Date 7-6-22

Expt. No. 05

Magnetic Effect of Current

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

Apparatus:
Stewart and Gee's type tangent galvanometer, a battery, a rheostat, an ammeter, a one-way key, a reversing key, connecting wires and sand paper.

Theory:

The intensity of magnetic field at a point on axis of circular coil of radius a having n turns at a distance x from center of coil is given by

$$B = \frac{\mu_0}{4\pi} \times \frac{2\pi n I a^2}{(a^2 + x^2)^{3/2}} \frac{Wb}{m^2}$$

$$= \frac{\mu_0 n I a^2}{2(a^2 + x^2)^{3/2}} \times 10^4 \text{ gauss}$$

I is current in ampere flowing through the coil

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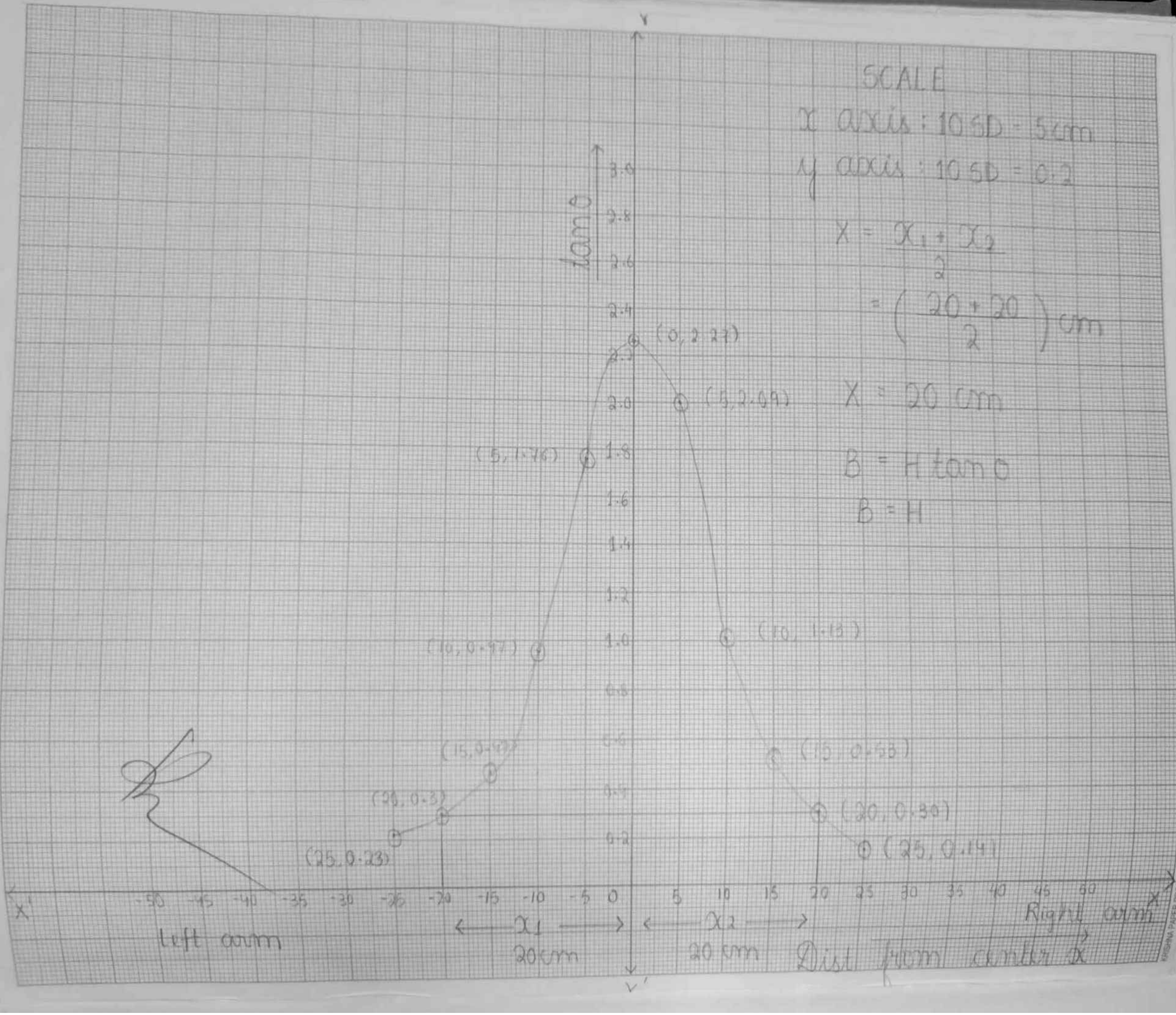


SCALE

x axis : 10 SD = 5cm

y axis : 10 SD = 0.2

$$X = \frac{x_1 + x_2}{2}$$

$$= \left(\frac{20 + 20}{2} \right) cm$$

$$X = 20 \text{ cm}$$

$$B = H \tan\theta$$

$$B = H$$

If field B is perpendicular to horizontal component of earth's field H and θ is deflection produced in a deflection magnetometer at a distance x due to earth's magnetic field, then

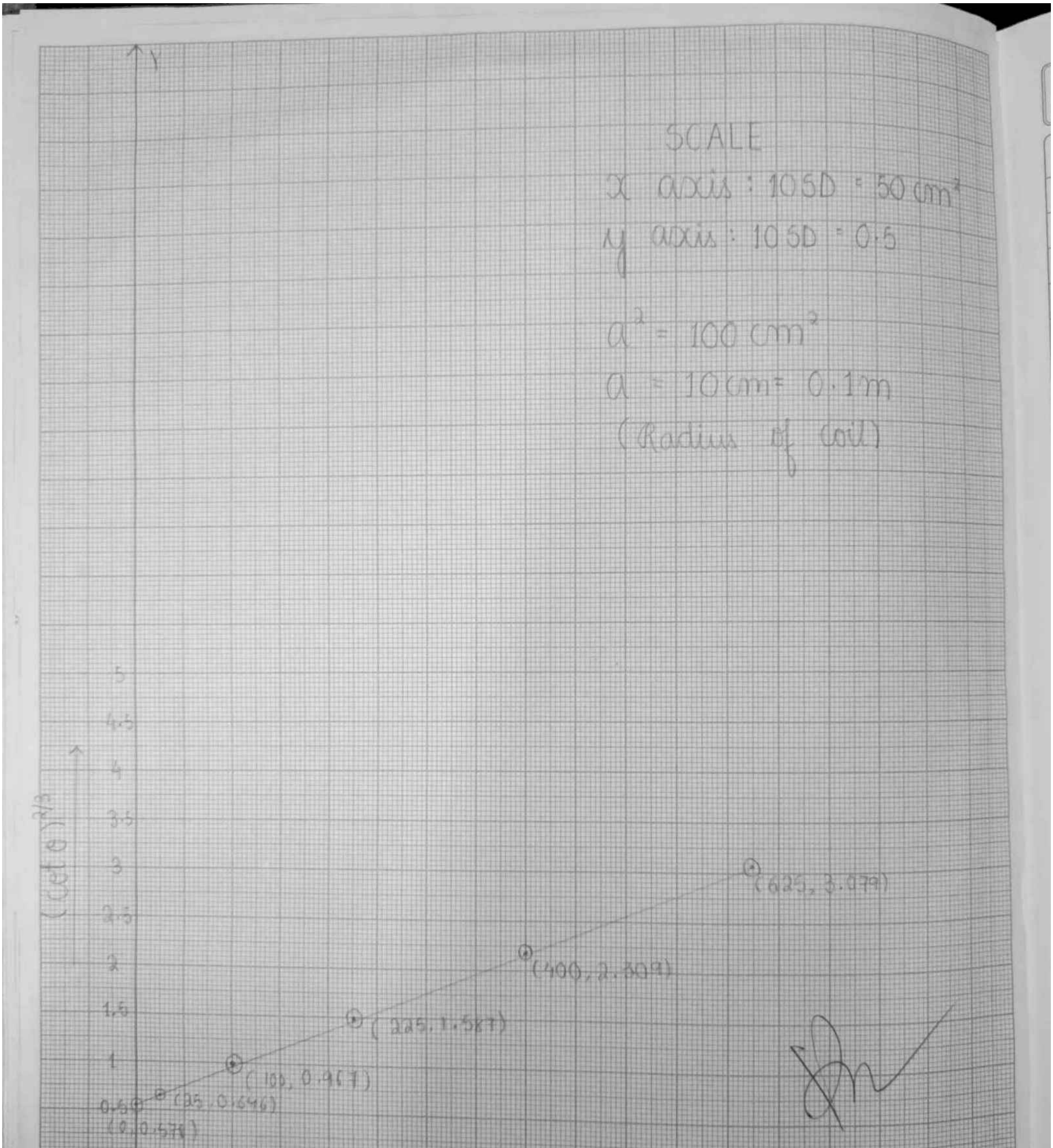
$$B = H\tan\theta = \frac{\mu_0 m I a^2}{2(a^2+x^2)^{3/2}} \times 10^4$$

or

$$\cot\theta = \frac{2H}{\mu_0 m I a^2}(a^2+x^2)^{3/2} \times 10^{-4}$$

Observation Table:

Sl. no	Dist from center x	Left side Direct		Reverse		Mean θ	$\tan\theta$	Right side Direct		Reverse		Mean θ	$\tan\theta$
		1	2	3	4			1	2	3	4		
1.	0	65	65	67	68	66.25	2.27	65	65	67	68	66.25	2.27
2	5	57	58	64	63	60.5	1.76	66	65	64	63	64.5	2.09
3.	10	43	45	46	45	44.75	0.97	51	50	48	45	48.5	1.13
4	15	25	27	25	25	25.5	0.47	30	30	28	25	28.25	0.53
5.	20	20	19	16	12	16.75	0.30	20	20	15	12	16.75	0.30
6.	25	13	15	10	12	13	0.23	12	13	5	4	8.5	0.14


SCALE
x axis : 10 SD = 50 cm²
y axis : 10 SD = 0.5
a² = 100 cm²
a = 10 cm = 0.1 m
(Radius of coil)
(cot θ)^{2/3}
x² (in cm²)
(625, 3.079)
(400, 2.309)
(225, 1.587)
(100, 0.967)
(25, 0.646)
(0, 0.578)
X
X'
Y
Y'
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Sl. no	x	x^2	Mean $\tan\theta$	$\cot\theta$	$(\cot\theta)^{2/3}$
1.	0	0	2.27	0.440	0.578
2.	5	25	1.925	0.519	0.646
3.	10	100	1.05	0.952	0.967
4.	15	225	0.5	2	1.587
5.	20	400	0.285	3.508	2.309
6.	25	625	0.185	5.405	3.079

Calculation :

1. Distance of coil from graph 1.

$$a^2 = 100 \text{ cm}$$
$$a = 10 \text{ cm} = 0.1 \text{ m}$$

2. Distance where field due to coil is equal to horizontal component due to earth's field : $X = \left(\frac{x_1 + x_2}{2}\right)$ cm

$$= \left(\frac{20 + 20}{2}\right) = 20 \text{ cm}$$

3. The value of magnetic field at

(a) center of coil :

B at $x = 0$

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

$$= \frac{4 \times 3.14 \times 10^{-7} \times 100 \times (0.1)}{2 \times 0.1}$$

$$= 0.628 \times 10^{-4} \text{ gauss}$$

(b) at distance $a/2$:
B at $x = a/2$

$$B = \frac{\mu_0 n I a^2}{2\left(\frac{5a^2}{4}\right)^{3/2}} = \frac{4 \times 3.14 \times 10^{-7} \times 100 \times 0.1 \times 0.01}{2\left(\frac{5 \times 0.01}{4}\right)^{3/2}}$$

$$= 0.450 \times 10^{-4} \text{ gauss}$$

Conclusion

1. From the above experiment, we concluded that :
   - radius of coil = 0.1 m
   - distance where field due to coil is equal to horizontal component due to earth's magnetic field is $\frac{20\text{ cm}}{2} = 10\text{ cm}$
2. Value of magnetic field is
   - at $x = 0$, $B = 0.628$ T
   - at $x = a/2$, $B = 0.45$T

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Precautions:

1 There should be no magnet, magnetic substances and current carrying conduction near apparatus.

2 Plane of coil should be set in the magnetic meridian.

3 Current should remain constant and should be reversed for each observation

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