Magnetism – Magnetic Strength

What Else Must a Model of Magnetism Explain?

# **Introduction**

# **Purpose** To investigate the affect of size and strength of magnetic objects.

**Discussion:**

 Scientists observed that a collection of iron filings behaves similarly to a solid nail. Magnetic poetry kits are popular gifts. Each kit comes with a collection of words on a magnetic backing. Do you think that the letter “a” magnet alone is as magnetically strong as the entire word “beautiful” magnet? While playing with the magnetic poetry kit, you notice that you have several “*the*” magnets. Would you expect that all of the “*the*” magnets are identical?

 You have been creating rubbed nails by rubbing the magnet along the nail. Do you think this is necessary, or could you create a rubbed nail without actually rubbing?

###### Part 1 Does the Size of a Magnetic Object Make a Difference?

**Materials** Compass Bar Magnet Meter Stick Metric Ruler

#  Masking Tape 4 Different Sized Nails Cow Magnet

**Procedures**

1. Before beginning, make a general inference about the relationship (if any) between the **size of a magnet** and **the strength of its magnetic field** (*magnetic influence*).

2. Obtain a compass and set up your compass as shown below. If you cannot obtain a compass, try using a phone app compass. Use tape or a plastic ruler to make an East-West line.

2 cm

S

N

E

W

3. Throughout this unit’s lab, we have encouraged you to make PREDICTIONS before actually testing or experimenting. This is good practice and you should always continue to do so in all labs. However, the labs will only include your actually observations and test results from now on.

4. Make a mark on the tape 2 cm from the E-marking on the compass. Eventually you will place the point of each nail 2 cm away from the 90-degree mark on the compass. You should have four different nails that are similarly shaped, but different in size, and hopefully the same composition.

* Start with the smallest nail, rub it with the magnet to make it a “Head North” nail, and place it on the line with its pointy end lying directly over the 2 cm mark.
* BE SURE TO KEEP THE BAR MAGNET, YOUR WATCH, METALIC OBJECTS AT LEAST ONE METER AWAY FROM THE COMPASS.
* Complete the table below and record the angle of deflection of the compass needle.
* Repeat this process with the next largest nail. **Make sure you rub the nail in exactly the same way and the same number of strokes as you rubbed the first, smallest, nail.** Place its pointy end directly over the 2 cm mark and record the angle of deflection.
* Continue with all the nails and record the data in the table you copied.

|  |  |  |
| --- | --- | --- |
| **Nail According to Size** | **Length of Nail in cm** | **Compass Deflection in Degrees** |
| Trial 1 | Trial 2 | Trial 3 |
| Smallest |  |  |  |  |
| 2nd |  |  |  |  |
| 3rd |  |  |  |  |
| Largest |  |  |  |  |
|  |  |  |  |  |

5. How does your evidence support the inference you made? Look over the data in your table, what general inference can you make about the relationship (if any) between the **size of a magnetized nail** and **the strength of its magnetic field** (*magnetic influence*) the same distance away?

## Part 2 Do You Have to Rub an Object to Magnetize It?

Question: Can an unrubbed nail be magnetized (*that is, be made to behave like a rubbed nail*) without being touched by a magnet?

###### 1. A Student from a previous class thought about this and designed an experiment to find out. She first noticed that when an unrubbed nail was placed on the East-West line near the compass, with the pointed end aimed at the 90-degree mark, it caused no compass deflection at all. She then laid a bar magnet on the table and held the pointed end of the unrubbed nail about 0.5 cm away from the North end of the magnet, but without touching it ... as in the sketch below. Then she brought the nail over to the compass again. She slid the nail along the tape, bringing its pointed end closer and closer to the 90-degree mark on the compass.

0.5 cm

S

N

###### 2. TEST the previous student’s experiment:

* Begin by demagnetizing the nail and check that it will cause NO deflection of the compass needle when brought close to the 90-degree mark on the compass.
* Lay the nail on the table with its pointed end about 0.5 cm from the North pole of a magnet. Hold it there for exactly 5 seconds. BE CAREFUL NOT TO ALLOW THE NAIL TO TOUCH THE MAGNET. If they touch, demagnetize the nail again.
* Place the nail on the tape about 10 cm from the compass and slide it towards the 90-degree mark on the compass. Record your observation of the compass needle. How far, if any, did the compass needle deflect in degrees?

10 cm

S

N

E

W

3. **TEST** your prediction by turning the nail around so that the head end is now about 10 cm from the compass. Slide the head end towards the compass and record your observations of the compass needle. How far, if any, did the compass needle deflect in degrees?

4. Take the same nail (*after demagnetizing it*) and bring its head end 0.5 cm from the North pole of the bar magnet, and hold it there for exactly 5 seconds.

0.5 cm

S

N

5. Now bring the head end of the nail near the compass. Record your observation of the compass needle. How far, if any, did the compass needle deflect in degrees? Also record the distance at which the compass needle deflected.

6. You now know that a nail does not have to be rubbed in order to be magnetized; all that is necessary is that the nail be located near a magnet. But that brings up another question. Can a nail have different strengths of magnetism? That is, can there be weakly magnetized and more strongly magnetized nails, even though they are the same size and look identical (same composition)? We will test that next.

7. In order to test whether a nail can have different magnetic strengths, take two identical-looking nails, prepare them differently, and test the amount of compass deflection when held the same distance from the compass. You will perform FOUR different procedures to test this as follows:

Use the same compass set up as before. Once the nail is “magnetized” according to the FOUR option below, hold nail 2 cm from the compass to test each nail.

(1) rub the nail with the magnet just ONCE

(2) rub the nail with the magnet 6 more times

(3) hold a demagnetized nail 0.5 cm away from the N end of a magnet for 5 seconds

(4) hold a demagnetized nail 2 cm away from the N end of a magnet for 5 seconds

8. Complete the chart below, showing your observations for the four procedures of the magnetic strength of a nail.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **1 rub** | **7 rubs** | **0.5 cm away** | **2 cm away** |
| **Compass Reading** |  |  |  |  |

###### Part 3: Does the Size of the Magnet Determine its Magnetic Strength?

1. Place a bar magnet on the tape line so that its south pole is facing the 90-degree mark on the compass and is 30 cm away from the compass. Record the compass deflection you observed (Subtract the compass reading from 90 degrees to obtain the compass deflection).

* Move the same magnet to about 20 cm away from the compass and record the deflection.

2. Results of a second bar magnet are provided by the teacher.

2. Use a second bar magnet provided by the teacher and repeat the above procedures.

3. Use the cow magnet in place of a bar magnet to perform the same procedures. Do NOT hold the cow magnet near the compass for a long time or it may ruin the compass.

* Complete the chart below:

|  |  |
| --- | --- |
| Magnet Type | Compass Deflection in Degrees |
| **30 cm away** | **20 cm away** |
| Bar Magnet 1 |  |  |
| Bar Magnet 2 |  |  |
| Cow Magnet |  |  |

2. What can you conclude, based on your observations, concerning the strength of a magnet in relation to the size of the magnet?

###### ANSWERS

###### Part 1 Does the Size of a Magnetic Object Make a Difference?

**Procedures**

2. Obtain a compass and set up your compass as shown below. If you cannot obtain a compass, try using a phone app compass. Use tape or a plastic ruler to make an East-West line.

2 cm

S

N

E

W

|  |  |  |
| --- | --- | --- |
| **Nail According to Size** | **Length of Nail in cm** | **Compass Deflection in Degrees** |
| Trial 1 | Trial 2 | Trial 3 |
| Smallest | 4.8 cm | **38⁰** | **17⁰** | **32⁰** |
| 2nd | 5.0 cm | **55⁰** | **44⁰** | **41⁰** |
| 3rd | 6.5 cm | **45⁰** | **45⁰** | **53⁰** |
| 4th | 8.2 cm | **28⁰** | **51⁰** | **56⁰** |
| Largest | 10.0 cm | **74⁰** | **65⁰** | **67⁰** |

5. How does your evidence support the inference you made? Look over the data in your table, what general inference can you make about the relationship (if any) between the **size of a magnetized nail** and **the strength of its magnetic field** (*magnetic influence*) the same distance away?

**The nail with the most iron (Fe) will be the strongest magnet. The longer the nail, the more the compass was deflected by the magnetic force of the nail. The smallest nail deflected ~ 30**⁰**, while the longest nail deflected ~67**⁰**.**

## Part 2 Do You Have to Rub an Object to Magnetize It?

0.5 cm

S

N

###### 2. TEST the previous student’s experiment:

* Begin by demagnetizing the nail and check that it will cause NO deflection of the compass needle when brought close to the 90-degree mark on the compass.
* Lay the nail on the table with its pointed end about 0.5 cm from the North pole of a magnet. Hold it there for exactly 5 seconds. BE CAREFUL NOT TO ALLOW THE NAIL TO TOUCH THE MAGNET. If they touch, demagnetize the nail again.
* Place the nail on the tape about 10 cm from the compass and slide it towards the 90-degree mark on the compass. Record your observation of the compass needle. How far, if any, did the compass needle deflect in degrees?

10 cm

S

N

E

W

3. **TEST** your prediction by turning the nail around so that the head end is now about 10 cm from the compass. Slide the head end towards the compass and record your observations of the compass needle. How far, if any, did the compass needle deflect in degrees?

**The nail deflected the compass up to 35**⁰**, meaning that the nail became slightly magnetized even without touching the magnet.**

4. Take the same nail (*after demagnetizing it*) and bring its head end 0.5 cm from the North pole of the bar magnet, and hold it there for exactly 5 seconds.

0.5 cm

S

N

5. Now bring the head end of the nail near the compass. Record your observation of the compass needle. How far, if any, did the compass needle deflect in degrees? What phenomenon is occurring which also occurs with static electricity?

**The nail deflected the compass up to 35**⁰ again**, meaning that the nail became slightly magnetized even without touching the magnet. Bringing the nail close to but not touching the magnet caused an INDUCED magnetism.**

6. You now know that a nail does not have to be rubbed in order to be magnetized; all that is necessary is that the nail be located near a magnet. But that brings up another question. Can a nail have different strengths of magnetism? That is, can there be weakly magnetized and more strongly magnetized nails, even though they are the same size and look identical (same composition)? We will test that next.

7. In order to test whether a nail can have different magnetic strengths, take two identical-looking nails, prepare them differently, and test the amount of compass deflection when held the same distance from the compass. You will perform FOUR different procedures to test this as follows:

Use the same compass set up as before. Once the nail is “magnetized” according to the FOUR option below, hold nail 2 cm from the compass to test each nail.

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(2) rub the nail with the magnet 6 more times

(3) hold a demagnetized nail 0.5 cm away from the N end of a magnet for 5 seconds

(4) hold a demagnetized nail 2 cm away from the N end of a magnet for 5 seconds

8. Complete the chart below, showing your observations for the four procedures of the magnetic strength of a nail.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **1 rub** | **7 rubs** | **0.5 cm away** | **2 cm away** |
| **Compass Reading** | **52⁰** | **71⁰** | **27⁰** | **13⁰** |

###### Part 3: Does the Size of the Magnet Determine its Magnetic Strength?

1. Place a bar magnet on the tape line so that its south pole is facing the 90-degree mark on the compass and is 30 cm away from the compass. Record the compass deflection you observed (Subtract the compass reading from 90 degrees to obtain the compass deflection).

* Move the same magnet to about 20 cm away from the compass and record the deflection.

2. Results of a second bar magnet are provided by the teacher.

3. Use the cow magnet in place of a bar magnet to perform the same procedures. Do NOT hold the cow magnet near the compass for a long time or it may ruin the compass.

* Complete the chart below:

|  |  |
| --- | --- |
| Magnet Type | Compass Deflection in Degrees |
| **30 cm away** | **20 cm away** |
| Bar Magnet 1 | **12⁰** | **40⁰** |
| Bar Magnet 2 | **20⁰** | **50⁰** |
| Cow Magnet | **27⁰** | **60⁰** |

2. What can you conclude, based on your observations, concerning the strength of a magnet in relation to the size of the magnet?

**Substances with the same amount of iron (Fe) particles may vary in magnetic strength based on the number of iron particles that get aligned. Materials with more iron particles have a greater potential for magnetic strength.**