Bell Ringer: Change in Magnetic Field Strength with Distance – ID: 13739

Based on an activity by Russell Brown

Time required
15 minutes

Topic: Electricity and Magnetism

- *Map and describe the magnetic field around a permanent magnet or electromagnet.*

Activity Overview

In this activity, students will use a precompiled data set to determine the relationship between magnetic field strength and the distance from a magnet.

Materials

To complete this activity, each student will require the following:

- *TI-Nspire™ technology*
- *pen or pencil*
- *blank sheet of paper*

TI-Nspire Applications

Calculator, Graphs & Geometry, Lists & Spreadsheet, Notes

Teacher Preparation

Students will probably be familiar with the effects of magnets, but may not know the quantitative relationships between magnetic field strength and distance. Before beginning this activity, review the concept of magnetic field strength with students.

- *The screenshots on pages 2–4 demonstrate expected student results. Refer to the screenshots on page 5 for a preview of the student TI-Nspire document (.tns file).*
- ***To download the student .tns file and solution .tns file, go to education.ti.com/exchange and enter "13739" in the search box.***
- *This activity is related to activity 8548: A Magnetic Attraction. If you wish, you may extend this bell-ringer activity with the longer activity. You can download the files for activity 8548 at education.ti.com/exchange.*

Classroom Management

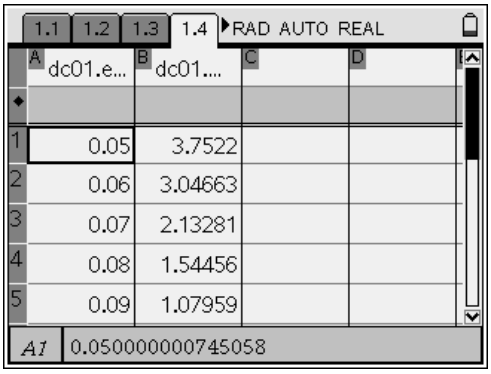
- *This activity is designed to be **teacher-led** with students following along on their handhelds. You may use the following pages to present the material to the class and encourage discussion. Note that the majority of the ideas and concepts are presented only in **this** document, so you should make sure to cover all the material necessary for students to comprehend the concepts.*
- *Students may answer the questions posed in the .tns file using the Notes application or on blank paper.*
- *In some cases, these instructions are specific to those students using TI-Nspire handheld devices, but the activity can easily be done using TI-Nspire computer software.*

The following question will guide student exploration in this activity:

- What is the relationship between the strength of a magnetic field and the distance from its source?

Students will use a precollected data set to determine the relationship between magnetic field strength and distance. The data were collected using a magnetic field sensor.

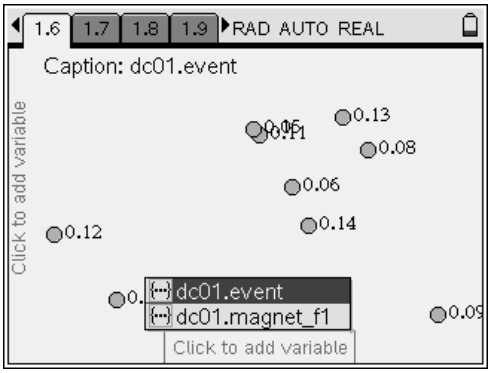
Step 1: Students should open the file **PhysBR_week29_mag_field.tns** and read the first three pages. They should then move to page 1.4, which shows magnetic field strength and distance data for a magnet. Students should study the data and answer question 1.

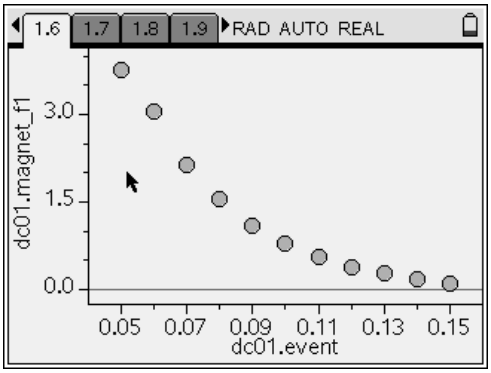


Q1. Predict the functional form of the magnetic field strength vs. distance relationship.

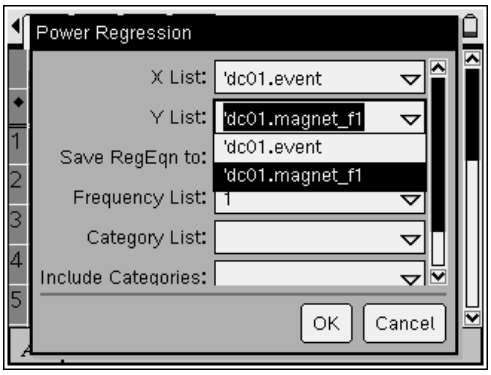
A. *Students' answers will vary. Encourage them to justify their answers.*

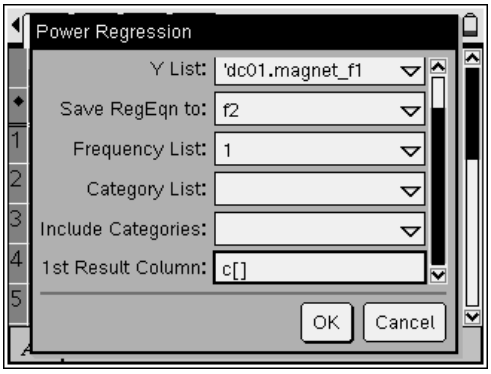
Step 2: Next, students should move to page 1.6 and create a plot of magnetic field strength vs. distance for the data. To make the plot, students should click (press ⓔ) on the area just below each axis. A list of available variables will pop up. They should choose **dc01.event** for the *x*-variable and **dc01.magnet_f1** for the *y*-variable. Alternatively, they can add the *x*- and *y*-variables using the **Plot Properties** menu (**Menu > Plot Properties > Add X Variable** or **Add Y Variable**). Discuss the shape of the graph with the students. Some students will probably assume that this is an inverse-square relationship. Ask them how they could determine whether an inverse-square function fits the data. They should reason that a power regression can provide information about the curve. You may need to guide them to this conclusion.

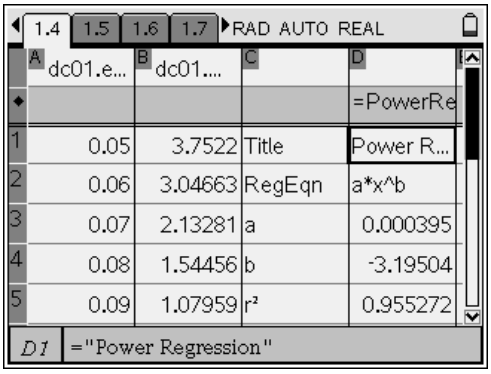




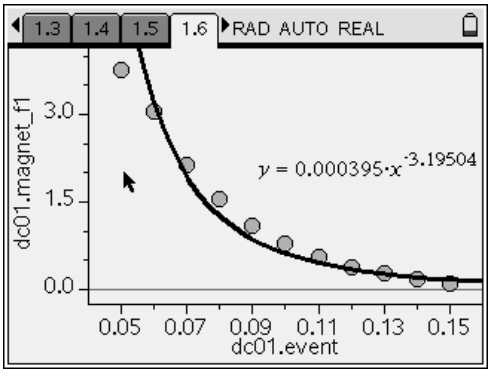
Step 3: Next, students should carry out a power regression (**Menu** > **Statistics** > **Stat Calculations** > **Power Regression**) on Columns A and B on page 1.4. They should use Column A (**dc01.event**) for the *X List* and Column B (**dc01.magnet_f1**) for the *Y List*. They should store the values in Column C. Discuss the calculated value of variable *b* with students. They should conclude that the relationship is not, in fact, an inverse-square relationship. Instead, it is an inverse-cube relationship—that is, magnetic field strength decreases in direct proportion to distance cubed.







Step 10: Next, students should graph the regression equation on the plot of the data on page 1.5. They should use the **Regression** tool (**Menu > Analyze > Regression**) to plot the regression.



Finally, students should answer questions 2–5. The questions and their answers (in italics) are given below.

Q2. Was the prediction you made in question 1 correct? If not, identify any errors in your reasoning.

A. *Students' answers will vary. Encourage metacognitive thinking to help students identify their errors in reasoning.*

Q3. How well do the results of the power regression support the "ideal" relationship between field strength and distance given below?

$$B = \frac{\mu_0}{4\pi}\frac{2\mu}{d^3}$$

(In this equation, μ_0 and μ are constants.) Explain your answer.

A. *The results of the power regression agree with the "ideal" relationship. The ideal relationship indicates that magnetic field intensity should decrease in inverse proportion to distance cubed, and the power regression yields an exponent of nearly –3.*

Q4. How does the decrease in magnetic field strength with distance compare to the decrease in light intensity with distance? Which decreases more rapidly?

A. *Magnetic field strength decreases by distance cubed, and light intensity decreases by distance squared. Therefore, magnetic field strength decreases more rapidly with distance than does light intensity.*

Q5. Magnet A is twice as strong as magnet B. At which point will the magnetic field strength be greater: 2*x* cm from magnet A, or *x* cm from magnet B? Assume the field strength follows the same functional form as the one you explored in this activity. Explain your answer.

A. *The magnetic field strength of magnet A,* B_{A0}*, is twice that of magnet B,* B_{B0}*. In other words,* $B_{A0} = 2B_{B0}$*. The following equations can be written:*

$$B_A \propto \frac{B_{A0}}{d_A^3}$$

$$B_B \propto \frac{B_{B0}}{d_B^3}$$

Substituting yields the following:

$$B_A \propto \frac{B_{A0}}{d_A^3} = \frac{2B_{B0}}{(2d_B)^3} = \frac{2B_{B0}}{8d_B^3} = \frac{B_{B0}}{4d_B^3}$$

*Therefore, the magnetic field strength 2*x *cm from magnet A is one-quarter that at* x *cm from magnet B.*

Suggestions for Extension Activities: If you wish, you may have students collect their own magnetic field strength data to confirm this relationship. They could also investigate the magnetic field around induced magnets or study the field around magnets with different shapes.

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(Student)TI-Nspire File: *PhysBR_week29_mag_field.tns*