Science Objectives

- Students will understand the relationship between magnetic flux density and the strength of the electrical current.
- Students will determine the value of the magnetic constant.

Vocabulary

- Magnetic flux density
- Electric Current

About the Lesson

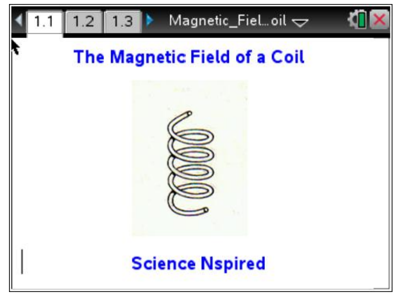
- This lesson demonstrates the proportional relationship between the magnetic flux density at the center of a long, electrically charged coil and the strength of the electrical current. This is a more advanced experiment for high school students.
- As a result, students will:
  - Create a closed circuit
  - Determine a relationship from a graph.
  - Calculate the value for the magnetic constant.
  - Calculate percent error of the experimental value from the given true value.

TI-Nspire™ Navigator™

- Send out the .tns file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.
- Enter items as appropriate for use of TI-Navigator.

Activity Materials

- *Magnetic_Field_of_a_Coil*.tns document
- TI-Nspire™ Technology
- Magnetic Field Sensor
- Data Collection Interface (i.e., EasyLink)
- Coil with 1,000 turns
- Ammeter (moving coil rectifier)
- Low-voltage power supply



TI-Nspire™ Technology Skills:

- Download a TI-Nspire document
- Open a document
- Move between pages
- Collect data using probe

Tech Tip:

Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity

- Magnetic_Field_of_a_Coil_Student.doc
- Magnetic_Field_of_a_Coil_Student.pdf

TI-Nspire document

- Magnetic_Field_of_a_Coil.tns

Discussion Points and Possible Answers

Move to pages 1.2 – 1.4.

Have students answer questions 1 - 2 on the handheld, the activity sheet, or both.

Q1. What do you predict is the relationship between the magnetic flux density inside a coil and the number of turns of the coil?

Answer: The magnetic flux density inside a coil will increase when the number of turns increase.

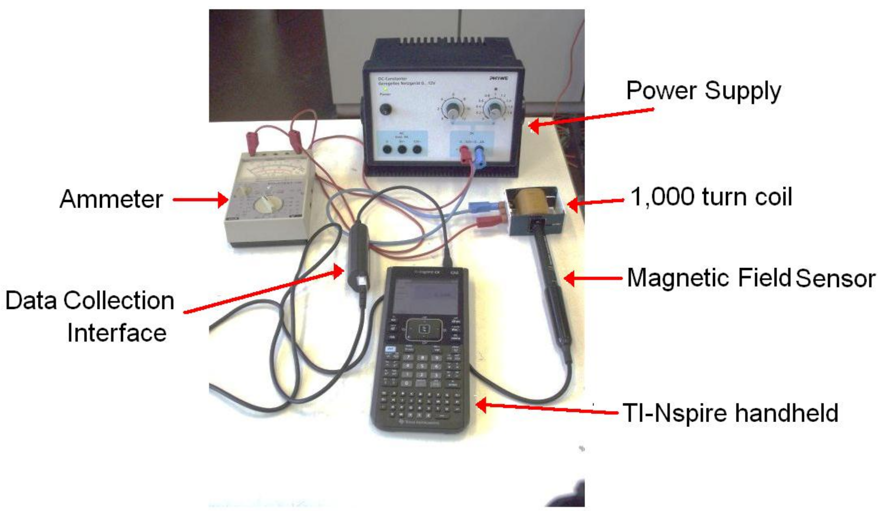
Q2. What do you predict is the relationship between amount of current through a coil and the magnetic flux density?

Sample Answer: The magnetic flux density through a coil is directly proportional to current. When the current increases the magnetic flux density will increase.

Move to page 1.5.

1. Direct students to set up the experiment materials as shown in the picture below. They need to connect the power supply, ammeter and coil. Then they place the Magnetic Field Sensor into the coil in an axial position.

2. Students will then connect the sensor to the data-collection interface, such as EasyLink™ or the Lab Cradle, and connect the interface to the TI-Nspire handheld or computer.



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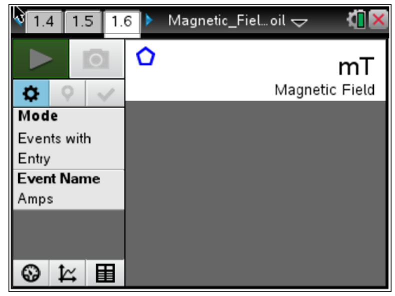
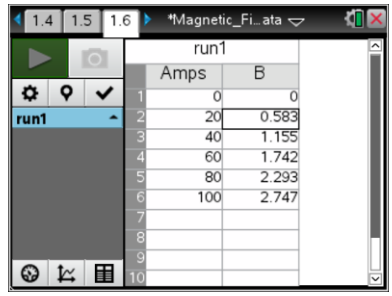


3. The data collection has already been set up for students in the .tns file. If students do not see the experiment set up as Events with Entry listed in the gray box on the right, they need to choose **Menu > Experiment > Collection Mode** and select **Events with Entry**. Enter **Amps** as the Name. Select OK.
4. Students can now turn on the power supply and set it to 0 mA.



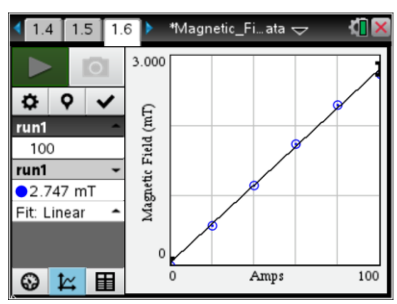
5. Click the **Start Data Collection** button . When ready to record a magnetic field reading, students are to click the Keep button and type the amount of amperage. The first entry should be when the amperage is 0. Record the magnetic field reading in the data table.

6. To complete the experiment, students are to increase the amperage in intervals of 20 mA up to 100 mA. For each voltage, they will click the Keep button to record the data. Note: The last column, magnetic constant will be calculated later.

<u>**Sample Data**</u>:

Amps (mA)	Magnetic Field (mT)	Magnetic Constant
0	**0**	**--**
20	**0.583**	**0.00137**
40	**1.155**	**0.00136**
60	**1.742**	**0.00136**
80	**2.293**	**0.00135**
100	**2.747**	**0.00135**

7. When students click the **Graph** tab they will see a graph of the results of their experiment. They need to sketch the results on graph on the activity sheet.



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Have students answer questions 3 - 6 on the handheld, the activity sheet, or both.

Q3. What is the relationship between the magnetic flux density and the electrical current? Explain your findings.

<u>Answer</u>: The magnetic flux density inside a long, air-filled, coil behaves in direct proportionality to current. A line through the origin is produced in the diagram.

Q4. The equation for magnetic flux density at the inside of a coil is $B = \mu_0 \cdot \mu_r \cdot \frac{I \cdot n}{l}$, where μ_0 is the magnetic constant, μ_r is the relative permeability, *n* is the number of coils, *I* (uppercase i) is the electrical current, and *l* (lowercase L) is the length of the core. Solve the equation for μ_0. Calculate the value for the magnetic constant μ_0 for each row in the table in step 6.

<u>Answer</u>: $\mu_0 = \frac{B \cdot l}{\mu_r \cdot I \cdot n}$; It is important to note, that *B* is measured in mT.

Q5. Calculate the average value for the magnetic constant from the values in the third column of your data table. Compare the average value to 1.26 × 10^{-6} Vs/Am.

<u>Sample Answer</u>: μ_0 = 1.346 × 10^{-6} Vs/Am

Q6. Percent error can be found using the formula $\frac{|\text{experimental value} - \text{true value}|}{\text{true value}} \times 100$. Calculate the percent error using the experimental value (average value) and the true value, 1.26 × 10^{-6} Vs/Am.

<u>Sample Answer</u>: $\frac{|1.346 \times 10^{-6} - 1.26 \times 10^{-6}|}{1.26 \times 10^{-6}} \times 100 = 6.8\%$

TI-Nspire Navigator Opportunities

Make a student a Live Presenter show their results of the experiment. Throughout the lab, discuss the activity with students using Slide Show. At the end of the lab, collect the .tns files and save to Portfolio.

Wrap Up

When students are finished with the activity, pull back the .tns file using TI-Nspire Navigator. Save grades to Portfolio. Discuss activity questions using Slide Show.

Assessment

- Formative assessment will consist of questions embedded in the .tns file. The questions will be graded when the .tns file is retrieved. The Slide Show will be utilized to give students immediate feedback on their assessment.
- Summative assessment will consist of questions/problems on the chapter test.