

## 40. Magnetic Field of Solenoid A: Measuring $B$ vs. $I$

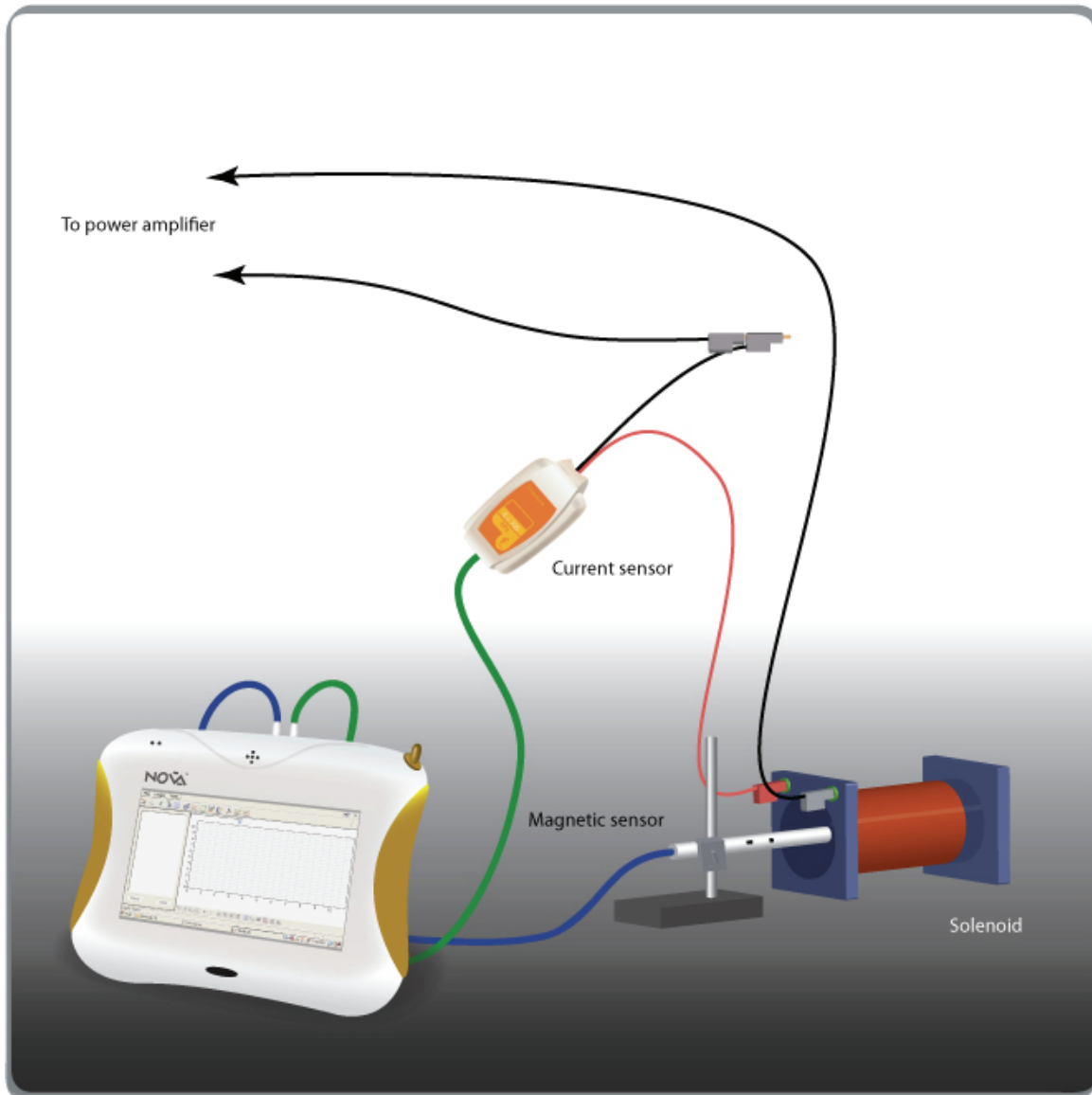


Figure 1

### Introduction

In this experiment we explore the relationship between the magnetic field and the current through the solenoid.



The magnetic field in the center of a solenoid is measured with the help of the Magnetic Field sensor. At the same time the current through the solenoid is measured with a Current sensor.

We use a signal generator to sweep through a range of currents. So we can produce live graph of B vs. I.

In the case of a long solenoid the magnetic field in the center is given by:

$$B = \frac{\mu_0 NI}{\ell}$$

$N$  - Number of turns

$I$  - The current through the solenoid

$\ell$  - The length of the solenoid


$\mu_0$  - The magnetic permeability

## Equipment

- Nova5000
- Solenoid
- Magnetic Field sensor ( $\pm 10$  mT)
- Stand to hold the Magnetic Field sensor
- Current sensor ( $\pm 2.5$  A)
- Signal generator with power amplifier

## Equipment Setup Procedure

1. Launch MultiLab.
2. Connect the Current sensor to Input 1 (I/O-1) of the Nova5000.
3. Connect the Magnetic Field sensor to Input 2 (I/O-2) of the Nova5000.
4. Assemble the equipment as shown by Figure 1.

- a. Place the Magnetic Field sensor so that its end can be placed at the center of the solenoid.
  - b. Set the signal generator to triangular waveform and its frequency to 0.1 Hz.
  - c. Set the output level so that the current won't exceed 2.5 A.
5. Click **Setup**  on the main toolbar and program the data logger according to the setup specified below.

## Data Logger Setup

### Sensors:

Input 1: Current  $\pm 2.5$  A

Input 2: Magnetic Field  $\pm 10$  mT

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### Rate:


100 samples per second

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### Samples:

2000 samples

## Experimental Procedure

1. Place the Magnetic Field sensor so that its end is in the center of the solenoid.
2. Turn on the signal generator.
3. Click **Run**  on the main toolbar to begin recording data.
4. A graph of the results will appear automatically (Figure 3). That will be the graphs of the magnetic field and the current as a function of time. If they don't follow the same trend, change the direction of the current in the solenoid and repeat the experiment.

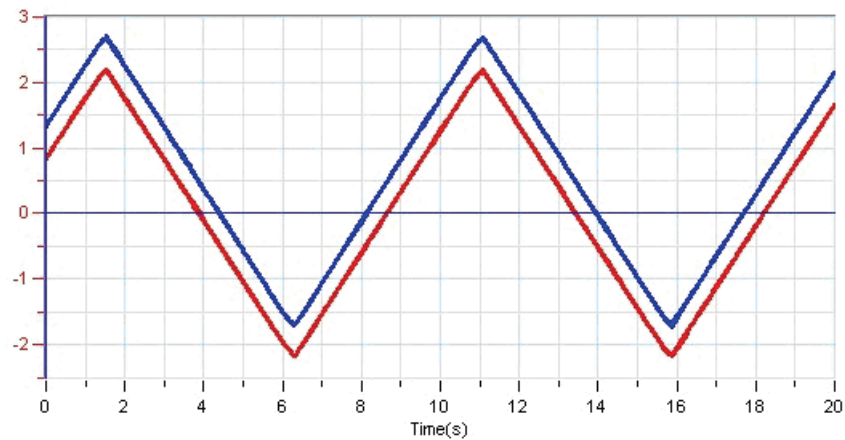



Figure 2

## Data Analysis

1. Click **Format graph**  on the graph toolbar.
2. Select **Exp. # Current I/O-1** in the **X-axis** list then click **OK**.

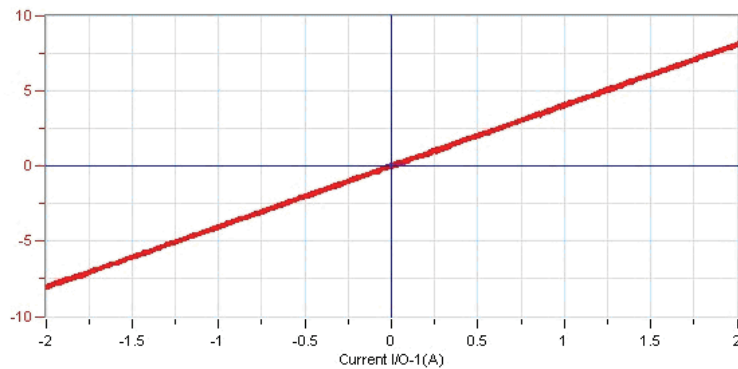



Figure 3

3. Apply a linear fit to the graph: click **Linear fit**  on the main toolbar. The fit equation will be displayed in the information bar at the bottom of the graph window
4. Use the slope of the linear regression to calculate  $\mu_0$  - The magnetic permeability. Write it down in your notebook.
5. Compare your result with the known value:

$$\mu_0 = 4\pi \cdot 10^{-7} \frac{Tm}{A}$$