Earth's magnetic field and magnetic elements.

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 05
CHAPTER NAME : MAGNETISM AND MATTER

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Terrestrial Magnetism:

i) Geographic Axis is a straight line passing through the geographical poles of the earth. It is the axis of rotation of the earth. It is also known as polar axis.

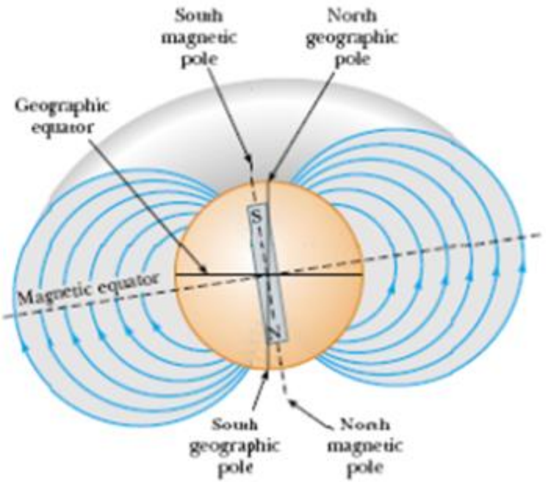
ii) Geographic Meridian at any place is a vertical plane passing through the geographic north and south poles of the earth.

iii) Geographic Equator is a great circle on the surface of the earth, in a plane perpendicular to the geographic axis. All the points on the geographic equator are at equal distances from the geographic poles.

iv) Magnetic Axis is a straight line passing through the magnetic poles of the earth. It is inclined to Geographic Axis nearly at an angle of 11.3°.

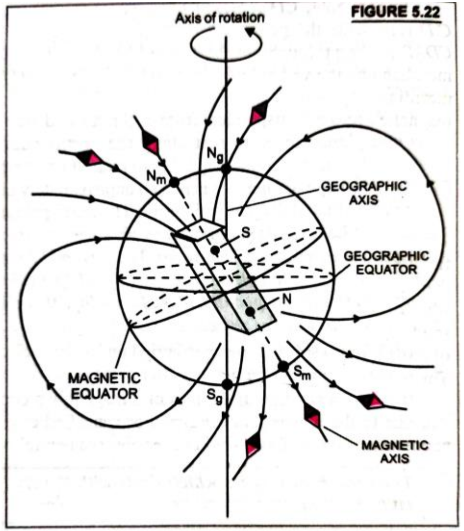
v) Magnetic Meridian at any place is a vertical plane passing through the magnetic north and south poles of the earth.

vi) Magnetic Equator is a great circle on the surface of the earth, in a plane perpendicular to the magnetic axis. All the points on the magnetic equator are at equal distances from the magnetic poles.



Earth's magnetic field

- The magnetic field of the earth is now thought to arise due to electrical currents produced by the convective motion of metallic fluids (consisting mostly of molten iron and nickel) in the outer core of the earth.
- The magnetic field lines of the earth resemble that of a (hypothetical) magnetic dipole located at the centre of the earth. The axis of the dipole does not coincide with the axis of rotation of the earth but is presently titled by approximately 11.3º with respect to the later.
- If one looks at the magnetic field lines of the earth, one sees that unlike in the case of a bar magnet, the field lines go into the earth at the north magnetic pole (Nm) and come out from the south magnetic pole (Sm).
- A magnetic needle, which is free to swing horizontally, would then lie in the magnetic meridian and the north pole of the needle would point towards the magnetic north pole.



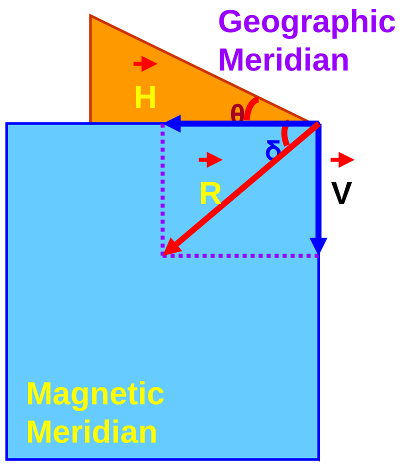
MAGNETIC ELEMENTS

To describe the magnetic field of the earth at a point on its surface, we need to specify three quantities, viz., **the declination D**, the **angle of dip or the inclination I** and the **horizontal component of the earth's field H**. These are known as the element of the earth's magnetic field.

Declination (θ):

The angle between the magnetic meridian and the geographic meridian at a place is Declination at that place.

It varies from place to place.



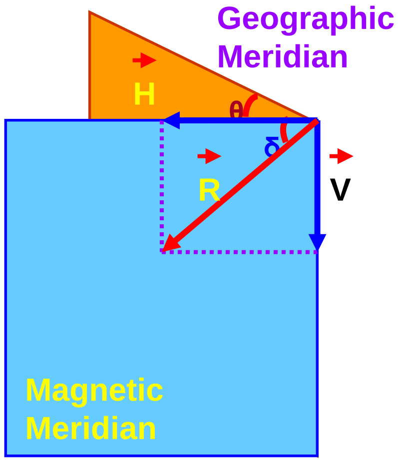
Dip or Inclination (δ):

The angle between the horizontal component of earth’s magnetic field and the earth’s resultant magnetic field at a place is Dip or Inclination at that place.

It is zero at the equator and 90° at the poles.

Horizontal Component of Earth's Magnetic Field (B_H):

The total intensity of the earth's magnetic field does not lie in any horizontal plane. Instead, it lies along the direction at an angle of dip (δ) to the horizontal. The component of the earth's magnetic field along the horizontal at an angle δ is called Horizontal Component of Earth's Magnetic Field.



$$H = R \cos \delta$$

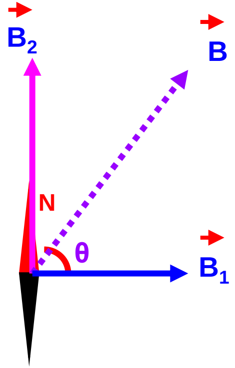
Similarly Vertical Component is $V = R \sin \delta$

such that $R = \sqrt{H^2 + V^2}$

Tangent Law:

If a magnetic needle is suspended in a region where two uniform magnetic fields are perpendicular to each other, the needle will align itself along the direction of the resultant field of the two fields at an angle θ such that the tangent of the angle is the ratio of the two fields.

$$\boxed{\tan \theta = B_2 / B_1}$$



Horizontal Component of Earth's Magnetic Field (B_H):

More about angle of dip δ

(*i*) At a place **on the magnetic poles**, total earth's magnetic field is perpendicular to the surface of earth *i.e.* vertical.

$\therefore \quad R = V \qquad$ As $V = R \sin \delta \qquad \therefore \quad \sin \delta = 1 \; ; \; \delta = 90^\circ$

As $\quad H = R \cos \delta = R \cos 90^\circ = 0$ therefore, *at magnetic poles*, $\delta = 90^\circ$ and $H = 0$

i.e., earth always has a horizontal component except at magnetic poles. A freely suspended magnet at poles will stand vertical with its north pole pointing towards earth's geographical north pole (which is magnetic south), and vice-versa.

(*ii*) At a place **on the equator,** total earth's magnetic field is parallel to the surface of earth *i.e.* horizontal.

$\therefore \quad R = H$

As $\quad H = R \cos \delta \qquad \therefore \qquad \cos \delta = 1 \; ; \; \delta = 0^\circ$

As $\quad V = R \sin \delta = R \sin 0^\circ = 0$. Therefore, at the equator, $\delta = 0^\circ$ and $V = 0$

i.e., earth always has a vertical component except at equator. A freely suspended magnet at equator will stand horizontal.

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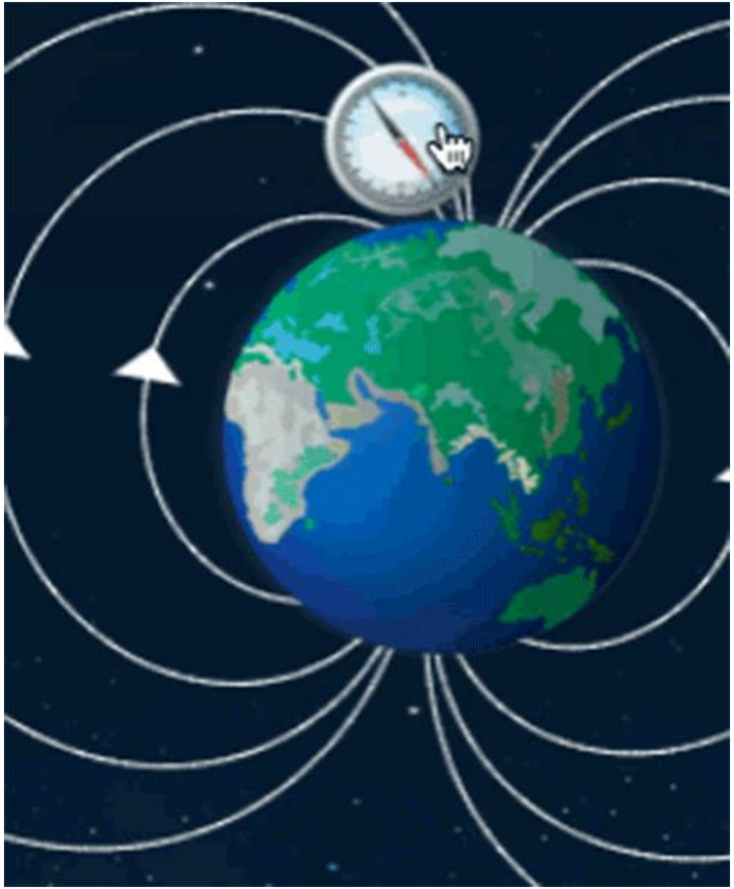
Horizontal Component of Earth's Magnetic Field (B_H):



Numerical

Question: At a place, the horizontal component of earth's magnetic field is B and the angle of dip is 60^0. What is the value of horizontal component of the earth's magnetic field at equator?

Numerical

Question: The horizontal component of earth's magnetic field at a place is B and the angle of dip is 60^0. What is the value of vertical component of the earth's magnetic field?

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Numerical

Question: A magnetic needle free to rotate in a vertical plane orients itself vertically at a certain place on the earth. What are the values of

a) Horizontal component of the earth’s magnetic field and
b) Angle of dip at this place?

MCQ type

1. Angle of dip is the angle between

(a) magnetic meridian and geographic meridian
(b) magnetic axis and geographic axis
(c) earth's total magnetic field and its horizontal component
(d) earth's total magnetic field and its vertical component

2. A compass needle which is allowed to move in a Horizontal plane is taken to a geomagnetic pole. It will

(a) become rigid showing no movement
(b) stay in any position
(c) stay in north- south direction only
(d) stay in east - west direction only

3. If the Horizontal and vertical components of earth's magnetic field are equal, then the angle of dip is

(a) 60^0
(b) 45^0
(c) 90^0
(d) 0^0

MCQ type

Assertion (A): The magnetic poles of earth do not coincide with geographic poles.
Reason (R): The discrepancy between the orientation of a compass and true north-south direction is known as magnetic declination

Assertion (A): The vertical component of earth ‘s magnetic field exists everywhere except at magnetic equator
Reason (R): The angle of dip is zero at the equator and 90° at the poles.

MCQ type

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(b) magnetic axis and geographic axis
(c) earth's total magnetic field and its horizontal component
(d) earth's total magnetic field and its vertical component

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THANKING YOU

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