontal table carries a current of 2.5 A in the direction 100 south of west to 10° north of east. The magnetic meridian of the place happens to be 10° west of the geographic meridian. The earth's magnetic field at the locations 0.33G and the angle of dip is zero. Ignoring the thickness of the cable, locate the line of neutral points.

? The horizontal component of earth's magnetic field is 0.2 G and total magnetic field is 0.4 G. Find the angle of Dip.1

Ans: $\cos\theta = 0.2/0.4 = ½$. Therefore $\theta = 60°$.

? What is the origin of earth's magnetic field? Or, what is *dynamo effect*?

Ans: The origin of the earth's magnetic field is not fully known. But the most accepted reason up to now is the **dynamo-effect**. According to this, the core of the earth is very hot and molten. Circulating ions in the highly conducting region of the earth's molten core could form current loops and produce magnetic field. What is the precise mode of action and energy which sustains such circulating current is not known.

The origin of the earth's magnetic field may be the contributed by more than one factors, but the dynamo effect is certainly one of them because this theory is supported by the following facts:

(i) that moon has no magnetic field because moon has no molten core.

(ii) that Venus has a weaker magnetic field because of the slower rate of rotation. **(iii)** that Jupiter has a greater magnetic field because of the faster rate of rotation.

? How earth's magnetic field changes globally?

Ans: The earth's magnetic field at the surface of the earth is approximately 3.6×10^{-5}T or 0.36 G. The earth appears as a dipole of dipole moment $\cong 8.0\times10^{22}$Am^2. The earth's magnetic field falls below 10^{-6}T above 30,000 km. Beyond this height the *solar wind* which consists of streams of charged particles emerging out continuously from the Sun disturbs the dipole pattern of the earth's magnetic field.
