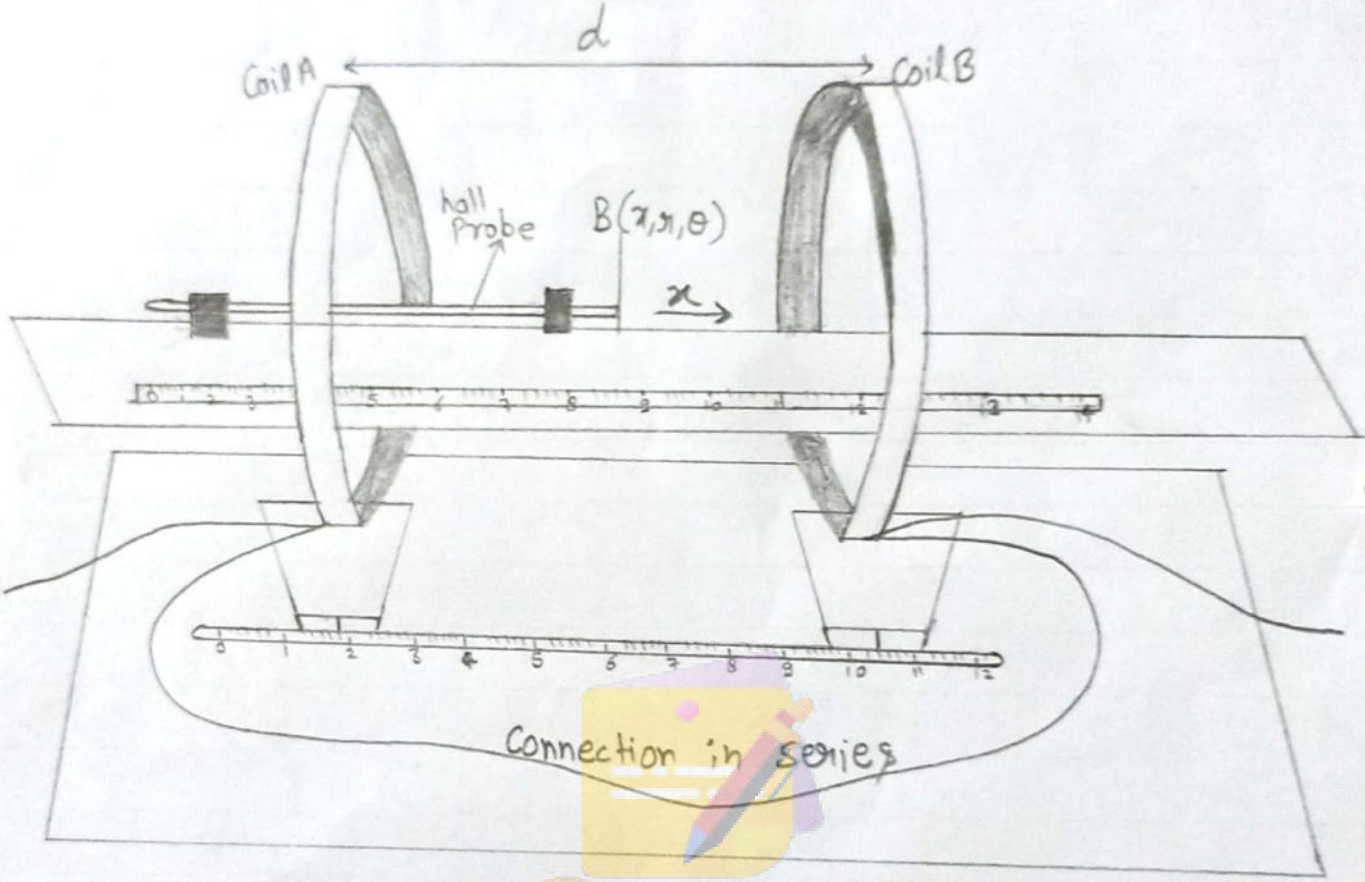
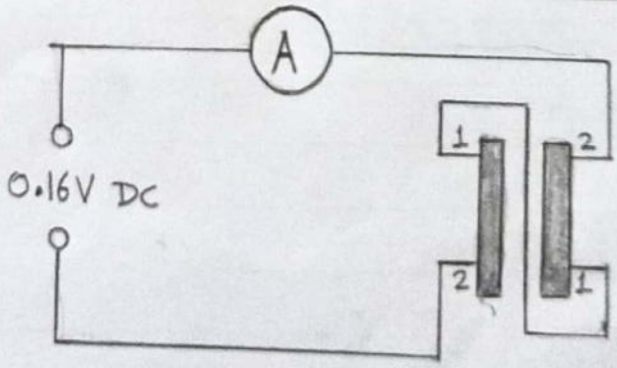


Helmholtz Coil Arrangement.



Wiring Diagram for Helmholtz Coil

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"Experiment - 10"

Date 06/03/2022
Page No.

"Helmholtz Coil"

Objective :-

① To study the variation of magnetic field along the axis generated by two coaxial and identical current carrying coils.
② To study the effect of seperation between coils on magnetic field.
③ To generate nearly constant magnetic field.

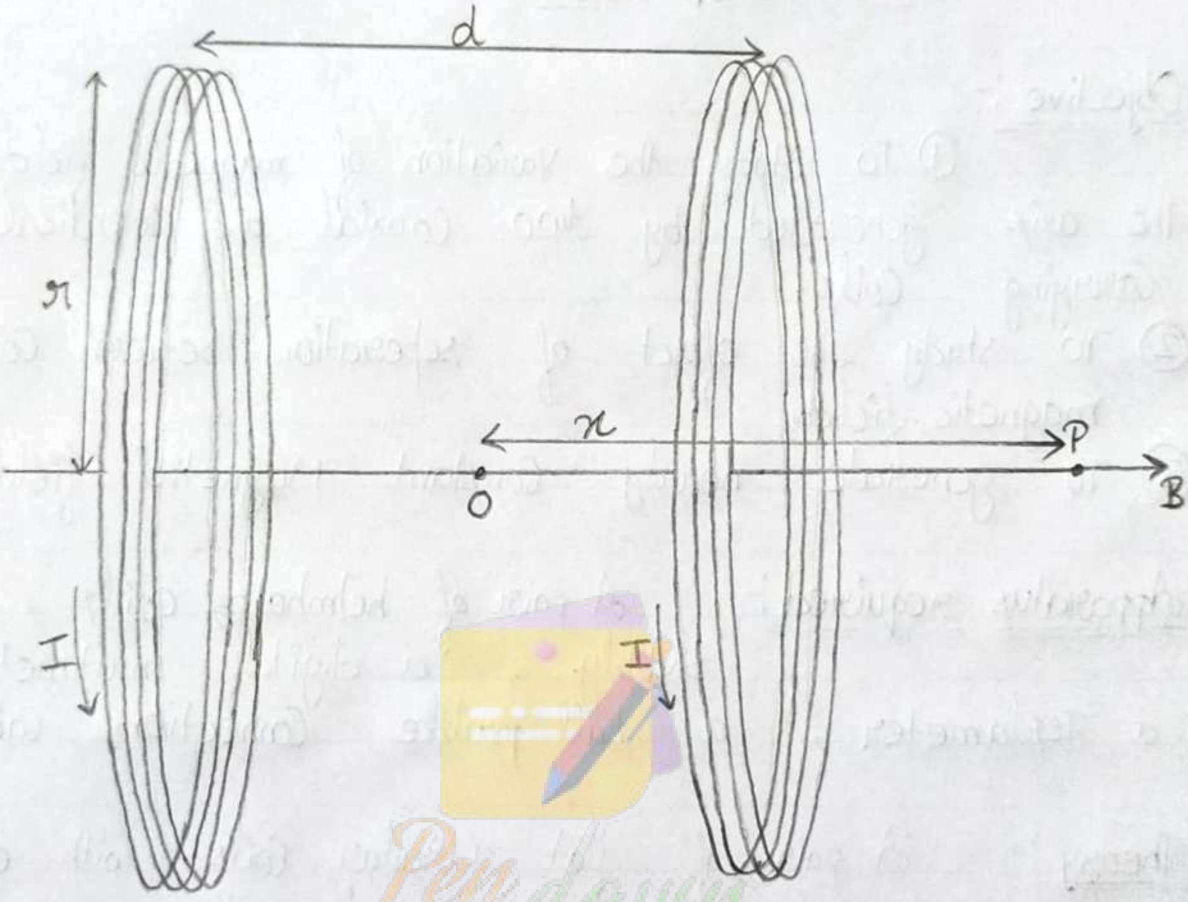
Apparatus required :- A pair of helmholtz coils, a power supply, a digital multimeter, a Teslameter, a hall probe, connection cables.

Theory :- A pair of flat circular coils with equal number of turns and equal radius, arranged with a common axis and connected in series is referred as Helmholtz Coil.
If two identical coils lie on the centre axis with a distance d, the magnetic field at a distance x away from centre of coil will be -

$$B = \frac{\mu_0 N I r^2}{2}\left[\frac{1}{\left[r^2+\left(x-\frac{d}{2}\right)^2\right]^{3/2}} + \frac{1}{\left[r^2+\left(x+\frac{d}{2}\right)^2\right]^{3/2}}\right]$$

$$B = \frac{\mu_0 N I}{2r}\left[\frac{1}{\left[1+\left(x-\frac{d}{2r}\right)^2\right]^{3/2}} + \frac{1}{\left[1+\left(x+\frac{d}{2r}\right)^2\right]^{3/2}}\right]$$

where r = radius of the coil.



□ Magnetic field along <u>Central axis</u> <u>of</u> <u>Helmholtz Coils</u> <u>at</u> <u>a</u> <u>distance</u> <u>x</u>.

Observations:-

Radius of Coil = 7 cm

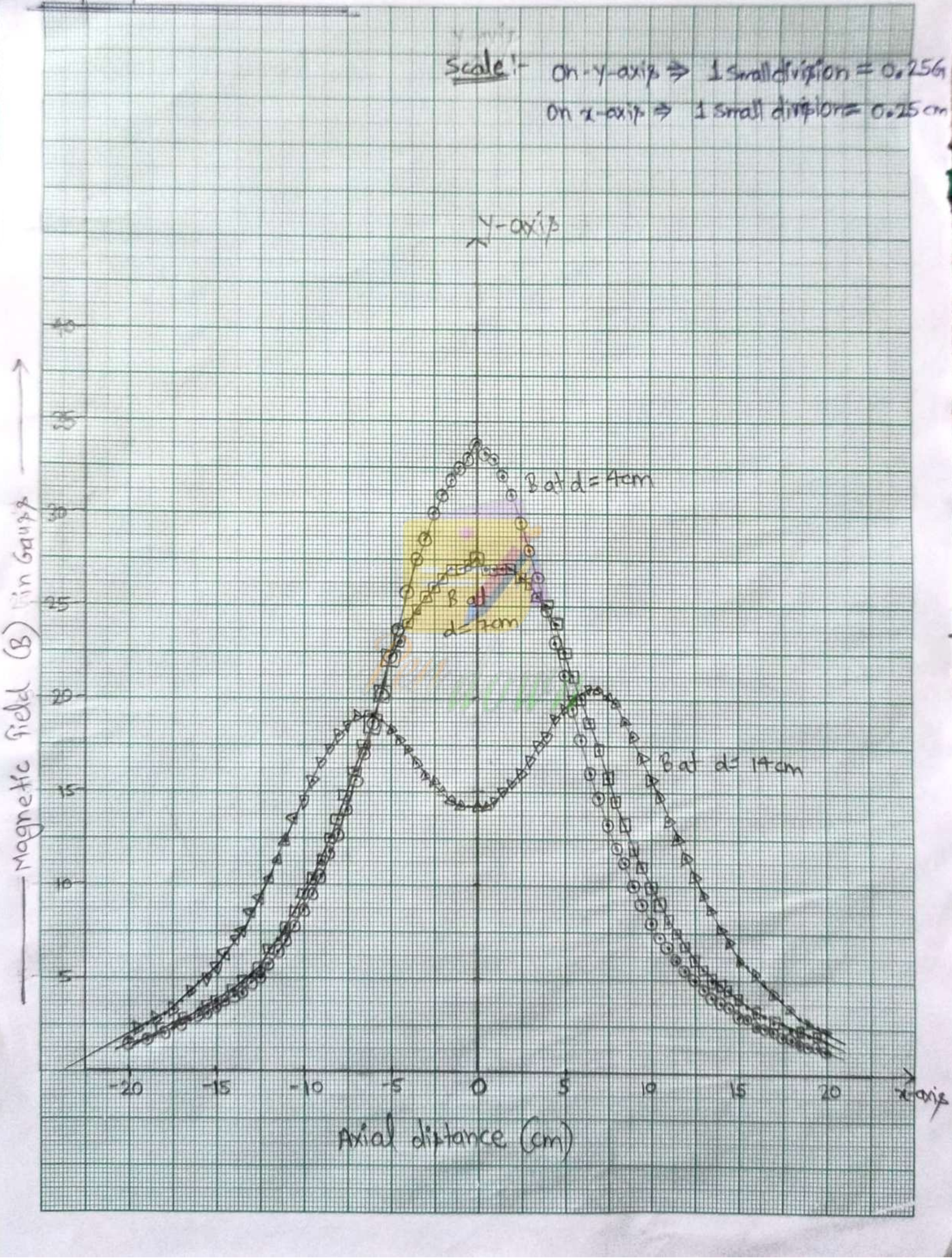
$I_0 = 0.5A$

$R = 0.07m$

	Magnetic field (B) (in Gauss)				Magnetic field (B) (in Gauss)		
x(cm)	d=4cm	d=7cm	d=14cm	x(cm)	d=4cm	d=7cm	d=14cm
-20.0	1.4	1.4	2.0	0.0	33.7	27.4	14.2
-19.5	1.5	1.5	2.3	0.5	33.3	27.0	14.2
-19.0	1.6	1.7	2.5	1.0	32.9	27.1	14.5
-18.5	1.8	1.9	2.7	1.5	32.1	27.0	14.9
-18.0	2.0	2.0	3.1	2.0	31.1	26.9	15.4
-17.5	2.2	2.2	3.3	2.5	29.5	26.5	16.0
-17.0	2.4	2.5	3.7	3.0	28.0	26.2	16.7
-16.5	2.5	2.7	4.3	3.5	26.4	25.5	17.4
-16.0	2.7	2.9	4.7	4.0	24.8	25.0	18.1
-15.5	2.9	3.2	5.1	4.5	23.0	23.9	18.9
-15.0	3.3	3.5	5.6	5.0	21.3	22.6	19.4
-14.5	3.6	3.8	6.2	5.5	19.5	21.2	19.9
-14.0	3.9	4.3	7.0	6.0	17.8	19.9	20.2
-13.5	4.1	4.7	7.6	6.5	16.1	18.7	20.4
-13.0	4.8	5.1	8.5	7.0	14.7	17.2	20.4
-12.5	5.1	5.5	9.2	7.5	13.3	15.7	20.1
-12.0	5.8	6.2	10.2	8.0	12.1	14.5	19.6
-11.5	6.4	6.9	11.2	8.5	11.2	13.2	18.8
-11.0	7.0	7.6	12.3	9.0	9.9	11.9	17.9
-10.5	7.7	8.4	13.4	9.5	8.9	11.0	16.8
-10.0	8.6	9.3	14.4	10.0	8.0	9.9	15.7
-9.5	9.4	10.2	15.5	10.5	7.2	9.0	14.7
-9.0	10.4	11.2	16.4	11.0	6.7	8.1	13.6
-8.5	11.7	12.3	17.2	11.5	6.0	7.4	12.6
-8.0	12.8	13.6	18.1	12.0	5.5	6.8	11.5
-7.5	13.9	14.7	18.5	12.5	4.9	6.1	10.5
-7.0	15.6	16.0	18.9	13.0	4.5	5.6	9.4
-6.5	17.1	17.5	19.0	13.5	4.0	5.0	8.7
-6.0	18.7	18.7	19.0	14.0	3.8	4.5	7.7
-5.5	20.3	20.3	18.6	14.5	3.4	4.0	7.1

-5.5	20.3	20.3	18.6	14.5	3.4	4.0	7.1
-5.0	22.3	21.4	18.1	15.0	3.1	3.7	6.3
-4.5	23.7	22.8	17.8	15.5	2.9	3.4	5.7
-4.0	25.6	23.9	17.2	16.0	2.6	3.1	5.2
-3.5	27.2	24.7	16.6	16.5	2.4	2.9	4.6
-3.0	28.6	25.5	15.8	17.0	2.2	2.6	4.2
-2.5	29.8	26.0	15.5	17.5	1.9	2.4	3.8
-2.0	30.9	26.5	14.9	18.0	1.8	2.1	3.5
-1.5	31.8	26.9	14.5	18.5	1.6	2.0	3.1
-1.0	32.5	27.1	14.3	19.0	1.5	1.8	2.8
-0.5	32.9	27.2	14.1	19.5	1.5	1.7	2.6
				20.0	1.3	1.5	2.3

Graph b/w B and x :-



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Result:- The variation of magnetic field along the axis generated by two Co-axial and identical Current Carrying Coils is depicted in the graph.

clearly, The magnetic field is depend on the seperation between coils by the relation

$$B = \frac{\mu_0 N I}{2r}\left[\frac{1}{\left[1+\left(x-\frac{d}{2r}\right)^2\right]^{3/2}} + \frac{1}{\left[1+\left(x+\frac{d}{2r}\right)^2\right]^{3/2}}\right] \quad \text{---(i)}$$

From graph, when the d = 7cm (i.e equal to the radius of coil), a region of constant Magnetic field is developed. from this experiment, the Magnetic field (B) = 27 Gauss (approx) is developed for a region of $x = -1.5$ cm to $x = 2.0$ cm.

For the separation (d) less than radius of coil, (i.e d = 4cm), the Magnetic field first increasing from $x = -20$ cm to $x = 0$ cm then decreasing over the region $x = 0$ cm to $x = 20$ cm, and the value of Maximum Magnetic field is at $x = 0$cm that is 33.7 Gauss.

For the separation (d) greater than radius of coil, (i.e. d = 14cm), the magnetic field increases from $x = -20$cm to $x = -6$cm then decrease for a region $x = -6$cm to $x = 0$cm then increase for $x = 0$ cm to $x = 7$cm then decrease for $x = 7$cm to $x = 20$cm, so we get Two local maxima in that graph.

Discussion :- To generate nearly constant magnetic field, the seperation b/w^n the coils should equal to radius of coil. i.e $d = r$

applying in equ^n (i)

$$B = \frac{\mu_0 N I}{2r}\left[\frac{1}{\left[1+\left(x-\frac{1}{2}\right)^2\right]^{3/2}} + \frac{1}{\left[1+\left(x+\frac{1}{2}\right)^2\right]^{3/2}}\right]$$

so over a greater region at centre of axis of coil (i.e $x=0$), we got nearly a constant magnetic field i.e

$$B = 0.716\,\frac{\mu_0 N I}{R} = \frac{0.72 \times 4 \times 3.14 \times 10^{-7} \times 390 \times 0.5}{0.07}$$

$B = 27.1$ Gauss.

☆ Magnetic field at any point along central axis of helmholtz coils can be found by summing individual magnetic field of each coil via super position principle.

Precautions :- ① All the magnetic materials and current carrying conductors should be at considerable distance from apparatus.

② Read the position of pointer of hall probe carefully.

③ Pass the current carefully in the coil under its ability of withstand (i.e 1.5 A) normally.