Experiment P52: Magnetic Field of a Solenoid (Magnetic Field Sensor, Power Amplifier)

Concept	Time	SW Interface	Macintosh® file	Windows® file
magnetism	45 m	700	P52 Mag Field Solenoid	P52_SOLE.SWS

EQUIPMENT NEEDED	
• *Science Workshop* ™*Interface*	• meter stick
• Magnetic Field Sensor	• (2) Patch Cords
• Power Amplifier	• Solenoid*

(*such as the SE-8563 Primary/Secondary Coils)

PURPOSE

The purpose of this laboratory activity is to measure the magnetic field inside a solenoid and compare the magnetic field to a theoretical value based on the current through the solenoid.

THEORY

The magnetic field inside a very long solenoid is given by:

$$\boldsymbol{B} = \mu_o \boldsymbol{nI}$$

where $\mu_o = 4\pi \times 10^{-7}$ (tesla•meters)/amp, $\boldsymbol{I}$ is the current (amps), and $\boldsymbol{n}$ is the number of turns of wire per unit length (#/meter) of the solenoid. Notice that this expression is independent of the radius of the coil and the position inside the coil.

PROCEDURE

In this activity, the Magnetic Field Sensor measures the magnetic field strength inside a cylindrical solenoid. The Power Amplifier provides a direct current through the solenoid.

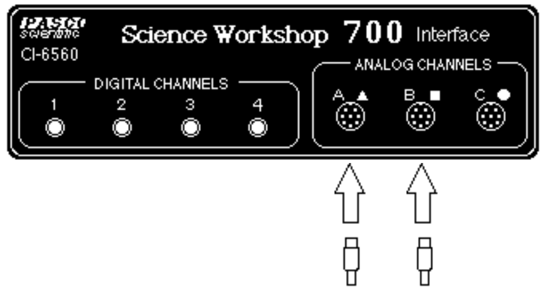
The *Science Workshop* program records and displays the magnetic field, the position, and the current through the solenoid. You will compare the measured magnetic fields inside the solenoid to the theoretical magnetic field calculated on the basis of current and the number of turns of wire per unit length.

PART I: Computer Setup

1. Connect the *Science Workshop* interface to the computer, turn on the interface, and turn on the computer.

2. Connect the Magnetic Field Sensor DIN plug to Analog Channel A on the interface.

3. Connect the Power Amplifier to Analog Channel B. Plug the power cord into the back of the Power Amplifier and connect the power cord to an appropriate electrical receptacle.

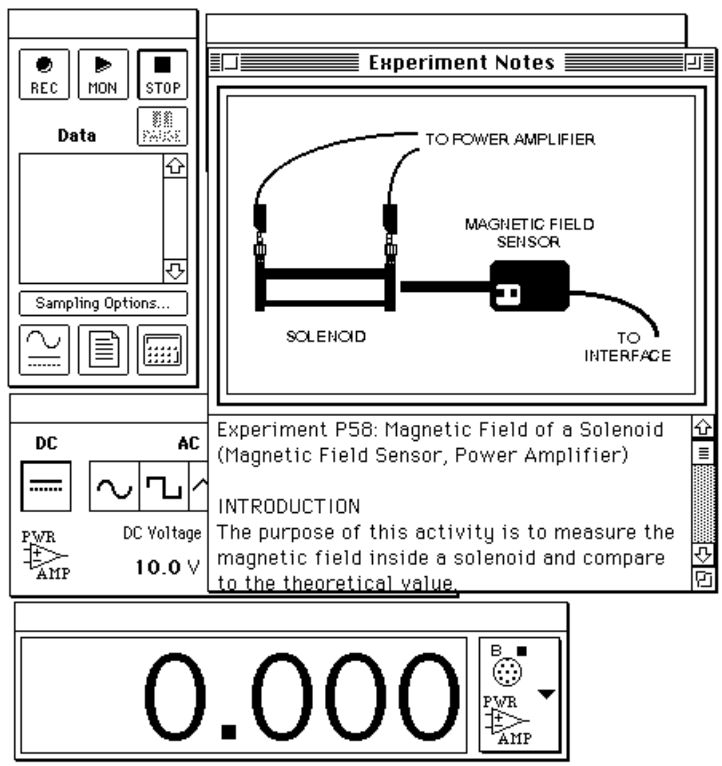


4. Open the *Science Workshop* document titled as shown:

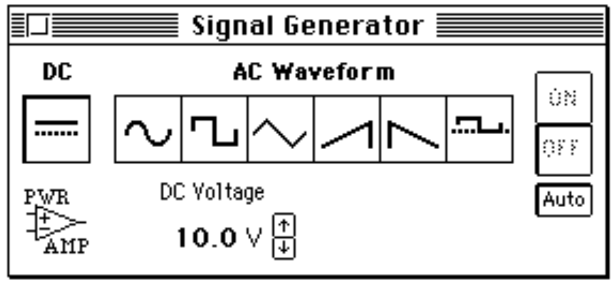
Macintosh	Windows
P52 Mag. Field Solenoid	P52_SOLE.SWS

- The document opens with a Digits display of magnetic field strength and a Digits display of current. It also has the Signal Generator window that controls the Power Amplifier.

- Note: For quick reference, see the Experiment Notes window. To bring a display to the top, click on its window or select the name of the display from the list at the end of the Display menu. Change the Experiment Setup window by clicking on the **Zoom** box or the **Restore** button in the upper right hand corner of that window.



5. The Signal Generator is set to output DC at 10.0 V. It is set to **Auto** so it will start automatically when you click **MON** or **REC** and stop automatically when you click **STOP** or **PAUSE**.



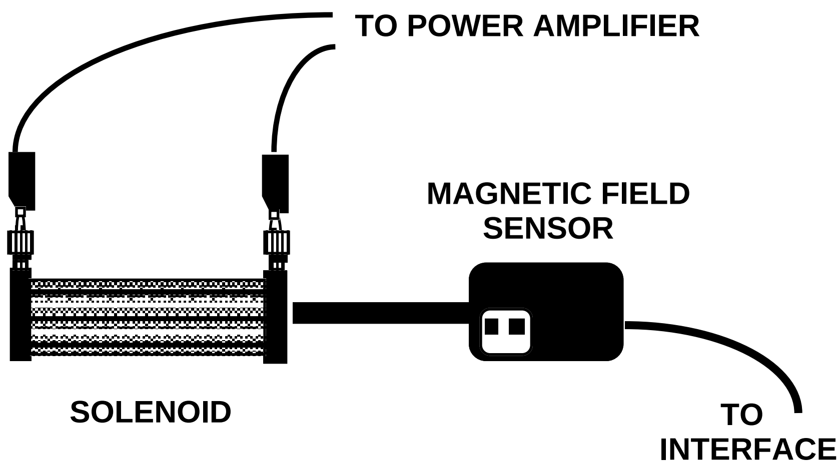
6. Arrange the windows so you can see the Digits display for Current and the Digits display for Magnetic Field Strength.

PART II: Sensor Calibration & Equipment Setup

- You do not need to calibrate the Magnetic Field Sensor or the Power Amplifier. The Magnetic Field Sensor produces a voltage that is directly proportional to the magnetic field strength as follows: 10 millvolts = 10 gauss (where 1000 gauss = 0.1 tesla). The sensor's range is ±2000 gauss.

1. Use only the outer coil of the Primary/Secondary Coil set. Use patch cords to connect the output of the Power Amplifier to the input jacks on the solenoid.

2. Position the solenoid and Magnetic Field Sensor so the end of the sensor can be placed inside the solenoid.

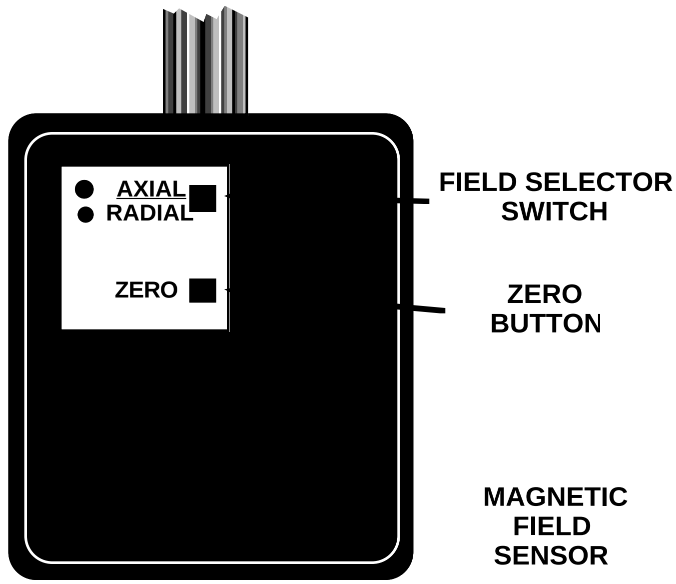


PART III: Data Recording

1. Hold the Magnetic Field Sensor far away from any source of magnetic fields and zero the sensor by pushing the ZERO button on the sensor box.

2. Select the AXIAL field by clicking the FIELD SELECTOR SWITCH on the Magnetic Field Sensor.

3. Return the sensor to its position next to the solenoid.



4. Click the **MON** button (
) to begin monitoring data. The Signal Generator will start automatically.

5. Record the value of current from the Digits display into the Data section.

6. Insert the sensor rod into the center of the coil. Move the sensor around inside the coil to see if the radial position of the sensor changes the reading on the computer.

7. Record the reading for the axial component of the magnetic field inside the coil in the middle, away from either end of the coil. Record this value in the Data section.

8. Remove the Magnetic Field Sensor from the coil. Select the RADIAL field by clicking the FIELD SELECTOR SWITCH on the sensor box. Hold the sensor far away from any source of magnetic fields and re-zero the sensor by pushing the ZERO button on the sensor box.

9. Insert the sensor rod into the center of the coil. Record the reading for the radial component of the magnetic field in the Data section.

10. Measure the length of the solenoid coil.

- Note: When measuring the coil, make sure that you only measure the length of the solenoid with the wrapped coil and not the entire solenoid.

ANALYZING THE DATA

DATA

Recorded Current = ______ amps

Length of Primary Coil = ______ cm

Theoretical Magnetic Field = ______ gauss

Measured Magnetic Fields (gauss)

Axial (gauss)	Radial (gauss)

1. Calculate the theoretical value of the magnetic field inside the coil using the measured current, length, and number of turns for the coil (for the SE-8653 outer coil, the number of turns is 2920). Record this value.

QUESTIONS

1. Did the axial reading change when the sensor was moved radially outward from the center toward the windings on the coil?

2. Was the axial reading different from the reading in the middle of the coil when the sensor was inside but near the ends of the coil?

3. By comparing the axial and radial readings, what can you conclude about the direction of the magnetic field lines inside a solenoid?

4. Compare the theoretical value to the axial value using a percent difference. What are some factors that could account for this percent difference?