Hanoi University of Science and Technology
School of Engineering Physics

LAB REPORT

For Electrics and Thermodynamics

Experiment 2

Student name : Nguyen Viet Anh
Student ID : 20150143
Group number : 1

Name: Nguyen Viet Anh Date: 1st April 2017
ID : 20150143

Experiment 2

Measurement of magnetic field inside a solenoid with finite length

I. Purpose

- Explore the relationship between the magnetic field and the current through the solenoid.
- Calculate the magnetic field produced by a short, thick solenoid considered as theoretical prediction then compare to the measured fields.

II. Experiment results:

1. Investigation of the magnetic field at the positions along the axis of solenoid - B(x)

***** Measurement result** ($I = 0.35\ (A)$ $U = 6(V)$)

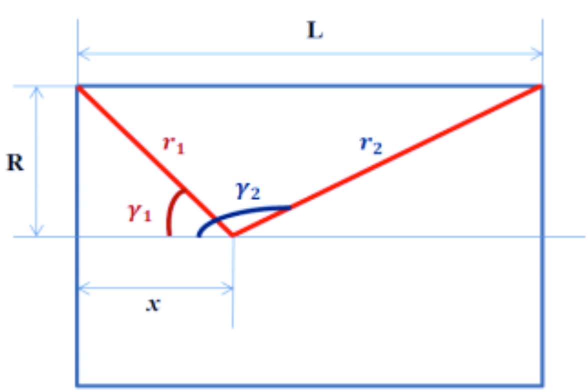
Table 1:

x (cm)	0	1	2	3	4	5	6	7	8	9	10
B (mT)	0.79	1.24	1.43	1.52	1.56	1.59	1.50	1.51	1.51	1.52	1.53

x (cm)	11	12	13	14	15	16	17	18	19	20
B (mT)	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53

x (cm)	21	22	23	24	25	26	27	28	29	30
B (mT)	1.52	1.52	1.50	1.50	1.59	1.57	1.52	1.45	1.29	0.92

***** Calculate using theory:**



- The theoretical magnetic field :

$$B = \frac{\mu_0 \mu_r}{2} I_0.n.(\cos\gamma_1 - \cos\gamma_2) = \frac{\mu_0 \mu_r}{2} I\sqrt{2}.n.(\cos\gamma_1 - \cos\gamma_2)$$

where:

n = 2500turn/m   R = 2.02 cm   L = 30 cm

$\mu_0 = 4\pi.10^{-7} H/m$ $\cos\gamma_1 = \dfrac{x}{\sqrt{x^2+R^2}}$ $\cos\gamma_2 = \dfrac{x-L}{\sqrt{(L-x)^2+R}}$

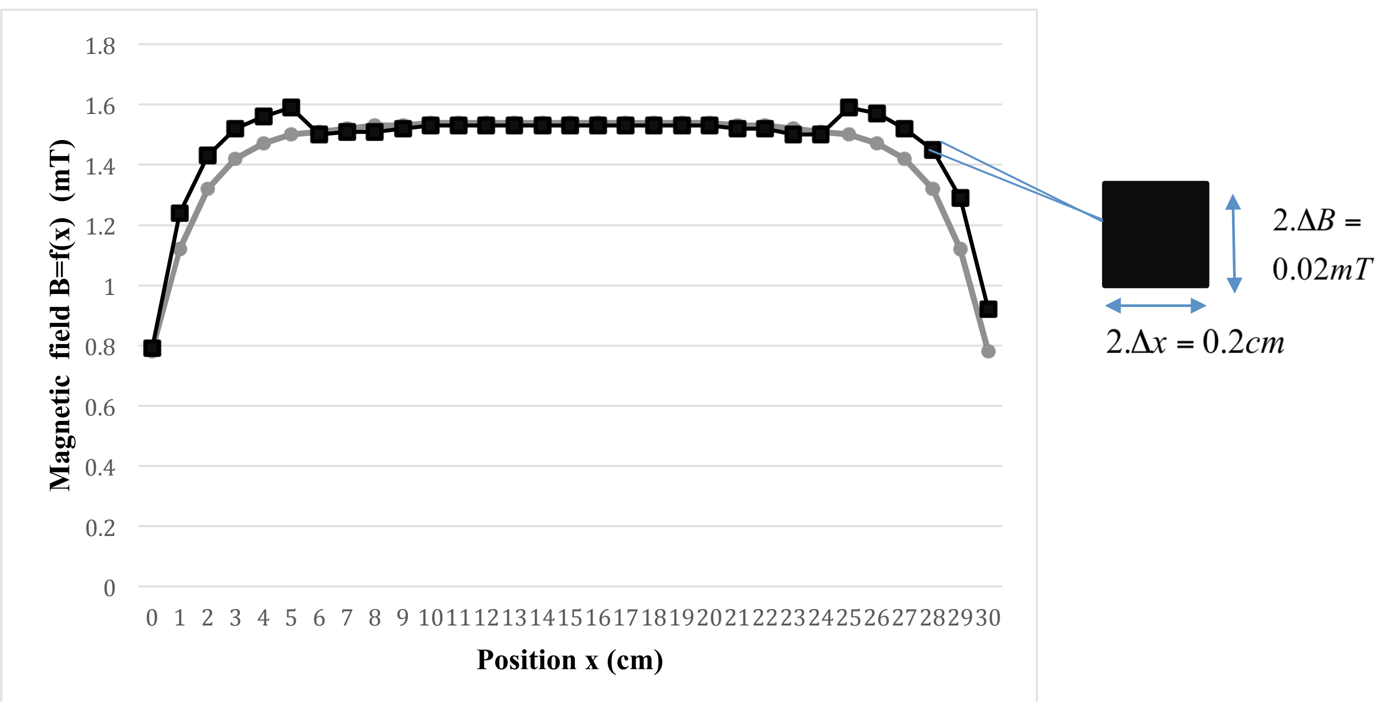
$\mu_r = 1$

⇨ **Theoretical data table**

x (cm)	0	1	2	3	4	5	6	7	8	9	10
B (mT)	0.78	1.12	1.32	1.42	1.47	1.50	1.51	1.52	1.53	1.53	1.54

x (cm)	11	12	13	14	15	16	17	18	19	20
B (mT)	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54

x (cm)	21	22	23	24	25	26	27	28	29	30
B (mT)	1.53	1.52	1.51	1.50	1.47	1.42	1.32	1.12	0.78	1.53



Plot of ***B = f(x)*** based on the measured results.

Comment:

- The graph show that the magnetic field inside a solenoid depends on the position of the probe inside. The magnitude of the magnetic field increase from 0.79 to 1.59 when x from 0 -> 5 cm, and then stable until x = 25cm then decrease with exact the same pace as it increase. The graph is symmetric around the point x=15 (cm)

=> The magnetic field is uniform at the middle and less uniform at two ends.

2. **Measurement of the relationship between the magnetic field and the current through the solenoid - B(I)**

***** Measurement result**

$x = 15cm$

I (A)	0.1	0.2	0.3	0.4	0.5	0.6	0.7
B (mT)	0.65	1.05	1.56	2.06	2.54	3.02	3.53

***** Calculate using theory:**

Theoretical equation:

$$B_0 = \mu_0 \mu_r n I_0$$

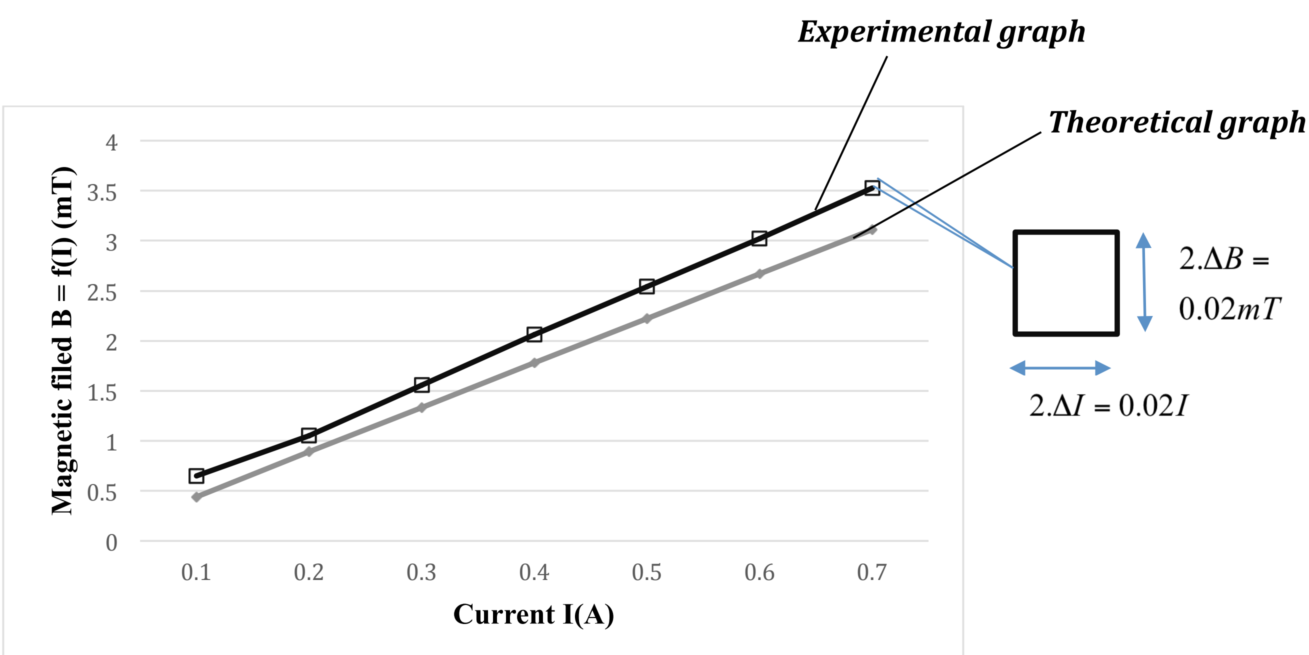
where:

$\mu_0 = 4\pi.10^{-7} H/m$ $\mu_r = 1$ n = 2500turn/m $I_0 = I\sqrt{2}$

⇨ **Theoretical data table:**

I (A)	0.1	0.2	0.3	0.4	0.5	0.6	0.7
B (mT)	0.44	0.89	1.33	1.78	2.22	2.67	3.11

Make a plot of ***B = f(I)*** based on the measured results.



Comment: The graph shows that the magnitude of the magnetic field and the current has a linear relationship (the magnetic field is proportional to the current).

3. **Comparison of experimental and theoretical magnetic field**

   I = 0.4 A

x (cm)	0	15	30
B (mT)	0.92	1.98	1.05

From the measured result table, we see that:

- With a fixed current, the magnetic field has maximum value at $x = 15(cm)$ (at the middle of the solenoid) and min value at x $= 0$(cm) and $x = 30(cm)$ (the beginning and ending point).

We have:

$$B = \frac{\mu_0\mu_r}{2}.I.n_0(cos\gamma_1 - cos\gamma_2)$$

In this case, μ_r=1

$n_0 = \frac{N}{L} = \frac{750}{300\times10^{-3}} = 2500$

$I_0 = I\sqrt{2} = 0.4\sqrt{2} = 0.566$

$cos\gamma_1 = \frac{x}{\sqrt{R^2+x^2}}$

$cos\gamma_2 = -\frac{L-x}{\sqrt{R^2+(L-x)^2}}$

$R = \frac{D}{2} = \frac{40.3}{2} = 20.2\ (mm)$

+) x=0 (cm): $cos\gamma_1$=0; $cos\gamma_2$=-0.998

$B = \frac{\mu_0\mu_r}{2}.I.n_0(cos\gamma_1 - cos\gamma_2) = \frac{1.256\times10^{-6}}{2}\times0.566\times2500\times(0 + 0.998) = 0.89$

+) x=15 (cm): $cos\gamma_1$0.991; cos=-0.991

$B = \frac{\mu_0\mu_r}{2}.I.n_0(cos\gamma_1 - cos\gamma_2) = \frac{1.256\times10^{-6}}{2}\times0.566\times2500\times(0.991 + 0.991) = 1.76$

+) x=30 (cm): $cos\gamma_1$=0.998; $cos\gamma_2$=0

$B = \frac{\mu_0\mu_r}{2}.I.n_0(cos\gamma_1 - cos\gamma_2) = \frac{1.256\times10^{-6}}{2}\times0.566\times2500\times(0.998 - 0) = 0.89$

***** Comparison between theoretical values and experimental values**

x (cm)	$B_{theoretical}$ (mT)	$B_{experimental}$ (mT)
0	0.89	0.92
15	1.76	1.98
30	0.89	1.05

The result from the experiment is approximately close to the theoretical values. The different due to the uncertainty of the instruments used.