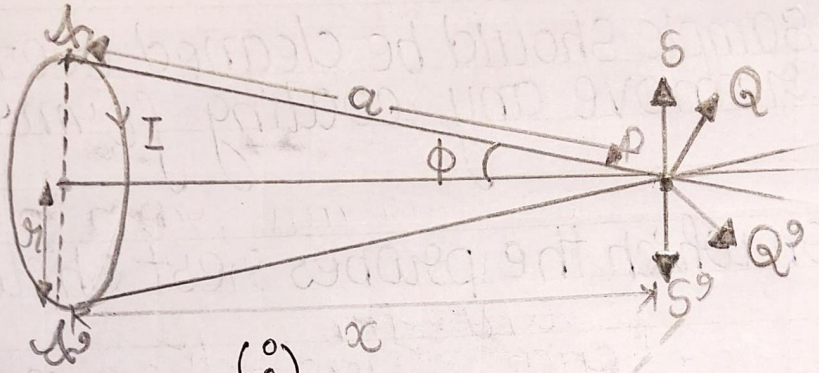
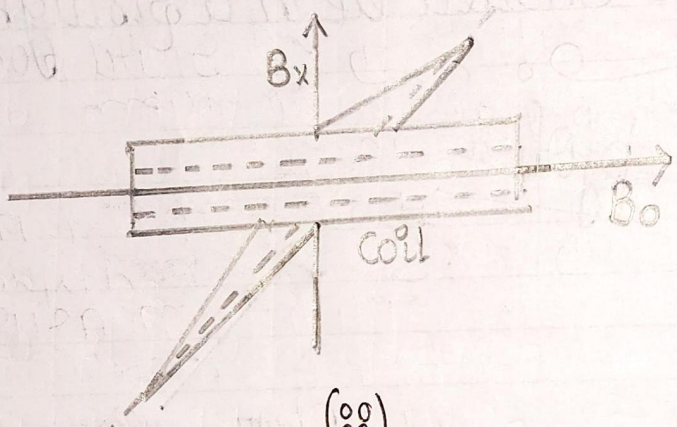
Experiment No: 4

The field dB due to a small element dl of wire.



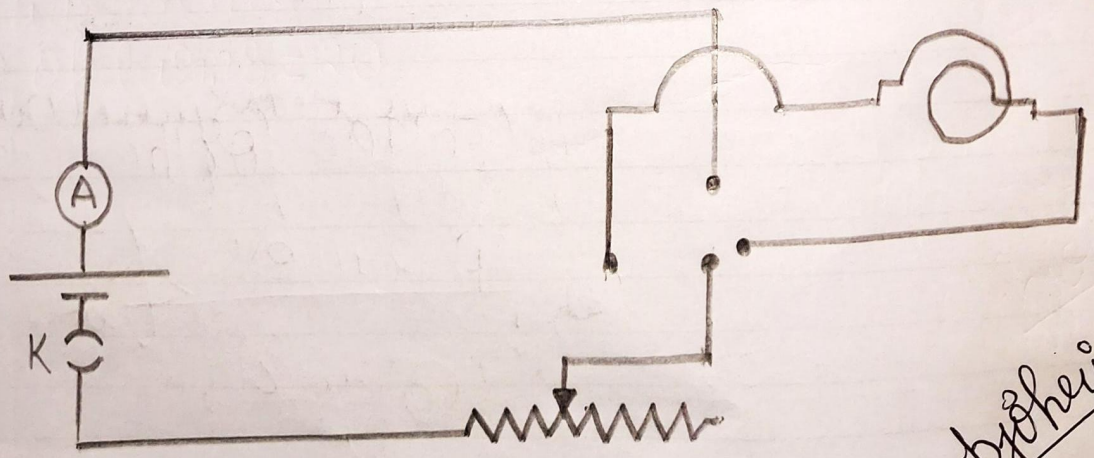
(i)



(ii)

Compass needle

$B_x = B_0 \tan\theta$



(iii) Circuit Diagram

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Experiment No: 04

1) Aim: To study the variation of magnetic field with distance along the axis of a circular coil carrying current.

2) Apparatus Required: Circular coil, compass box, ammeter, rheostat, commutator, cell, Key, connection wires, etc. The purpose of the commutator is to allow the current to be reversed only in the coil.

3) Theory: According to Biot-Savart's law, the magnetic field B at a point P for a conductor reversed by the current I is made up of the contributions of the infinitesimal parts of the conductor, the length and direction of which are described by the vector. Consider a circular coil of radius 'a', carrying a current I. Consider a pt. P, which is at a distance 'x' from the centre of coil. Consider that the loop is made up of large no. of short elements, generating magnetic fields. At the centre of coil, field would be uniform. As the location of point increases from the centre of the coil, the field decreases. Since the field B_x from the coil is acting perpendicular

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to the horizontal intensity of earth's magnetic field, B_0 and the compass needle align at an angle θ with the vector sum of these two fields. The horizontal component of earth's magnetic field varies greatly over the surface of earth.

4) Formula used:

$$\vec{dB} = \frac{\mu_0 \times}{4\pi}\left(\frac{i\vec{dl} \times \vec{r}}{r^3}\right)$$

$$B_x = \frac{\mu_0 n I \times}{2}\left(\frac{r^2}{(x^2+r^2)^{3/2}}\right)$$

Where,
n = number of turns in the coil
r = radius of coil
μ_0 = Absolute permeability of free space
x = Distance from centre of coil

$$B_x = B_0 \tan\theta$$

B_0 = Horizontal Intensity of Earth's magnetic field.

$$B_0 = 3.5 \times 10^{-5}\ T$$

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Observation Table.

Table 1

Current (in A)	Deflection from Current direct θ_1	θ_2	reverse θ_3	θ_4	Mean θ	Tan θ	$B_x = B_0 \tan\theta$ (10^{-5})	B_H (10^{-5})
0.167	36	37	37	37	36.75	0.747	2.614	2.617
0.143	32	33	33	33	32.75	0.643	2.25	2.243
0.125	29	30	30	30	29.75	0.572	2.002	1.962
0.111	26	27	27	26	26.25	0.493	1.7255	1.744
0.1	24	25	24	24	24.25	0.45	1.575	1.57
0.091	22	23	23	22	22.5	0.414	1.449	1.427
0.083	20	21	20	20	20.25	0.368	1.288	1.308
0.077	19	20	19	19	19.25	0.349	1.2215	1.208
0.071	17	18	18	17	17.5	0.315	1.1025	1.21

Radius = 8 cms
No of turns = 20

Jyothis

Table 2

Radius in (cms)	Deflection from current direct reverse				Mean θ	Tan θ	$B_x = B_o \tan\theta$ (10^{-5})	B^{th} (10^{-5})
	θ_1	θ_2	θ_3	θ_4				
5	82	82	82	83	82.25	7.347	25.715	25.12
6	80	81	80	81	80.5	5.975	20.913	20.93
7	79	79	79	79	79	5.144	18.004	17.94
8	77	78	78	78	77.75	4.605	16.118	15.7
9	76	76	75	76	75.75	3.937	13.78	13.96
10	74	75	74	75	74.5	3.605	12.618	12.56

$x = 0$ cms

$n = 20$ turns ,

$B_o = 3.5 \times 10^{-5}$ T

Pjohri

Table 3

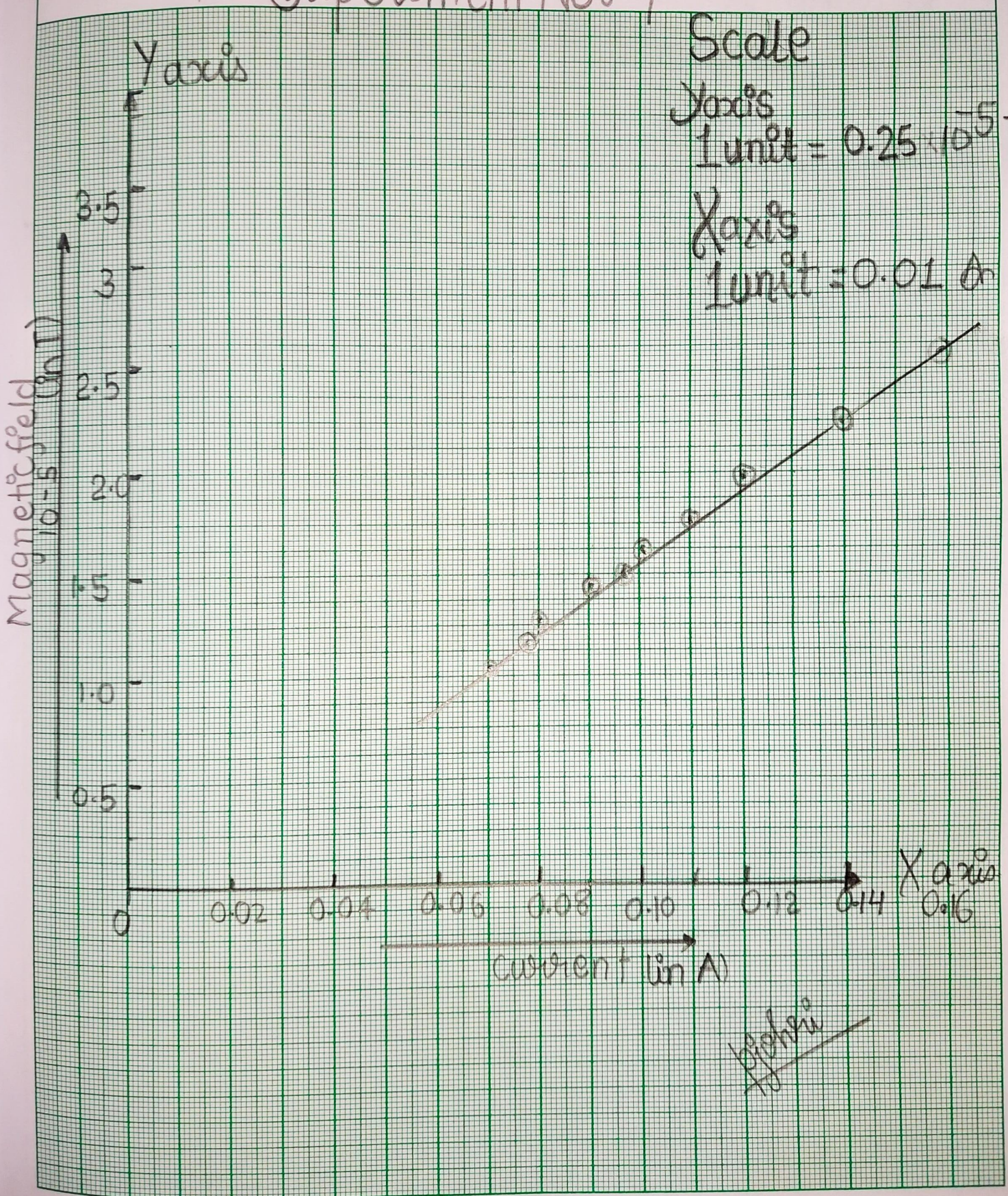
Distance from (x) centrecm	Deflection on Left side				Deflection on Right Side				Mean θ
	Direct		Reverse		Direct		Reverse		
	θ_1	θ_2	θ_3	θ_4	θ_1	θ_2	θ_3	θ_4	
5	70	70	70	70	70	70	70	70	70
10	47	48	47	47	47	47	47	48	47.25
15	25	25	24	25	24	25	25	25	24.75
20	12	13	12	13	12	13	12	13	12.5
25	8	8	7	8	7	8	7	8	7.625

Magnetic field as a function of 'x'
R = 8 cms, n = 20 turns

pjohn

Distance from centre (cms)	tanθ	$B_x = B_0 \tan\theta$ (10^{-5})	B_{th} $[10^{-5}]$
5	2.747	9.6145	9.57
10	1.081	3.783	3.82
15	0.461	1.613	1.63
20	0.222	0.77	0.804
25	0.134	0.465	0.44

Experiment No: 4



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5) Procedure.

- First, preliminary adjustments should be done in order to properly align the apparatus with the earth's magnetic field.
- Using the Slider Rotate compass bar, the compass box can be rotated & its 90-90° reading to be parallel to the plane of the coil.
- Using the show normal button in the Simulator, go back to the experimental setup.
- Make the connection by dragging the connection wires
- Close the circuit using Insert Key
- Zoom compass box to view the reading of the pointer
- Using Slider radius of coil, change the radius of coil
- Adjust Rheostat slider to adjust the current.
- Show result button displays result after doing the experiment.

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o) A reset button is provided to reset the experimental setup.

o) The experiment can be repeated for different number of turns and radius of the coil and for different currents.

6) Result:

From the observation table and graph Biot-Savart's Law has been verified for a current carrying coil

(i) Magnetic field is directly proportional to the strength of the current

(ii) Magnetic field varies directly as the function $\frac{r^2}{(x^2+r^2)^{3/2}}$ Ans.

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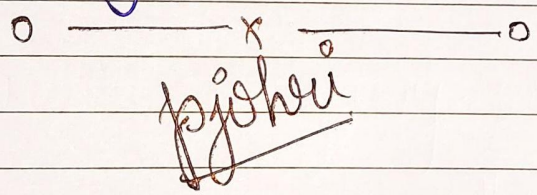
7.) Precautions and Sources of Error

- Care should be taken that there is no stray magnetic field or ferromagnetic material such as keys, screw driver etc, near the setup, while performing the experiment.
- The radius of the coil is calculated from the centre of the coil winding and not from the inside edge of the coil winding.



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