Variation of magnetic field at axis of circular coil

Object: To study the variation of magnetic field with the distance along the axis of current carrying circular coil using Stewart and Gee's apparatus.

Apparatus required: Stewart and Gee's type tangent galvanometer, a battery, a rheostat, an ammeter, a one way key, a reversing key (commutator) , connecting wires.

Formula:

If a current carrying coil is place in y-z plane then its axis will be x-axis. The magnetic field along the axis of coil is given by,

$$B = \frac{\mu_0 NI}{2} \frac{a^2}{(a^2 + x^2)^{3/2}} \qquad (1)$$

Where, μ_0 (= $4\pi \times 10^{-7}$) is the vacuum permeability, N is the number of turns of the field coil, I is the current in the wire, in amperes, a is the radius of the coil in meters, and x is the axial distance in meters from the center of the coil.

If θ is the deflection produced in magnetometer at a certain position on the axis of coil then magnetic field at that point will be,

$$B = H \tan\theta \qquad (2)$$

The equations (1) and (2) implies that the graph between x and $\tan\theta$ will give the variation of magnetic field at the axis of circular coil.

Figure and Circuit Diagram

Fig 1. Tangent Galvanometer

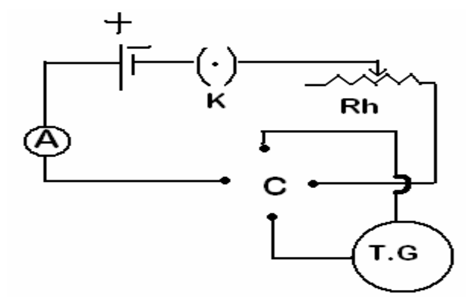

Fig 2. Circuit diagramme

Procedure:

1. Place the instrument in such a way that the arms of the magnetometer lie roughly east and west and the magnetic needle lies at the centre of the vertical coil. Place the eye a little above the coil and rotate the instrument in the horizontal plane till the coil, the needle and its image in the mirror provided at the base of the compass box, all lie in same vertical plane. The coil is thus set roughly in the magnetic meridian. Rotate the compass box so that the pointer lies on the 0-0 line.

2. Connect all the components as shown in circuit diagramme.

3. Adjust the value of the current so that the magnetometer at central position gives a deflection of the order of 70^0-75^0. Note this magnetometer reading for the both directions of currents. This will give you θ value at x=0.

4. Now slide the magnetometer along the +axis of coil with an increment of 2cm and note the deflection of needle in magnetometer (both ends of needle position) for the both directions of current in coil. Record a number of observations. (x=0,2,4, 6, 8, 10, 12cm)

5. After this, repeat the point 4 for the magnetometer position along –axis of coil. i.e. repeat the observation by shifting the magnetometer in the opposite direction and keeping the current constant at the same value.

Observations.

1. Least count of the magnetometer =
2. Current I =
3. Deflection in needle at x=0, (θ_0)=
4. *tan* θ_0=

5. Table A: Deflection in magnetometer along +axis of coil.

Sr. No	Distance of needle from centre of centre, ***x (cm)***	Deflection on East arm					***tanθ***
		Current in one direction		Current in reverse direction		Mean θ in deg.	
		θ_1	θ_2	θ_3	θ_4		
1.	2						
2.	4						
3.	6						
4.	8						
5.	10						
6.	12						
7.	14						
8.	16						

6. Table B: Deflection in magnetometer along -axis of coil.

Sr. No	Distance of needle from centre of centre, ***x (cm)***	Deflection on East arm					***tanθ***
		Current in one direction		Current in reverse direction		Mean θ in deg.	
		θ_1	θ_2	θ_3	θ_4		
1.	2						
2.	4						
3.	6						
4.	8						
5.	10						
6.	12						
7.	14						
8.	16						

Plot in *x* and *tanθ*: *The plot of* ***tanθ vs x*** *will be found as shown in Fig 3.*

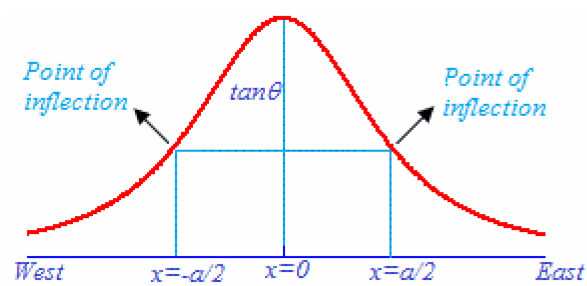

Fig. 3

Result: With help of the graph between tan θ and x, following points can be concluded.

1. The intensity of magnetic field is maximum at the centre and goes on decreasing as we move away from the centre of the coil towards right or left.

2. The point on the both side of graph where curve becomes convex to concave (i.e. the curve changes its nature) are called the point of inflection. The distance between the two points of inflexion is equal to the radius of the circular coil.

3. The radius of coil= distance between points of inflection=……….cm

Precautions:

1. *There should be no magnet, magnetic substances and current carrying conductor near the apparatus.*
2. *The plane of the coil should be set in the magnetic medium.*
3. *The current should remain constant and should be reversed for each observation.*