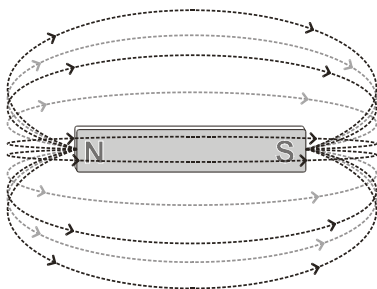


Magnetic Field vs. Distance - EZ

Magnetism is an inherent quality of a magnet that allows it to interact with other objects with a force of attraction or repulsion. Magnets strongly attract materials made of iron, nickel, or cobalt plus some other rare elements. Such materials are called *ferromagnetic* as opposed to *paramagnetic* materials which are weakly attracted to magnets. A third class of materials are called *diamagnetic* and repel the effects of magnetic fields.



Magnetic field around a bar magnet

The field lines are more concentrated near the poles of the magnet so the magnetic field is said to be stronger near the poles. The strength of the magnetic field can be measured using a Magnetic Field Sensor. The more magnetic field lines that pass through the white dot on the sensor, the stronger the field. When the field lines pass into the end of the sensor with the white dot, the magnetic field reading is negative. What do you think would happen if the Magnetic Field Sensor were turned around so that the lines went outward from the white dot?

OBJECTIVE

In this experiment, you will investigate how the strength of the magnetic field from a bar magnet varies with distance from the magnet.

MATERIALS

TI-84+ graphing calculator
CBL2
Magnetic Field Sensor

unmarked bar magnet or cow magnet
masking tape
meter stick

PROCEDURE

1. Tape the Magnetic Field Sensor to the table with the white dot facing sideways. You may wish to bend the probe tip if it works better with your experimental station. Tape the meter stick so it lines up with the tip of the probe and starts from 0.0 at the end of the probe.

Magnetic Field

2. Prepare your calculator for data collection by plugging the Magnetic Field Sensor into one of the analog jacks on the CBL2. Set the switch to the 0.2 mT or LOW $\times 10$ amplification setting. Launch *EasyData* under the [APPS] key. Note that the Magnetic Field Sensor has been detected and a default data collection has been set up for you.
3. Press the button under [File] and then select **New** to reset the application. Press the button under [Setup] then select **Events with Entry**.
4. Press the button under [Setup] then choose **Zero**. The Zero Sensor(s) screen is displayed with a continually updated sensor reading. When the displayed reading stabilizes, press the button under [Zero].
4. Move all magnets far away from the Magnetic Field Sensor. Zero the Magnetic Field Sensor by pressing the button under [Setup] then choose **Zero**. The Zero Sensor(s) screen is displayed with a continually updated sensor reading. When the displayed reading stabilizes, press the button under [Zero]. This cancels out the effect of surrounding magnetic fields on the readings you will be taking.
5. Lay the magnet along the meter stick with one end 40 cm from the sensor. Begin data collection by pressing the button under [Start]. Note that a [Keep] menu choice appears on the screen. No data is recorded until you press the button under [Keep].
6. When the readings stabilize, press the button under [Keep]. On the window that appears, enter the distance (40). Press the button under [OK] to complete recording this data point.
7. Now move the magnet towards the sensor in 5-cm increments, repeating step 6 but entering the respective distances. When you have finished 5 cm, you may wish to include 2.5 cm, also.
8. Press the button under [Stop]. Examine the graph and characterize what it tells you about how the magnetic field varies as you move away from the end of the magnet.
9. Press the button under [File] and choose **Store Run**. This stores your run and readies *EasyData* to take a second run.
10. Place the magnet 40 cm from the sensor with the opposite end pointing towards the sensor. Repeat steps 6-8.
11. How does this second graph compare to the first one? Are there any similarities? Are there any striking differences? Why do you think the biggest difference occurred?
12. To see both graphs together, press the button under [Plots] and select the option which will show L2 and L3 vs L1.
13. Export the data to Logger Pro, sketch or print the graph as directed by your teacher.

ANALYSIS

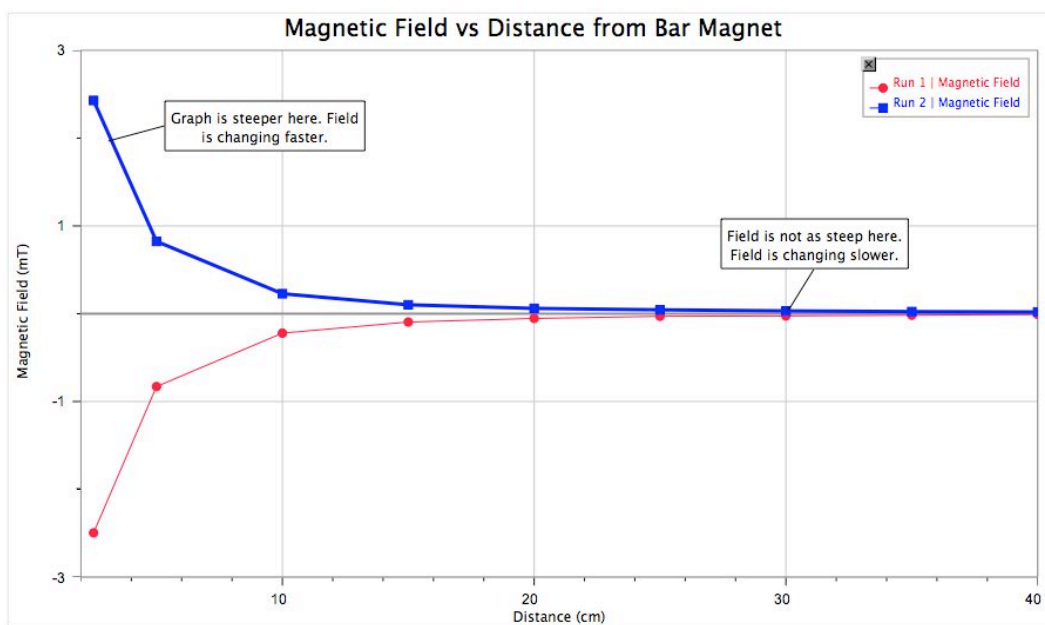
1. As you examine the graphs you obtained, does the strength of the magnetic field change at a constant rate as you move away from the end of a bar magnet? If not, where does it change the fastest, near the end or far from the end? (Note that this is not asking about how strong the magnetic field is.)
2. Are the two graphs symmetric, that is, at a given distance do they have the same values? What does your answer tell you about the poles on your magnet?
3. How would you expect the graphs to change if you replaced your magnet with one that is stronger?

TEACHER NOTES

NOTE

This lab assumes a fairly weak bar magnet. If yours is strong, the Magnetic Field Sensor may reach its maximum value early in the experiment and not go any higher. Stop data collection and change the switch to the 6.4-mT (High) setting. Press on the button under **File** then choose **New**. Go back to Procedure step 3 to take fresh data. Be sure to zero the Magnetic Field Sensor again with this new sensitivity.

SAMPLE DATA



ANSWERS

1. Nearer to the magnet, the rate the magnetic field changes is greater than when one is farther from the magnet. The slope (steepness) of the graph is greater, meaning that for the same change in distance, there is a larger change in the magnetic field strength.
2. If your answer is "yes", the strengths of the two poles are nearly the same. Sometimes you will find a magnet that has one pole that is stronger than the other, although this is unlikely with new magnets.
3. The graphs would look very similar, but they would go to higher values at every point. Thus they would curve up faster and go higher.

Clarence Bakken
February 2008