

Magnetic Metals

Introduction

A common misconception students have regarding magnetism is that all metals are magnetic or are attracted to a magnet. Used as a demonstration or a student activity, this simple test dramatically shows that only certain metals are affected by a magnetic field.

Concepts

- Magnetic domains
- Magnetic field
- Magnetic materials

Materials

- | | |
|--|---------------|
| Bar magnet, Alnico | Scissors |
| Clamp holder | Support stand |
| Metal strips, various (e.g., Fe, Ni, Al, Cu, Pb) | Tape |
| Paper clip, small | Thread, 50 cm |
| Ruler, metric | |

Safety Precautions

Use caution when handling metal strips. The edges may be sharp. Be sure the magnet is secure in the clamp holder. Dropping a magnet may result in breakage or a weakening of its magnetic force.

Procedure

1. Set up a support stand and attach a clamp holder approximately 30 cm above the base.
2. Clamp a strong alnico bar magnet securely in the holder.
3. Tie one end of a piece of thread to a small paper clip.
4. Place the paper clip on the underside of the extended end of the bar magnet.
5. Pull the thread taut toward the table.
6. Pull the thread gradually until the paper clip remains suspended approximately 1 cm below the magnet. *Note:* The paper clip may need to be held in place just under the magnet to determine the length of string needed to keep the paper clip suspended.
7. Tape the free end of the thread to the table so the paper clip remains suspended just below the magnet. See Figure 1.
8. Obtain various metal strips such as aluminum, copper, iron, lead, nickel, and zinc.
9. Choose one metal strip and, holding one end, pass the other end through the space between the paper clip and the magnet. Do not allow the metal to touch either the magnet or the paper clip.
10. Have students observe any change in the position of the paper clip.
11. Repeat steps 9 and 10 with each of the other metal strips.

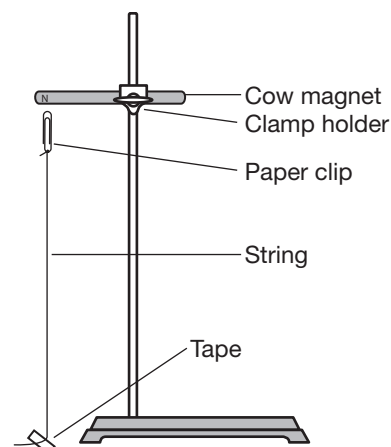


Figure 1.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School

- MS-PS1 Matter and Its Interactions
 - PS1.A: Structure and Properties of Matter
- MS-PS2 Motion and Stability: Forces and Interactions
 - PS2.A: Forces and Motion
 - PS2.B: Types of Interactions

Disciplinary Core Ideas: High School

- HS-PS1 Matter and Its Interactions
 - PS1.A: Structure and Properties of Matter
- HS-PS2 Motion and Stability: Forces and Interactions
 - PS2.B: Types of Interactions

Science and Engineering Practices

- Developing and using models
- Constructing explanations and designing solutions

Crosscutting Concepts

- Cause and effect
- Structure and function

Tips

- Many different metal strips may be used in this activity. Iron and nickel should always be included so students observe that only certain metals are magnetically susceptible.
- Magnets of various shapes may be used. The magnet needs to be strong enough to keep the paper clip suspended below the magnet while allowing a metal strip to pass through the gap.
- As an extension to this activity, clamp various coins, including a nickel, in a wooden clothespin one at a time and pass the coin through the space between the paper clip and magnet. Have students predict the results. Students may be surprised that even though a strip of nickel is magnetically susceptible, a nickel coin is not. Allow students to draw conclusions regarding the composition of a nickel coin from their observations. A U.S. nickel coin is made of an alloy which is 75% copper and only 25% nickel—not enough nickel to be affected by a magnetic field. Canadian nickels minted between 1922 and 1981, however, are almost pure nickel, and are affected by a magnetic field.
- To further explore magnetism, the student laboratory kits, Introduction to Magnets (Flinn Catalog No. AP6457) and Magnets and Magnetism (Flinn Catalog No. AP7013) may be used.

Discussion

Why are some metals affected by a magnetic field and others not? A material's ability to become a magnet is based on the interaction of the electrons in its atoms. Every electron spinning around the nucleus of an atom acts like a tiny magnet. In most materials, these tiny magnets are balanced so there is no net magnetic effect. Simply stated, in non-magnetic materials, for every tiny magnetic electron that points up, a tiny magnetic electron points down, canceling out any magnetic effect. In metals such as iron, nickel, and cobalt, the atoms possess excess magnetic electrons that are not balanced by other magnetic electrons. These materials are *magnetically susceptible*. Normally groups of these excess unbalanced magnetic electrons, known as *magnetic domains*, point in random directions. In this case the material is not magnetic. See Figure 2a. However, in the presence of a *magnetic field* (the region around a magnet in which a magnetic force acts), the magnetic domains begin to align themselves with the magnetic field of the permanent magnet. See Figure 2b. When the external magnetic field is removed, the magnetic domains will again point in random directions and the material will lose its magnetic property. In order to form a permanent magnet, a magnetically susceptible material must be formed or processed in such a way so that the magnetic domains are “locked” into one direction and do not become randomly oriented over time. See Figure 2c.

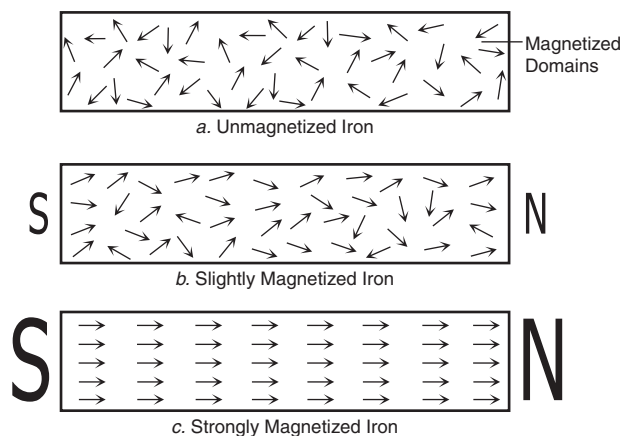


Figure 2.

When a material that is not magnetically susceptible is passed between the magnet and the paper clip, nothing happens. Since the material has no magnetic domains, no magnetic force interacts with the magnetic field of the permanent magnet. However, when an iron or nickel strip is passed between the magnet and the paper clip, the magnetic domains in the iron or nickel strip begin to align. This produces a weak magnetic field (Figure 2b) that interferes with the magnetic field of the permanent magnet, causing the paper clip to move or even fall.

References

Hapkiewicz, A. (1992). Finding a List of Science Misconceptions. MSTA Newsletter, 38 (Winter '92), pp 11–14.

Materials for *Magnetic Metals* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP9264	Bar Magnets, Pair, Alnico
A0178	Aluminum Strips, pkg/10
C0182	Copper Strips, pkg/6
I0058	Iron Strips, pkg/10
L0065	Lead Strips, pkg/6
N0089	Nickel Strips, pkg/6
Z0024	Zinc Strips, pkg/10
AP6457	Introduction to Magnets
AP7013	Magnets and Magnetism

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.