

Magnetic Mining

Student worksheet

Name: _____

Date: _____

Word Bank

(when appropriate, use these words in your short answers)

- Magnet
- Magnetic field
- Magnetic force
- Ferromagnetic material

Introduction

1. Write a brief description of what a magnet is.
2. Watch the introductory video and take notes below to answer the following questions:
 - What is special about the mines they are talking about in the video?
 - How were the mines able to detect a ship and destroy it?

Part 1: Find the Mines!

Follow these steps to do your investigations.

1. Find your group team members and gather all your materials, including your mobile device:
 - 7 ceramic disc magnets. Make 2 double magnets by placing 2 magnets on top of 2 other magnets. This gives you a total of 5 magnets (3 single and 2 double).
 - 5-6 pieces of grid paper (one grid paper copy on dark paper).
 - Duct tape

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- Pencil or pen
 - Mobile device with a sensor app, such as phyphox
 - Shoebox or transparent box with aluminum foil. If the box is transparent, use the aluminum foil to cover the sides of the box.
2. In your sensor app, open the magnetometer. If you need help with the app, ask your teacher.
 3. Make sure there are no metallic or magnetic (iron, steel, or nickel) objects close to the magnetometer. Write down below what your baseline reading for the magnetometer is:

My baseline reading is _____.

4. Locate the magnetometer in your mobile device by slowly moving one of the disc magnets (not too close) across the surface of your device while the magnetometer is taking measurements. Where the magnetometer readings are highest is where the magnetometer is located. Keep its location in mind for all your future measurements.
5. Using your disc magnets, practice taking measurements with the sensor app. During your investigation, try to answer the following questions and write your observations below. Make sure to record data that demonstrates your observations.
 - What happens when you bring a magnet close to the magnetometer?
 - What types of readings do you get?
 - How close does the magnetometer need to be to detect the magnet?
 - What factors affect the strength of magnetic force?
6. Cut one sheet of grid paper to fit inside of your box. Secure the paper with duct tape.
7. Decide where you will place your magnets (3 single magnets and 2 double magnets). When you have chosen where they will be located, use one of your sheets of grid paper to create a “key”

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with the magnets labeled clearly (also indicating if it is a double or single magnet) and tape the magnets down securely with duct tape. Write your names on the “key” sheet and turn it in to your teacher. You might also want to take a picture of your design for your records.”

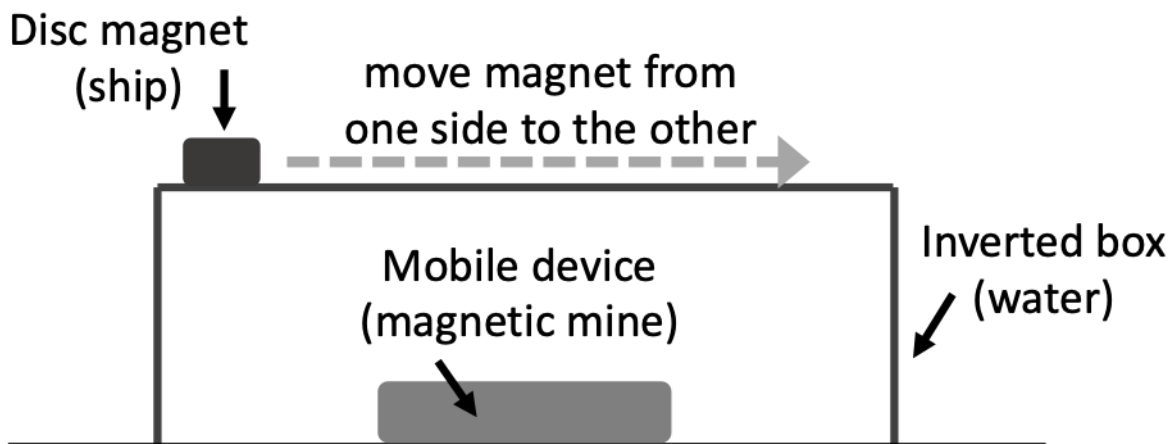
8. Cover the box with the dark construction paper and align its grid with the grid in your box. Make sure nobody can see inside your box and mark the box with your names.
9. Grab the extra grid paper printouts and your mobile device with the sensor app and move from your table to another. Leave your covered box behind. Use **ONLY** the magnetometer to determine where each of the groups placed their mines (the single and double magnets). You are not allowed to touch the boxes!
10. Review your data and recordings from the sensor app. Then, depending on your magnetometer readings, mark on a new grid paper where you think which of the magnet mines is located and whether it is a single or double magnet.
11. Then move on to the next table and repeat your mine search until you have filled out a grid paper with marked magnet locations for each group.
12. Once you are done, discuss the following with your group.
 - What was **EASY** about finding the magnets?
 - What was **HARD** about finding the magnets?
13. Discuss your answers to the previous questions with two other groups. What did you agree on? What did you disagree on?
14. Define the term **magnetic field** using your own words and your observations from this experiment.

Part 2: Save Your Ships!

You have been commissioned by the British Navy to find a way for ships to pass undetected by the German mines. You know that the mines work with magnetism. How can you protect your ships?

Follow these steps to do your investigation:

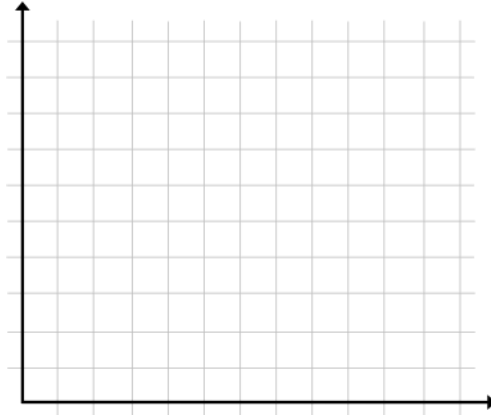
1. Find your group team members and gather all your additional materials, including your mobile device.
 - Clear, plastic box
 - Disc magnets
 - Mobile device with a sensor app, such as phyphox
 - Cloaking materials
 - Scissors, tape
2. Set up your experiment as shown in the Figure below. In this experiment, the magnetometer represents the _____, the magnet represents the _____, and the inverted box represents the _____.



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3. While recording the magnetometer data, move the ship (magnet) from one side of the water (box) to the other side across the magnetic mine (magnetometer). What does your graph look like? Make a sketch of your graph below and label the axes respectively.



4. Your goal in this investigation is to make modifications to your ship (magnet) to make it undetectable for the magnetic mine (magnetometer). Use your provided materials to create a design that minimizes the magnetometer readings when moving your ship across the box.
5. Before starting your investigations, keep the following in mind:
- Remember the location of your magnetometer
 - Remove any unwanted metallic objects or magnets close to the magnetometer
 - Keep the magnet (ship) at the same distance to the magnetometer while measuring (move it along the surface of the inverted box).
 - Take recordings with your sensor app and save each one to be able to compare your data afterwards.
6. As a group, come up with a design and make a drawing of your design below. When designing your cloaked ship, keep in mind what you have learned so far about magnets, magnetic fields, and magnetic forces.

7. Test and revise your design(s) until you are satisfied with your results. After each test, think about following questions:
 - How does your design work?
 - What works well? What does not work as well?
 - What changes do you need to make? Why and how?
8. Take a picture of your final design for your records.
9. Then test your modified ship while recording the data with your sensor app. Do three separate tests and record the data for each. Make sure that no other metallic objects or magnets are interfering with your measurements.
10. Look at the data from your three trials. In the data table below, enter the highest reading the magnetometer detected while your cloaked ship was moving across the magnetometer on the water surface. In the phyphox app you can select and pick the respective data points within the graph to view their values.
11. Calculate the average maximum magnetometer reading for all of your three trials and enter your result in the data table.

	Maximum magnetometer readings [microtesla]	Average of maximum magnetometer readings [microtesla]
Trial 1		
Trial 2		
Trial 3		

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12. Each group will present their design and results to the rest of the class and explain how the design works. Record the averages and a brief description for each group.

Group	Description of Design	Average maximum magnetometer readings [microtesla]

13. Create a line or a bar graph of the results for each group.

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14. Compare your results with the numbers from all other groups.

- Who was able to cloak their ship the best?
- Explain why this design worked the best. (Remember to use the Word Bank terms.)
- What cloaking materials were not as effective? Explain why.

Sum it all up! Describe what you learned about magnets, magnetic fields, magnetometers, etc. Include WHY it matters. Why is it important to understand magnets and how they work? This should be a well written paragraph of at least five sentences.

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Make a claim about magnets and magnetic fields. Then support your claim with a minimum of three pieces of evidence that you gathered in this experiment. Finally, include a short reasoning section that explains the scientific reasoning.