EXPERIMENT NO.9

VARIATION OF MAGNETIC FIELD

OBJECT:
To plot graph showing the variation of magnetic field with distance along the axis of a circular coil carrying current and evaluate from it the radius of the coil.

APPARATUS:
Stewart and Gee type galvanometer, Storage battery, Potentiometer, connecting wires and sprit level.

FORMULA USED:
The magnetic field B due to a current carrying coil, at a distance x from the centre of the coil is given

$$B = \frac{2\pi n a^2 I}{10^7 (a^2 + x^2)^{3/2}}$$

Where n = Number of turns in the coil
a = Radius of coil
I = Current flowing through the coil
x = Distance of axis point from the centre of coil

Figure1. Stewart and Gee type galvanometer

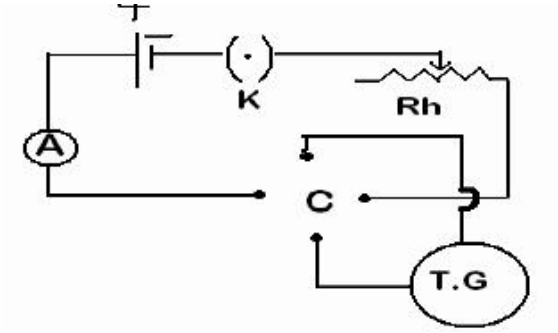

Figure2. Circuit Diagram

THEORY:
When a current is passed through a circular coil, it produces a magnetic field around itself. The direction of magnetic field can be determined by Fleming's right hand rule. The strength of a coil's magnetic field increases not only with increasing current but also with each loop that is added to the coil. In the tangent galvanometer there is a circular coil having one or more turns of wire, at the center of which a magnetic needle is either balanced on a point. The instrument is placed so that the plane of the coil is vertical and in the magnetic north and south plane.
For a coil of radius a, having n number of turns, the value of magnetic field at a distance x from the centre along the axis is given by

$$B = \frac{2\pi n a^2 I}{10^7 (a^2 + x^2)^{3/2}} \quad (1)$$

Obviously, the value of the magnetic field is maximum at the centre of the coil and decreases on going from the centre of coil. Since the magnitude of the horizontal component of earth's magnetic field is H. The compass needle aligns itself along the vector sum of B and H after rotating through an angle θ from its original orientation. The vector diagram as shown in figure (2) shows that

$$\tan\theta = \frac{B}{H} \quad (2)$$

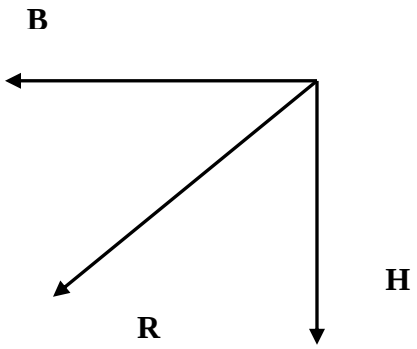

Figure 2. The vector diagram between B and H

Since the magnetic field of the earth is constant, and B depends directly on the current, the current is thus proportional to the tangent of the angle through which the needle has turned. From equations (1) and (2), we observe that variation of magnetic field involves the plotting of a graph between x and $\tan\theta$. The points at which the nature of curve changes are known as points of inflexion. Mathematically, these are obtained on equating second derivative of magnetic field of the coil to zero i.e. $\frac{d^2B}{dx^2} = 0$. It further provides that $x = \pm\frac{a}{2}$, it means points of inflexions lie at these distances from the centre of coil.

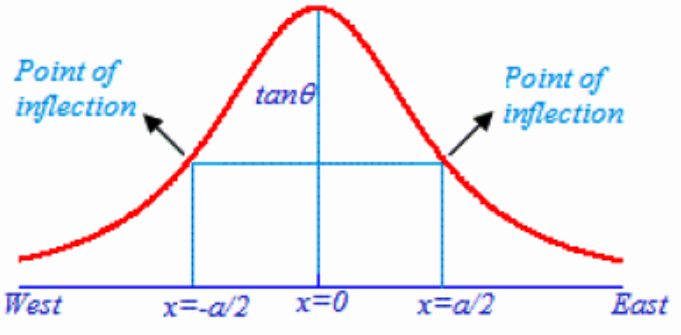

Figure2. The plot of tanθ versus x

PROCEDURE:

(1) Set the compass into magnetic meridian at centre of coil.

(2) Set the current in the coil such that deflection is almost 60^0 and note down the value of angles θ_1 and θ_2 at $x = 0$ (at constant current)

(3) Now, move the compass towards L.H.S for different values of x according to observations table.

(4) After completing the observations of L.H.S take similar observation for R.H.S for the same value of x.

OBSERVATIONS:

S. No.	**Distance (x)from the center of coil (in cm.)**	**Deflection in the coil**				**Deflection in the coil**			
		East Direction (L.H.S)				**West Direction (R.H.S)**			
		θ_1	θ_2	**Mean** θ	$\tan\theta$	θ_1	θ_2	**Mean** θ	$\tan\theta$
1.									
2.									
3.									
..									
..									
…									
..									
..									
15									

CALCULATION & RESULT:

(1) The radius of the coil as measured from the points of inflexion using the graph = …..cm.

(2) The radius of the coil as determined by the measurement of the circumference of the coil =….cm.

PERCENTAGE ERROR:

% error in the determination of radius of current carrying coil = ……..

PRECAUTIONS:

1. There should be no magnetic material or current carrying conductor in the neighborhood of the apparatus.
2. The coil should be adjusted in the magnetic meridian carefully.
3. Initial reading of the pointer must be set zero. If there is any error it must be taken into account while recording the deflection.