Lab 4 – STEWARTAND GEE'S EXPERIMENT

Introduction:

Electric currents generate magnetic fields. The magnitude and direction of the magnetic field generated depend on the specific geometry of the wire in which the current is flowing. In this experiment, we study about the flow of current in a circular coil. Using the Biot-Savart Law and Ampere's Law, the magnetic field B can be calculated.

Objective:

Educational:

Compare the intensity of magnetic field theoretically and experimentally by understanding the **working** of a tangent Galvanometer, which is based on the **principle** of the tangent law of magnetism.

Experimental:

To determine the field of induction at several points along the axis of a circular coil carrying current using Stewart and Gee's type of tangent galvanometer.

Pre Lab:

Reading:

Read the Biot Savart's law, Ampere's law and Tangent law in magnetism.

Written:

Keep the worksheet ready with required write up, Formulae, Tabular columns and theoretical values.

Apparatus Required:

Stewart and Gee's galvanometer, battery eliminator, ammeter, commutator, rheostat, plug keys, connecting wires.

Back Ground:

When a current of i-amperes exists through a circular coil of n-turns, each of radius a, the magnetic induction B at any point(P) on the axis of the coil is given by

$$\mathbf{B} = \frac{\mu_0 n i a^2}{2(x^2+a^2)^{3/2}} \text{-------------(1)}$$

where B is the magnetic induction on the axial line of the coil

$\mu_o = 4\pi \times 10^{-7}$ H/m (permeability of free space)

'n' is number of turns in the coil

'i' is the current through the coil

'a' is the radius of the coil (in cm)

'x' is the distance from the centre of the coil to the centre of the magnet (in cm)

When the coil is placed in the magnetic meridian, the direction of the magnetic field will be perpendicular to the magnetic meridian; i.e., perpendicular to the direction f the horizontal component of the earth's field; say B_e. When the deflection magnetometer is placed at any point on the axis of the coil such that the centre of the magnetic needle lies exactly on the axis of the coil, then the needle is acted upon by two fields B and B_e, which are at right angles to one another. Therefore, the needle deflects obeying the tangent law,

$$\mathbf{B = B_e Tan\Theta} \quad \text{-------------(2)}$$

B_e the horizontal component of the earth's field is taken from standard tables. The intensity of the field at any point calculated from equation (2) and verified using equation(1).

Figure:

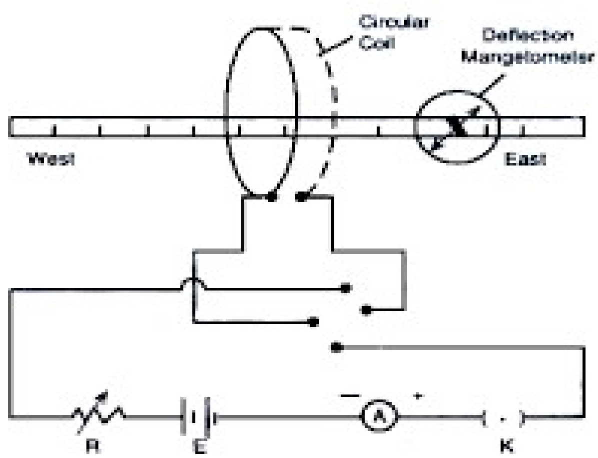


Figure Arrangement for the measurement of magnetic field along the axis of a current carrying coil

Procedure :

With the help of the deflection magnetometer and a chalk, a long line of about one meter is drawn on the working table, to represent the magnetic meridian. Another line perpendicular to this line is also drawn. The Stewart and Gee's galvanometer is set with its coil in the magnetic meridian, as shown in the figure. The external circuit is connected , keeping the ammeter, rheostat away from the deflection magnetometer. This precaution is very much required because, the magnetic field produced by the current passing through the rheostat and the permanent magnetic field due to the magnet inside the ammeter affect the magnetometer reading, if they are close to it.

The magnetometer is set at the centre of the coil and rotated to make the aluminum pointer read (0,0) in the magnetometer. The key, K, is closed and the rheostat is adjusted so as the deflection in the magnetometer is about 60°. The current in the commutator is reversed and the deflection in the magnetometer is observed. The deflection in the magnetometer before and after reversal of current should not differ much. In case of sufficient difference say above 2° or 3° , necessary adjustments are to be made.

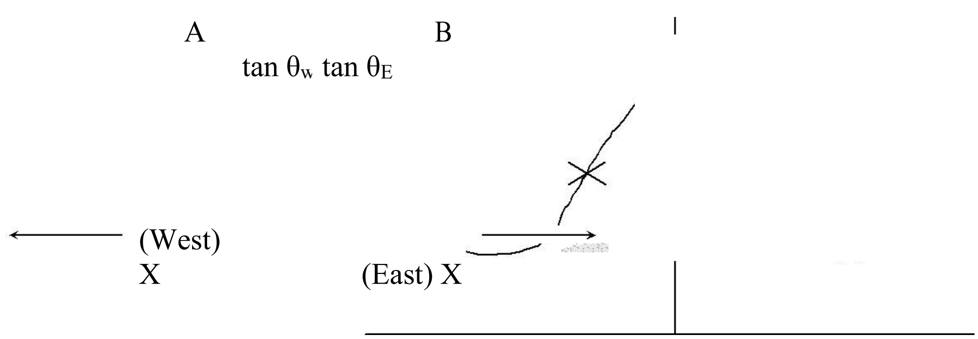
The deflections before and after reversal of current are noted when d = 0. The readings are noted in Table 1. The magnetometer is moved towards East along the axis of the coil in steps of 5 cm at a time. At each position, the key is closed and the deflections before and after reversal of current is noted. The mean deflection be denoted as $\text{Tan}\Theta_E$. The magnetometer is further moved towards east in steps of 5cm each time and the deflections before and after reversal of current are noted, until the deflection falls to 30°.

The experiment is repeated by shifting the magnetometer towards west from the centre of the coil in steps of 5cm, each time and deflections are noted before and after reversal of current. The mean deflection is denoted as $\text{Tan}\Theta_W$.

It will be found that for each distance (X) the values in the last two columns are found to be equal verifying equation (1) and (2).

A graph is drawn between X on x-axis and the corresponding $\text{Tan}\Theta_E$ and $\text{Tan}\Theta_W$ along y-axis. The shape of the curve is shown in the figure. The points A and B marked on the curve lie at distance equal to half the radius of the coil (a/2) on either side of the coil.

Graph:



Precautions:

1. The ammeter and voltmeter should be kept away from the deflection magnetometer because these meters will affect the deflection in magnetometer.
2. The current passing through rheostat will produce magnetic field and magnetic field produced
   by the permanent magnet inside the ammeter will affect the deflection reading.

Observation Table:

S. No	Distance of deflection magnetometer from centre of the coil(X) in meters	Deflection in the magnetometer East side						Deflection in the magnetometer West side						$\theta = \frac{\theta e + \theta w}{2}$	Tan θ	$B = B_e \tan \theta$	$B = \frac{\mu_0 n i a^2}{2(x^2 + a^2)^{3/2}}$
		θ_1	θ_2	θ_3	θ_4	Mean θe	Tan θe	θ_1	θ_2	θ_3	θ_4	Mean θw	Tan θw				

Result :

The theoretical and calculated values are approximately same.

Viva Voce

1. Define magnetic field induction.
2. Write units of magnetic field induction.
3. State the principle behind the experiment.
4. State Tangent Law.

Probing further Experiments

1.Study the variation in intensity of Magnetic field using a long straight current carrying conductor.

2. Study the action of transformer using the phenomena of Electromagnetic Induction.