Name Period Date

33. Magnetic Field: Permanent Magnet

Driving Question

How do you think the strength of the magnetic field of a permanent magnet changes as you get farther away from the magnet.

Background

The presence of magnetic fields permeates everyday life in many ways. A microwave oven contains a magnet that aides in directing radiation towards the center of the oven. Stereo speakers contain magnets that control the coils that accept the audio signals. Basic electric motors consist of magnets.

The strength of a magnetic field is measured in Tesla and varies with distance from a magnet. The strength of the magnetic field could vary inversely as the square of the distance, similar to the strengths of gravitational field or light from a point source. Or, the strength of the magnetic field could vary in a different way relative to the distance. A gravitational or electric field is radial, which means they radiate from a point. Magnetic fields consist of complete loops that surround and go through the magnet forming to distinct poles (north and south). What influence do you think this difference in the fields will have on the strength of a magnetic field over distance?

Materials and Equipment

For each student or group:

- Data collection system
- Magnetic field sensor
- Sensor extension cable (optional)
- Neodymium magnet (1/2" or 3/4")
- Meter stick (non-metallic)

Safety

Add these important safety precautions to your normal laboratory procedures:

- Keep magnets away from computers.
- Keep the magnet away from the magnet field sensor when you zero the sensor.

Sequencing Challenge

The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.

○	○	○	○
Place a magnet next to the 5 cm mark on the meter stick with the north pole of the magnet facing the sensor.	Place the magnetic field sensor so the end of the probe is even with the zero end of the meter stick.	Record a manually sampled data point for every 1cm increase in the magnet's position.	Place a meter stick on a flat surface.

Procedure

After you complete a step (or answer a question), place a check mark in the box (☐) next to that step.

Note: When you see the symbol "�" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Set Up

1. ☐ What two quantities will you measure?

____

2. ☐ What tools will you use to help you make these measurements?

____

3. ☐ Start a new experiment on the data collection system. �(1.2)

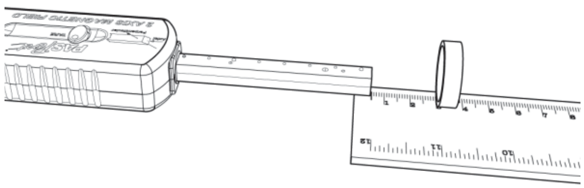
4. ☐ Connect the magnetic field sensor to the data collection system. �(2.1)

5. ☐ Put your data collection system into manual sampling mode with manually entered data. Name the manually entered data “Distance” and give it units of meters. �(5.2.1)

6. ☐ Display Magnetic Field on the y-axis of a graph with Time on the x-axis. �(7.1.1)

7. ☐ Change the variable on the x-axis to Distance. �(7.1.9)

8. ☐ How do you think the magnetic field will change with distance? Draw a prediction in the Magnetic Field versus Distance Prediction blank graph axes in the Data Analysis section. Be sure to label the graph axes.



9. ☐ Set the meter stick flat on a table.

10. ☐ Set the magnetic field sensor on the table so that the tip of the sensor is aligned with the "0 cm" marker on the meter stick.

11. ☐ If the sensor you are using has a Tare button, press it before bringing the magnet near the sensor.

12. ☐ Set the magnet on the table against the meter stick with the end of the north pole pointed towards the tip of the magnetic field sensor.

13. ☐ Slide the magnet along the meter stick until it is aligned with the 5 cm marker on the meter stick (0.05 m away from the tip of the sensor).

Collect Data

14. ☐ Go to the data table you created on the data collection system.

15. ☐ Make sure the north end of the magnet points toward the magnetic field sensor. If the magnetic field reading is negative, turn the magnet around.

16. ☐ Start a manually sampled data set �(6.3.1)

17. ☐ Starting at 0.05 m (5 cm) and ending at 0.15 m (15 cm), record a magnetic field value for each centimeter of distance, moving the magnet 1 cm at a time between each recorded value. �(6.3.2)

18. ☐ Stop the manually collected data set. �(6.3.3)

Analyze Data

19. ☐ Go to the Magnetic Field versus Distance graph you created on the data collection system.

20. ☐ Sketch the graph of Magnetic Field versus Distance in the Magnetic Field versus Distance blank graph axes in the Data Analysis section.

21. ☐ Based on this graph, what do you think the mathematical relationship is between the strength of the magnetic field and the distance from the magnet?

22. ☐ Apply a "Power" curve fit to the graph on your data collection system. �(9.5)

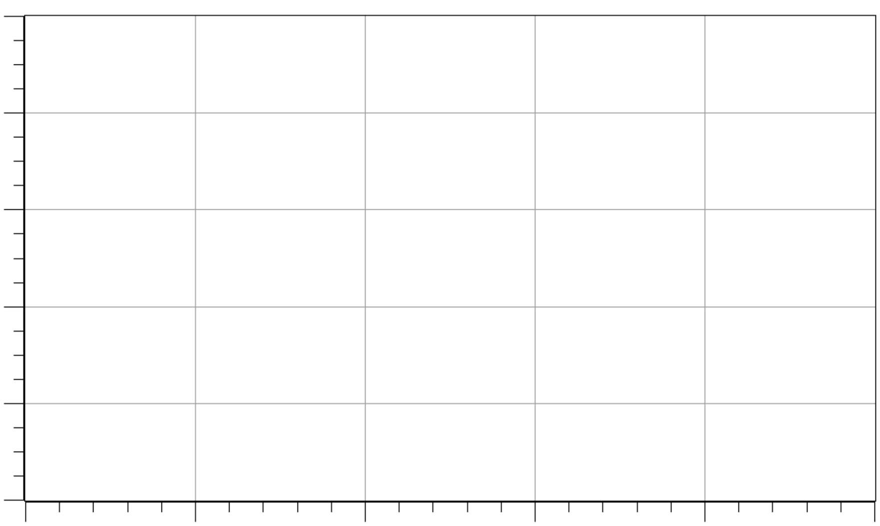
Note: If your data collection system does not support curve fits other than linear, try linearizing your data by building a calculation on the data and then applying the linear curve fit. If the linear curve fit is successful then the calculation describes the relationship between the variables.

23. ☐ Add the curve fit to your sketch in the Magnetic Field versus Distance graph in the Data Analysis section.

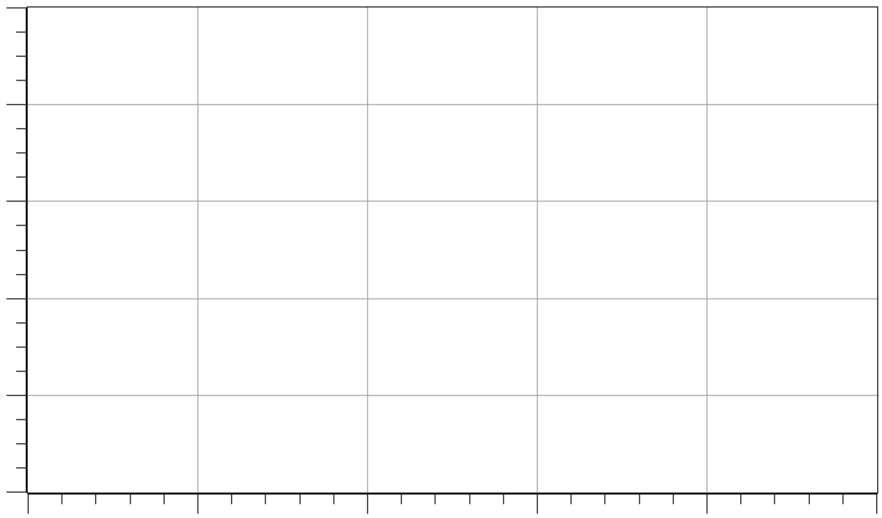
24. ☐ Save your experiment as instructed by your teacher. �(11.1)

Data Analysis

Magnetic Field versus Distance Prediction



Magnetic Field versus Distance



Analysis Questions

1. How does the actual graph compare to your prediction?

2. How well did your curve fit match your data?

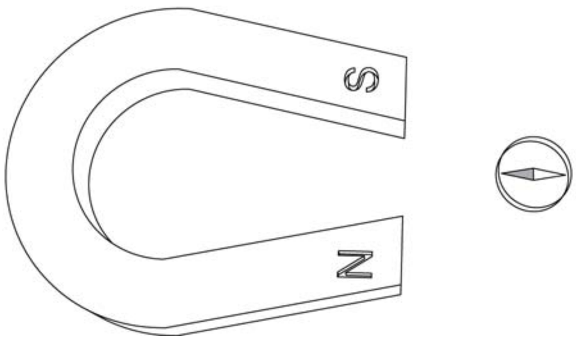
3. Was the mathematical relationship you chose in the Analyze Data Section representative of the theoretical relationship?

4. From the result of your curve fit, what do you conclude is the mathematical relationship between the magnetic field strength and distance?

Synthesis Questions

Use available resources to help you answer the following questions.

1. **The needle in a compass acts like a tiny bar magnet. When the needle is in the presence of a strong magnetic field, it will align itself with that field. If the red end of the needle represents the south pole of the "magnet," which direction would the red end point if the compass were placed between the poles of the magnet?**



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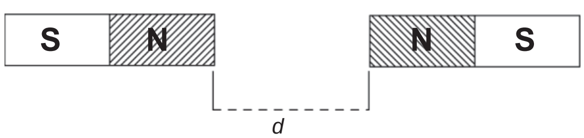
2. **If you had two identical bar magnets separated by distance d with the north pole of each magnet facing the other, what value would your magnetic field sensor read at distance *d*/2 (exactly half way between the magnets)?**



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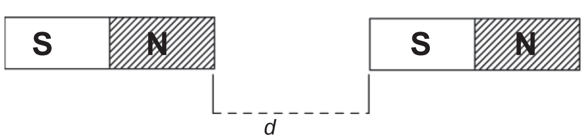
3. **If each magnet alone produces an axial magnetic field strength of 0.25 T at a distance *d*/2, what value would your magnetic field sensor read at distance *d*/2 if the north and south poles were facing each other a distance *d* apart?**



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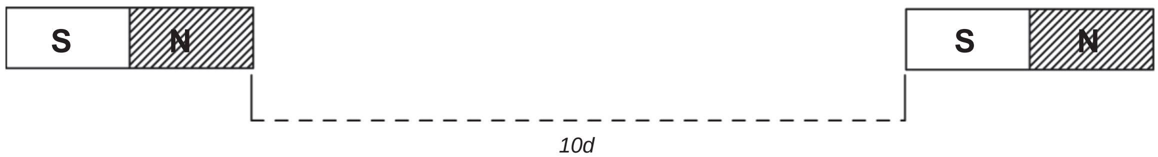
4. How will the magnetic field strength measured half way between the magnets change (increase, decrease, or stay the same) if the distance between the magnets in increase*d* from d to 10*d*?



Multiple Choice Questions

Select the best answer or completion to each of the questions or incomplete statements below.

1. A compass is positioned at a location near the north pole of a bar magnet with the white end of the needle pointing towards the north pole. How does the compass needle orient itself when placed near the south pole?

- **A.** The white end of the needle remains pointing towards the north pole
- **B.** The white end of the needle points perpendicular to the north pole
- **C.** The white end of the needle points away from the south pole
- **D.** The white end of the needle points inward towards the south pole.

2. As the magnitude of the magnetic field of a permanent (disc) magnet increases, the position of the sensor from the magnet will ____________.

- **A.** Increase
- **B.** Decrease
- **C.** Remain the same
- **D.** Decrease to zero

Key Term Challenge

Fill in the blanks from the list of randomly ordered words in the Key Term Challenge Word Bank.

1. Magnets come in many shapes and sizes, but all of them have two poles. We identify the poles as ________________ and South. An example of a strong ________________ magnet is called a neodymium magnet. A simple device, such as a ________________, is an example of a weak permanent ________________. The units for magnetic field strength are named after their founding fathers; such as ________________ and Gauss.

Key Term Challenge Word Bank

Paragraph 1

Bar

Compass

Magnet

North

Permanent

Tesla

West