What Affects the Strength of a Magnet?

NSES Content Standard B—Physical Science:
- Objects have many observable properties, including the ability to react with other substances.
- The position and motion of objects can be changed by pushing and pulling. The size of the change is related to the strength of the push or pull.
- Magnets attract and repel each other and certain kinds of other materials.

Objectives
- Children will create a temporary magnet.
- Children will observe what affects the strength of a magnet.

Explore
Teacher Preparation: Prepare a plastic bag of 10–15 small paperclips for each pair of children.

- Working in pairs, have children place a bar magnet, an iron nail, and small paperclips on the desk. Then have them take out a sheet of paper.
- Have children hold one end of the bar magnet and hang the nail from the other end of the magnet, so the head of the nail sticks to the magnet. (For the purpose of this activity, it does not matter which end of the magnet they use.)
- Ask them to predict how many paperclips they can pick up with the nail and write their predictions on the paper.
- Have each child dip the nail into the paperclips, lift it out, and count how many paperclips stick to the nail.
- Then have them record their results on the paper.

Teacher Background
A magnet is composed of many “tiny magnets,” (magnetic domains) that are aligned. All magnetic materials (materials which are attracted to a magnet) are also composed of these tiny magnets. In unmagnetized magnetic materials, these tiny magnets point in random directions. If most or all of these tiny magnets are aligned in one direction, the material will behave like a magnet.

The strength of the magnet depends on the size of the magnet and the number of its tiny magnets that are aligned. Placing a magnetic material into a magnetic field causes the tiny magnets to line up in the same direction and the material, at least temporarily, to become a magnet. When a bar magnet is brought near an iron nail, it will attract the tiny magnets in the nail,
causing them to line up in the same direction and making the nail a temporary magnet. When the bar magnet is removed, the tiny magnets will usually return to their random positions, and the nail will lose its magnetism.

**Vocabulary Development**

*temporary magnet, permanent magnet*

A good way to help children learn and remember new vocabulary words is to first assess their prior knowledge of a vocabulary word. They can attach the contextual meaning of a word to what they already know about it. Ask children to share some things that are temporary. Then ask them to share some things that are permanent. Ask children what they think a *temporary magnet* might be. Ask them what they think a *permanent magnet* might be. Have them add the new vocabulary words to their Science Journals.

**Common Misconceptions**

Some children may believe that larger magnets are always stronger than smaller magnets. This is not true. A magnet’s strength is not only determined by its size, but also by the material of which the magnet is made and the number of “tiny magnets” lined up in the magnet. A larger magnet will have a stronger magnetic field than a smaller magnet made of the same material. However, in some cases, a smaller magnet may actually have a stronger magnetic field. For example, a neodymium or a rare earth magnet would be stronger than a ceramic or ferrite magnet of the same size. Rare earth magnets have about 10 times the magnetic strength of ferrite magnets.

**Real World Connections**

A steel screwdriver can be magnetized so it will attract steel screws, making it easier to use. Iron and most steel contain tiny magnets that are randomly arranged in unmagnetized metal but can be aligned by exposure to a magnetic field. In pure iron, this alignment goes away quickly after the magnetic field is removed. A typical screwdriver, however, is made of carbon steel, so the alignment can last days, weeks, years, or even centuries after the magnetic field is gone.

A screwdriver can be magnetized permanently by exposing it briefly to a very strong magnetic field. Touching the screwdriver’s tip to one pole of a strong magnet will cause some permanent magnetization. Rubbing or tapping the screwdriver also helps free up the tiny magnets so they can align with the magnetic field.

**Objective**
Children will observe how a nail becomes a temporary magnet.

**Materials**
- bar magnet, iron nail, small paperclips, ruler

**Explore**
During the Explore activity, children should have observed that the nail is made of iron, a magnetic material. When the iron nail is brought in contact with the permanent bar magnet, the magnetic field of the bar magnet causes many of the tiny magnets in the iron nail to line up in the same direction and the nail to become a magnet. Ask children to predict whether the nail has become a permanent or a temporary magnet.

**Question**
Ask children, “How many paperclips will an iron nail pick up if it is held 1 cm below the bar magnet?”

**Prediction**
- Ask children to predict what will happen if they hold the iron nail 1 cm below the end of the bar magnet and try to pick up paperclips.

- Children will record their predictions on the Direct Inquiry activity sheet.

**Student Procedure**
1. Working in pairs, have children hold one pole of the bar magnet. Have children measure and hold the head of the nail 1 cm below the other pole of the bar magnet. (For the purpose of this activity, it does not matter which pole they choose.)

2. Maintaining the space between the magnet and the nail, have children dip the nail into the paperclips and lift it out.

3. Have them remove, count, and record the actual number of paperclips picked up by the nail.

4. Have them repeat the procedure two more times and record the results of each trial on the Directed Inquiry activity sheet.

**Conclusion**
- Have children compare how many paperclips stuck to the nail that was touching the bar magnet and how many paperclips stuck to the nail that was 1 cm away from the bar magnet.
• Ask children why the nail picked up more paperclips when it was touching the bar magnet. Children should state that the magnetism in the nail was stronger when it was touching the magnet.

• Ask children why the nail didn’t pick up as many paperclips when it was 1 cm away from the magnet. Help children conclude that as the nail gets farther away from the bar magnet, the magnetic field surrounding the magnet becomes weaker. Consequently, the magnetism in the nail also becomes weaker.

**Explanation**
The children observed that the nail is only a temporary magnet and loses its magnetism when taken out of the magnetic field of a permanent magnet. The temporary magnetism is weaker when moved farther out of the magnetic field of the permanent magnet. When the iron nail is placed in a magnetic field, the nail becomes magnetized. The closer the nail is to the magnet, the stronger the magnetic field of the nail, and the more paperclips it can pick up.

**More Questions**
• Ask children, “If you could do the activity again, what part of the activity would you like to change?”

• Make a list of these changes on the board. For example, if children want to find out if a different size nail would produce the same results, they would follow the procedure using a larger or smaller nail.

• The following Guided Inquiry activity exemplifies the procedure using one child’s sample question.
Lesson 4 • Magnetic Strength

Guided Inquiry Notes to Teacher

Objective
• Children will explore what affects the strength of a magnet.

Materials
bar magnet, iron nail, small paperclips

Based on the Directed Inquiry activity, children observed that a nail becomes a temporary magnet when touching a permanent magnet, but loses its magnetism when taken out of the magnetic field of a permanent magnet.

Question
Ask children, “How does the number of times a nail is rubbed with a bar magnet change the number of paperclips that stick to it?”

Hypothesis
• Ask children what happened when the nail was touching the end of a bar magnet and used to pick up paperclips. Children should respond that the nail became magnetized and picked up the paperclips.

• Tell children that there is another way that a nail can become magnetized by a permanent magnet. The tiny magnets in the nail can be lined up by rubbing the nail in the same direction with one pole of the magnet.

• Ask children how they think the number of times a nail is rubbed with a magnet will affect the strength of the magnetic field and the number of paperclips that stick to the nail.

• Have them formulate an If . . . then hypothesis. For example, “If the nail is rubbed (10–50) times with the magnet, then the nail will pick up (1–10) paperclips.”

List of Variables
• Manipulated or Independent Variable—The thing you change (the number of times the nail is rubbed).

• Responding or Dependent Variable—What you observe as a result of the change (the number of paperclips that stick to the nail).

• Controlled or Constant Variable—Everything else is the same (the bar magnet, the direction the nail is rubbed, the pole of the magnet used to rub the nail).

Student Procedure
1. Working with a partner, have children place an iron nail flat on the desk.

2. Holding the nail against the desk, have children rub the nail with the north pole of the bar magnet 10 times, in one direction only, from the head of the nail to the point.

3. Then have children dip the nail into the paperclips and slowly lift the nail out. Have them count the number of paperclips picked up by the nail and record their results.
4. Have children repeat the procedure four more times, rubbing the nail 10 more times with each trial (for a total of 20, 30, 40, and 50 times). Tell children to be careful not to drop their nails during the activity, because the nails will become demagnetized. If a nail is dropped during this activity, children should exchange it for a new nail and rub the new nail the total number of times listed on the chart where they stopped.

5. Have children fill in the chart provided on the Guided Inquiry activity sheet.

Conclusion
- Ask children to share their observations and write their conclusion on the Guided Inquiry activity sheet.
- If children need more guidance ask, “As the number of times the nail was rubbed with the bar magnet increased, how did the number of paperclips picked up change?”
- Answers may vary, but the magnet probably picked up a maximum of 3 paperclips.
- Have children write three true statements about the results of their investigation.
- An iron nail can be temporarily magnetized by rubbing it with a permanent magnet.
- The number of paperclips attracted to the nail increased when the nail was rubbed more times until it reached a limit when the number of paperclips remained constant.

Explanation
Children observed in the Explore and Directed Inquiry activities that an iron nail can be made into a temporary magnet by holding it against a pole or near a pole of a permanent magnet. They learned that rubbing an iron nail with a permanent magnet can also make an iron nail into a temporary magnet. The magnetism increases in strength the more the nail is rubbed until it is completely magnetized.

More Questions
Ask children, “If you could do the activity again, what part of the activity would you like to change?” List these changes on the board.

Full Inquiry Notes to Teacher
Expect children to come up with varied ideas. Some children might suggest using a larger or smaller nail. Others may want to try rubbing the nail with a different part of the bar magnet. Encourage them to suggest ideas that can be tested in the classroom.
Question: How many paperclips will an iron nail pick up if it is held 1 cm below the bar magnet?

Prediction: Predict how many paperclips the iron nail that is held 1 cm below the end of the bar magnet will pick up.

Predicted Results: ________ paperclips

Materials:
bar magnet
iron nail
small paperclips
ruler

Procedure:
1. Hold one pole of the bar magnet. Measure and hold the nail 1 cm below the other pole of the bar magnet.
2. Dip the nail into the paperclips and lift it out again. Try to keep the nail and bar magnet 1 cm apart.
3. Remove, count, and record the actual number of paperclips picked up by the nail.
4. Repeat the procedure two more times.
### Data Collection
Record your data in the chart below.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Number of Paperclips</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
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</tbody>
</table>

### Conclusion
Write one true statement about the results of your investigation.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

### Explanation
State your explanation for these results.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

### More Questions

________________________________________________________________________
Materials:
- bar magnet
- iron nail
- small paperclips
**Question:** How does the number of times a nail is rubbed with a bar magnet change the number of paperclips that stick to it?

**Hypothesis:** If ________________________________________________________ then ________________________________________________________________

What one thing will you change? _________________________________________

What will you observe or measure? _______________________________________

What variables will you keep the same? ___________________________________

**Procedure:**

1. Hold the nail flat against your desk. Rub the nail with the north pole of the bar magnet 10 times in one direction, from the head of the nail to the point.

2. Dip the nail into the paperclips, lift it out, and count how many paperclips stick to the nail.

3. Rub the nail with north pole of the bar magnet 10 more times in the same direction (total of 20 times).

4. Repeat this procedure 3 more times, rubbing the nail 10 more times with each trial (total of 30, 40, and 50 times).

**Data Collection:** Record your data in a graph. Use your recorded data to decide if your hypothesis was correct.
# Using Scientific Methods

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1. Ask a Question</td>
<td>Ask an important question.</td>
</tr>
<tr>
<td>2. Make a Hypothesis</td>
<td>State your hypothesis in the form of an <em>If...then</em> statement.</td>
</tr>
<tr>
<td>3. Control Variables</td>
<td>List the independent/manipulated variable, the dependent/responding variable, and the controlled/constant variables.</td>
</tr>
<tr>
<td>4. Plan and Test Your Hypothesis</td>
<td>Write the procedure you will follow in order to test your hypothesis.</td>
</tr>
<tr>
<td>5. Collect and Record Data</td>
<td>Decide which form of data collection and record keeping is best suited for your activity.</td>
</tr>
<tr>
<td>6. Conclusions</td>
<td>State your conclusions for the activity.</td>
</tr>
<tr>
<td>7. Explanations</td>
<td>Explain what happened during the activity and why you think this happened.</td>
</tr>
<tr>
<td>8. More Questions</td>
<td>Ask additional questions you wish to investigate.</td>
</tr>
</tbody>
</table>
Lesson 4 • Directed Inquiry Activity

**Question:** How many paperclips will an iron nail pick up if it is held 1 cm below the bar magnet?

**Steps:**

1. Count the paperclips that stick to the nail.
2. Repeat two more times.
3. Dip the nail into the paperclips and lift it out.
4. Record your results.

**Number of Paperclips**

<table>
<thead>
<tr>
<th>Trial</th>
<th>Number of Paperclips</th>
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<tbody>
<tr>
<td>Trial 1</td>
<td></td>
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<td>Trial 2</td>
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<tr>
<td>Trial 3</td>
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Lesson 4 • Guided Inquiry Activity

Question: How does the number of times a nail is rubbed with a bar magnet change the number of paperclips that stick to it?

Hypothesis: If the nail is rubbed _____ times with the magnet, then the nail will pick up _____ paperclips.

Steps:
1. Magnetize the nail.
2. Dip the nail into the paperclips and lift it out.
3. Count the paperclips that stick to the nail.
4. Repeat this procedure 4 more times. Rubbing the nail 10 more times with each trial (total of 20, 30, 40, and 50 times).
5. Make a graph. Across the bottom, show the number of times the nail was rubbed. On the side, show the number of paperclips it picked up. Record your results.

Materials
bar magnet
iron nail
small paperclips