

## Horizontal component of Earth's magnetic field ( $B_H$ ) using a Tangent Galvanometer

**AIM:** To determine the horizontal component ( $B_H$ ) of the earth's field.

**APPARATUS:** (1) Graduated Compass (2) Current carrying coil (3) Rheostat (4) power supply (5) switch for changing direction of current (6) Ammeter(Digital Multimeter) (7) spirit level

### THEORY:

The horizontal component of earth's magnetic field,  $B_H$ , is the projection of earth's magnetic field on surface of the earth. Earth's magnetic field varies with longitude and latitude. Horizontal component of earth's magnetic field ( $B_H$ ) in Bhubaneswar is 39 uT. To know magnetic field on a given location visit this link. <http://www.ngdc.noaa.gov/geomag-web/#igrfwmm>

### Tangent law

Consider a bar magnet with magnetic moment  $M$ , suspended horizontally in a region where there are two perpendicular horizontal magnetic fields, and external field  $B$  and the horizontal component of the earth's field  $B_H$ . If no external magnetic field  $B$  is present, the bar magnet will align with  $B_H$ . Due to the field  $B$ , the magnet experiences a torque  $\tau_D$ , called the deflecting torque, which tends to deflect it from its original orientation parallel to  $B_H$ . If  $\theta$  is the angle between the bar magnet and  $B_H$ , the magnitude of the deflecting torque will be,

$$\tau_D = MB\cos\theta$$

The bar magnet experiences a torque  $\tau_R$  due to the field  $B_H$  which tends to restore it to its original orientation parallel to  $B_H$ . This torque is known as the restoring torque, and it has magnitude.

$$\tau_R = MB_H\sin\theta$$

The suspended magnet is in equilibrium when,

$$\tau_R = \tau_D$$

$$MB\cos\theta = MB_H\sin\theta$$

$$\text{Rearranging gives } B = B_H\tan\theta \text{ -----(1)}$$

The above relation, called the tangent law, gives the equilibrium orientation of a magnet suspended in a region with two mutually perpendicular fields.

## Tangent Galvanometer:

A tangent galvanometer works based on Tangent law. It consists of a number of turns of copper wire wound on a hoop. At the center of the hoop a compass is mounted. When a direct current flows through the wires, a magnetic field is induced in the space surrounding the loops of wire. This magnetic flux is designated by  $B_i$ . The strength of the magnetic field induced by the current at the center of the loops of wire is given by Amperes law:

$$\text{Induced} \quad B_i = \frac{\mu_0 Ni}{2R}. \quad \text{-----}(2)$$

where  $\mu_0$  is the permeability of free space and has the value of  $4\pi \times 10^{-7}$  Newton/Amp<sup>2</sup>,  $N$  is the number of turns of wire, ' $i$ ' is the current through the wire, and  $R$  is the radius of the loop.

When the wire loops of the tangent galvanometer are aligned with the magnetic field direction of the Earth, and a current is sent through the wire loops, then the compass needle will align with the vector sum of the field of the Earth and the induced field as shown in Figure 1.

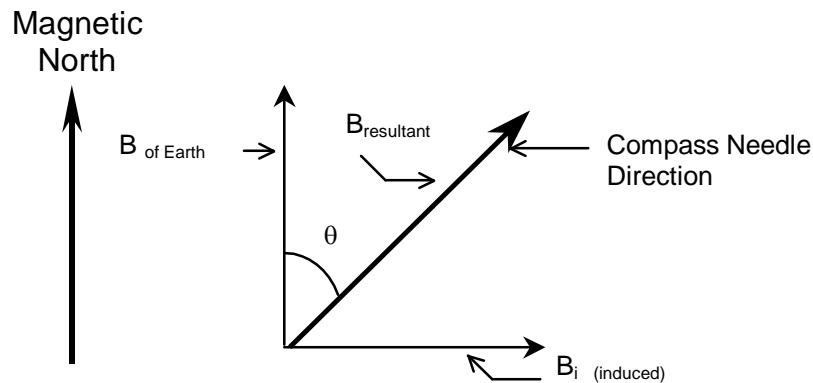


Fig. 1

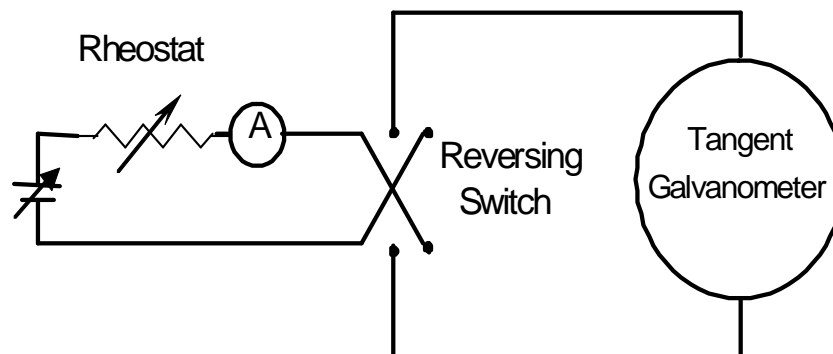


Fig. 2: CIRCUIT DIAGRAM

The horizontal component of the magnetic field of the Earth ( $B_H$ ) is calculated from the following relation:

$$B_H = \frac{B_i}{\tan\theta} \text{-----(3)}$$

**Diameter of the coil (R) = 13.6 cm.**

**Procedure:**

1. Level the graduated compass by a spirit level and also see that the current carrying coil is vertically placed.
2. Set the compass needle to 0-0 position. If there is offset in the pointer in the needle note down the value.
3. Connect the power supply, rheostat, ammeter and reversing switch as per the circuit diagram.
4. Connect the current carrying coil from the reversing switch to 50 turns position.
5. Always set the rheostat in middle position.
6. Slowly vary the power supply to set current in the ammeter (connect the digital multimeter in mA range with DC mode).
7. Note down the deflection in the compass for both left and right direction.
8. Always try to take observations in the range of  $15^\circ$ - $75^\circ$  in the compass.
9. Turn the power supply to initial position, then reverse the current direction at the reversing switch and repeat the measurements (use same current values).
10. After completing for 50 turns, follow the same procedure for the 500 turns position of the coil.
11. Compare the obtained magnetic field with Horizontal component of magnetic field at Bhubaneswar.

Table 1: For 50 turns

Current (mA)	Deflection of compass		Deflection of compass by reversing current direction		$B_i$ (Tesla)	$B_H$ (Tesla)
	Left	Right	Left	Right		

Table 2: For 500 turns

Current (mA)	Deflection of compass		Deflection of compass by reversing current direction		$B_i$ (Tesla)	$B_H$ (Tesla)
	Left	Right	Left	Right		

**Results:**