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Experiment-7

Magnetic Field and Biot – Savart Law

* **AIM:** i) Calculation of magnetic field along the axis of a circular current carrying coil using the tangent law of magnetism and
ii) Determination of radius of the current carrying coil from Biot – Savart law.

* **APPARATUS REQUIRED:** Cuicular coil, Compass, 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 while flowing in the same direction in the rest of the circuit.

* **FORMULAS USED:**

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

Here, r = radius of the coil(m)
n = number of turns in the coil.
I = current passing through the coil (A)
x = distance of the point (magnetometer) from the centre of the coil along its axis (m)

$$B_x = B_0 \tan\theta$$

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* OBSERVATIONS

Table 1

$r = 5cm$, $I = 0.500\ A$ $B_o = 3.5 \times 10^{-5}\ T$

$\mu_o = 4\pi \times 10^{-7}\ H/m$

Point of Compass (cm)		Direct Current		Reversed Current		Mean	tanθ	$B_x = B_o \times \tan\theta$
		θ_1	θ_2	θ_3	θ_4	(θ)		($\times 10^{-5}$ T)
	-14	4	5	3	5	4.25	0.074	0.259
	-12	5	6	5	6	5.5	0.096	0.336
Left	-10	9	10	10	11	9.75	0.171	0.571
Side	-8	15	16	15	16	15.5	0.277	0.969
	-6	25	26	25	25	25.25	0.471	1.648
	-4	40	41	39	40	40	0.839	2.936
	-2	55	56	55	56	55.5	1.455	5.092
Center	0	61	62	62	61	61	1.804	6.314
	2	55	56	55	55	55.25	1.441	5.043
	4	40	41	39	40	40	0.839	2.936
Right	6	25	26	25	25	25.25	0.471	1.648
Side	8	15	16	15	16	15.5	0.277	0.969
	10	9	10	10	11	9.75	0.171	0.598
	12	5	6	5	6	5.5	0.096	0.336
	14	4	5	3	5	4.25	0.074	0.259

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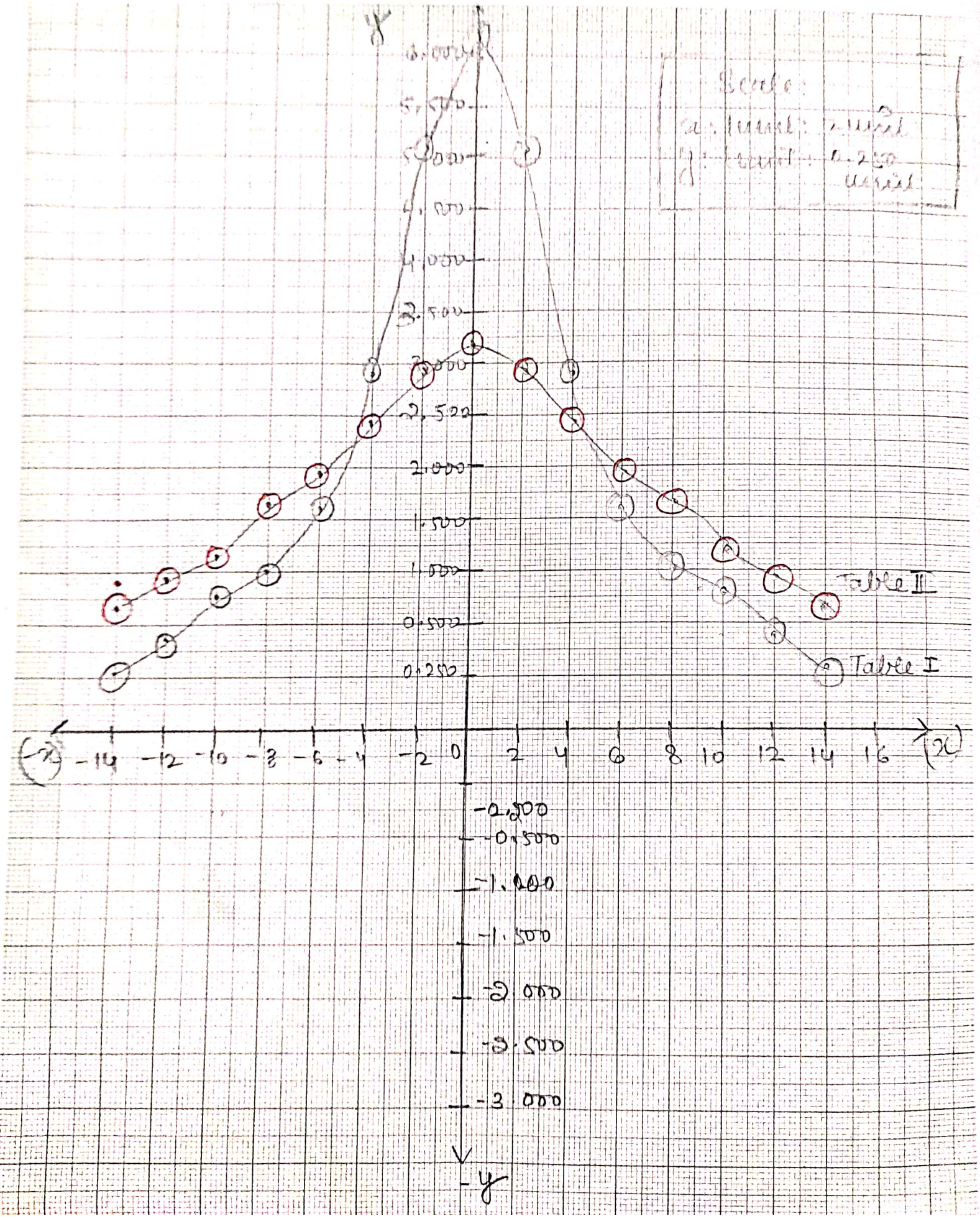
Table 2

$r = 10\ cm$ $I = 0.500\ A$ $B_0 = 3.5 \times 10^{-5} T$ $\mu_0 = 4\pi \times 10^{-7}\ H/m$

Point of Compass (cm)		Direct Current θ_1	Direct Current θ_2	Reversed Current θ_3	Reversed Current θ_4	Mean (θ)	$\tan\theta$	$B_x = B_0 \times \tan\theta$ ($\times 10^{-5} T$)
	-14	9	10	10	11	9.75	0.171	0.598
	-12	13	14	13	14	13.5	0.240	0.840
Left	-10	17	18	17	18	17.5	0.315	1.102
side	-8	23	24	23	24	23.5	0.434	1.519
	-6	29	30	29	30	29.5	0.565	1.808
	-4	35	36	35	36	35.5	0.713	2.495
	-2	40	41	40	40	40.25	0.846	2.961
Center	0	41	43	42	43	42.25	0.908	3.178
	2	40	41	40	40	40.25	0.846	2.961
	4	35	36	35	36	35.5	0.713	2.495
	6	29	30	29	30	29.5	0.565	1.808
Right	8	23	24	23	24	23.5	0.434	1.519
side	10	17	18	17	18	17.5	0.315	1.102
	12	13	14	13	14	13.5	0.240	0.840
	14	9	10	10	11	9.75	0.171	0.598


Scale:
x: 1 unit = 1 unit
y: 1 unit = 0.250 unit
Table II
Table I
x
y
-14
-12
-10
-8
-6
-4
-2
0
2
4
6
8
10
12
14
16
5.000
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.250
-0.250
-0.500
-1.000
-1.500
-2.000
-2.500
-3.000

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* CALCULATIONS

** B_x at $x=0$ from Table 1 is 6.314×10^{-5} T

$$B_x = \frac{\mu_0 n I r^2}{2(x^2+r^2)^{3/2}} \text{ T} \qquad n=10,\ H_0 = 4\pi \times 10^{-7},\ I = 0.5 \text{ A},\ x=0$$

$$6.314 \times 10^{-5} = \frac{4\pi \times 10^{-7} \times 10 \times 0.5 \times r^2}{2((0)^2 + r^2)^{3/2}}$$

$$6.314 \times 10^{-2} = \frac{4\pi \times 10 \times 0.5 \times r^2}{2r^3}$$

$$r_0 = \frac{2 \times 3.14 \times 5 \times 10^{-2} \times 22}{6.314 \times 7}$$

$$\boxed{r_0 = 4.973 \times 10^{-2} \text{ m}}$$

Initial Radius $= 5 \text{ cm} = 5 \times 10^{-2}$ m

$r_0 = 4.973 \times 10^{-2}$

$$\% \text{ error} = \frac{|r_0 - R|}{R} \times 100$$

$$\% \text{ error} = \frac{|4.973 - 5|}{5 \times 10^{-2}} \times 100 \times 10^{-2} = \frac{0.027}{5 \times 10^{-2}}$$

$$\boxed{\% \text{ error} = 0.54\%}$$

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(i) $B_{x=r} = \dfrac{\mu_0 n I r^2}{2(x^2+r^2)^{3/2}}$

$B_{x=0} = \dfrac{\mu_0 n I r^2}{2(0-r^2)^{3/2}}$

$\dfrac{B_{x=r}}{B_{x=0}} = \dfrac{\dfrac{\mu_0 n I r^2}{2(x^2+r^2)^{3/2}}}{\dfrac{\mu_0 n I r^2}{2(r^2)^{3/2}}} = \left(\dfrac{r^2}{2r^2}\right)^{3/2}$

$= \left(\dfrac{1}{2}\right)^{3/2} = \boxed{\dfrac{1}{2\sqrt{2}}}$