MODULE 05

MAGNETIC FIELD IN A SOLENOID

1. EXPERIMENT OBJECTIVES

1.1 Study the magnitude of the magnetic field strength inside and outside the solenoid .
1.2 Determine the relationship between magnetic field strength and electric current,
1.3 Determine the relationship between magnetic field strength and coil density,
1.4 Determine constant permeability magnetic μ_0 .

2. TOOLS USED

Gambar 5.1. Tools used.

2.1 LabQuest2 interface device,
2.2 DC- variable power supply ,
2.3 Rheostat ,
2.4 Amperemeter,
2.5 Magnetic field sensor,
2.6 Solenoid standard board,
2.7 Solenoid and board,
2.8 Connecting wires.

3. BASIC CONCEPTS

A solenoid can be made by winding a wire around a tube in a certain number of turns. If an electric current flows through the solenoid, a magnetic field will be generated inside the solenoid. The magnitude of the magnetic field is expressed by the equation:

$$\boldsymbol{B} = \mu_0 n\ i \qquad (5.1)$$

Where:

B : magnetic field strength (Gauss / Tesla)
μ_0 : permeability constant (Tesla-meter/Ampere)
n : number of turns per unit length of solenoid (1/m)
i : electric current (Ampere)

4. EXPERIMENTAL STEPS

4.1 Experiment Tools Set Up

4.1.1 Set magnetic field sensor to *LabQuest* interface on Channel 1. set up sensor sensitivity to position *High.*

4.1.2 Stretch the Slinky solenoid to 1 m in length. Arrange so that the distance between the coils is approximately the same length.

4.1.3 Make a series circuit of the power supply, ammeter and rheostat. Connect the circuit to the solenoid.

4.1.4 Set the length of the solenoid to 1 meter. Place the sensor in the middle of the solenoid.

4.1.5 Turn on supply Power with voltage 10 V and set current Suite up to 500 mA.

4.1.6 Click the *Zero button* to ignore the influence of environmental magnetic fields.

4.1.7 Observe the magnitude of the magnetic field in *LabQuest.* Rotate the sensor so that the part marked white faces parallel to the solenoid axis. This is the most sensitive sensor position.

4.1.8 Press the button *play* to retrieve data. If the data shown by the Tesla Meter is stable enough, press the *Stop button* and record the value .

4.1.9 Reverse the sensor position, then record the measurement value.

4.2 Observe Strong Magnetic Field Relationship in Solenoid with Electric current

4.2.1 Set the length of the solenoid to 1 meter. Place the sensor in the middle of the solenoid.

4.2.2 Click the *Zero button* to ignore the influence of environmental magnetic fields.

4.2.3 Turn on supply power, set current circuit at 100 mA.

4.2.4 Press the button *play* to retrieve data. After data recording stops, record the average of measured value (using function *Analyze a Statistics)*

4.2.5 Repeat experimental steps 3 and 4 above for each 100 mA increase in current until a current of 700 mA is reached. *(consult with a practicum assistant).*

4.2.6 Repeat the experimental steps with measurements starting from a current of 700 mA to 100 mA (difference of 100 mA).

4.2.7 Tabulate the data that has been obtained in Table 5.1.

Table 5.1. Data from magnetic field measurements of the current applied to the solenoid.

length:				
No	Measurement goes up		Measurement down	
	I(*A*)	*B* (mT)	*I*(*A*)	*B* (mT)
1	0.1		0.7	
2	0.2		0.6	
3	0.3		0.5	
…	…		…	
7	0.7		0.1	

4.3 Observe Strong Magnetic Field Relationship in Solenoid with Coil Density

4.3.1 Set the solenoid length to 1.6 meters. Place the sensor in the middle of the solenoid.

4.3.2 Click the *Zero button* to ignore the influence of environmental magnetic fields.

4.3.3 Turn on supply power , set current Suite up to 700 mA,

4.3.4 Press the button *play* for retrieve data. After data recording stops, record the average of measured value (using function *Analyze a Statistics*)

4.3.5 Repeat steps 1 to 4 for different numbers of coils per meter at several points. (consult with practicum assistant).

4.3.6 Tabulate the data that has been obtained in Table 5.2.

Table 5.2. Data from magnetic field measurements on the number of coils per unit length of the solenoid.

Solenoid length:				
No	Measurement docked		Measurement stretch	
	N/l (turns / m)	*B* (mT)	*N/l* (turns / m)	*B* (mT)
1				
2				
3				
…				

4.4 Observe the distribution of magnetic field values inside and outside the solenoid

4.4.1 Adjust the length of the solenoid until it reaches 1 meter.

4.4.2 Take 9 samples of magnetic field measurement points inside the solenoid as in Figure 5.2 without clicking the Zero button first .

4.4.3 Measure the magnetic field outside the solenoid, namely on each side of the solenoid .

4.4.4 Apply a current of 700 mA to the solenoid.

4.4.5 Record the measurement values according to the specified points.

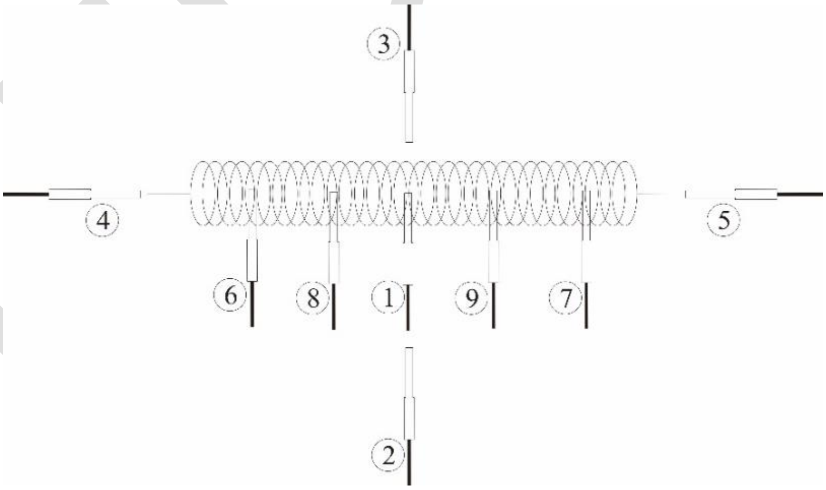

Figure 5.2 Location of measurement.

5. ANALYSIS AND DISCUSSIONS

5.1 Experiment with the tool setup section.

5.1.1 Explain why it is necessary to use the zero button!

5.1.2 Explain why the measured value of B changes sign (+, -) when it is reversed!

5.2 Experiment of magnetic field strength in the solenoid with current electricity relationship.

5.2.1 Create a graph between the electric current as the Y axis and the magnetic field strength as the X axis (first convert the units to SI form)

5.2.2 How is the magnetic field in solenoid a related to electric current ?

5.2.3 Perform linear regression, then determine μ_0.

5.2.4 Count percentage difference mark (error) μ_0 which is obtained through test with reference value

5.3 Experiment of Magnetic Field strength in Solenoid with Density Coil Relationship.

5.3.1 Create a graph between the solenoid coil density as the Y axis and the magnetic field strength as the X axis (first convert the units to SI form)

5.3.2 How is the magnetic field in solenoid a related to the density of the solenoid coils ?

5.3.3 Perform linear regression, then determine μ_0.

5.3.4 Count percentage difference mark (error) μ_0 which is obtained through test with reference value

5.4 Experiment on the distribution of magnetic field values inside and outside the solenoid.

5.4.1 How is the distribution of the magnetic field inside the solenoid ? Explain, and correlate the explanation with Ampere's law.

5.4.2 How is the magnitude of the magnetic field outside the solenoid? Explain, and correlate the explanation with Ampere's law.

5.5 REFERENCES

Bertrand, Peggy Ann. (2015) : *AP Physics 1 and 2 Induiry-Based Lab Investigations*, 243 – 245.

Campbell, Larry., Spector, Donald., Allen, Ted. (2003) : *Physics 160 Laboratory Manual*, Hobart and William Smith Colleges, xix – xxi.

Giri, P. K., (2005) : *Physics Laboratory Manual for Engineering Undergraduates*, Indian Institute of Technology Guwahati, 107 – 109.

Halliday, D., Resnick, R., Walker, J. (2006) : *Fundamentals of Physics 6th Edition*, John Wiley & Sons, 785 – 786.

Lenda, Andrzej. (2000) : *Physics Laboratory*, International School of Technology of Cracow, 41-1 – 41-3.

Sutrisno, (2000) : *Seri Fisika Dasar*, Penerbit ITB, 84 – 85.