Ferromagnetic Material

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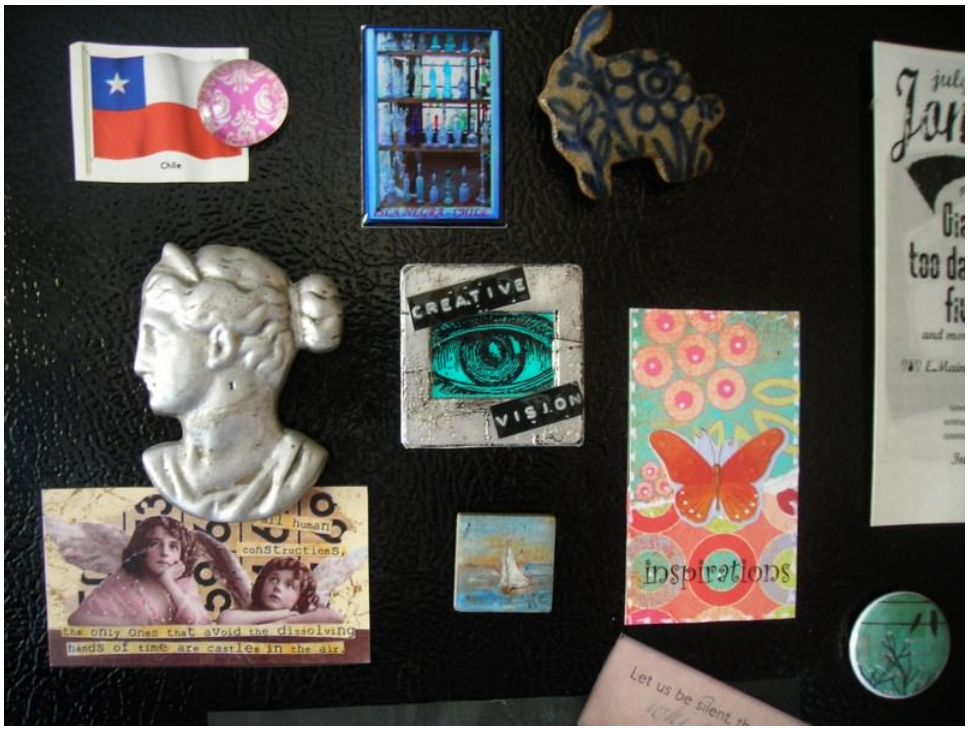
CHAPTER 1 Ferromagnetic Material

- Explain what makes a material magnetic.
- Define ferromagnetic materials, and describe how they can be magnetized.
- Distinguish between temporary and permanent magnets.
- Describe magnetite.



This collection of magnets is located in a familiar place: a refrigerator door. No doubt you've handled refrigerator magnets like the ones in this photo. You probably know first-hand that they stick to metal refrigerators but not to surfaces such as wooden doors and glass windows. Wood and glass aren't attracted to a magnet, whereas the steel refrigerator is. Obviously, only certain materials respond to magnetic force.

What Makes a Material Magnetic?

Magnetism is the ability of a material to be attracted by a magnet and to act as a magnet. Magnetism is due to the movement of electrons within atoms of matter. When electrons spin around the nucleus of an atom, it causes the atom to become a tiny magnet, with north and south poles and a magnetic field. In most materials, the north and south poles of atoms point in all different directions, so overall the material is not magnetic. Examples of nonmagnetic materials include wood, glass, plastic, paper, copper, and aluminum. These materials are not attracted to magnets and cannot become magnets.

In other materials, there are regions where the north and south poles of atoms are all lined up in the same direction. These regions are called **magnetic domains**. Generally, the magnetic domains point in different directions, so the material is still not magnetic. However, the material can be magnetized (made into a magnet) by placing it in a magnetic field. When this happens, all the magnetic domains line up, and the material becomes a magnet. You can see this in the **Figure** 1.1. Materials that can be magnitized are called **ferromagnetic materials**. They include iron, cobalt, and nickel.

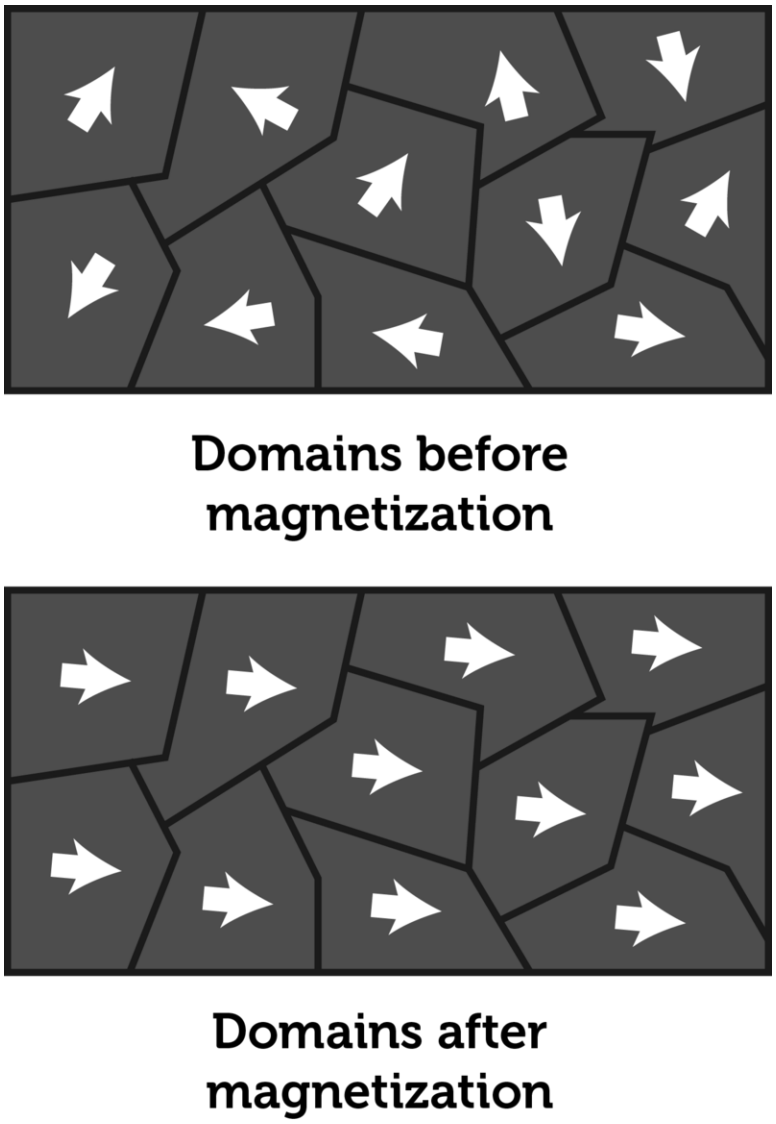


FIGURE 1.1

Magnetic domains must be lined up by an outside magnetic field for most ferromagnetic materials to become magnets.

Temporary and Permanent Magnets

Materials that have been magnetized may become temporary or permanent magnets.

- If you bring a bar magnet close to pile of paper clips, the paper clips will become temporarily magnetized, as all their magnetic domains line up. As a result, the paper clips will stick to the magnet and also to each other (see the **Figure** 1.2). However, if you remove the paper clips from the bar magnet's magnetic field, their magnetic domains will no longer align. As a result, the paper clips will no longer be magnetized or stick together.

- If you stroke an iron nail with a bar magnet, the nail will become a permanent (or at least long-lasting) magnet. You can see how it's done in the **Figure** 1.3. The nail's magnetic domains will remain aligned even after you remove the nail from the magnetic field of the bar magnet.

Q: Even permanent magnets can be demagnetized if they are dropped or heated to high temperatures. Can you explain why?

FIGURE 1.2

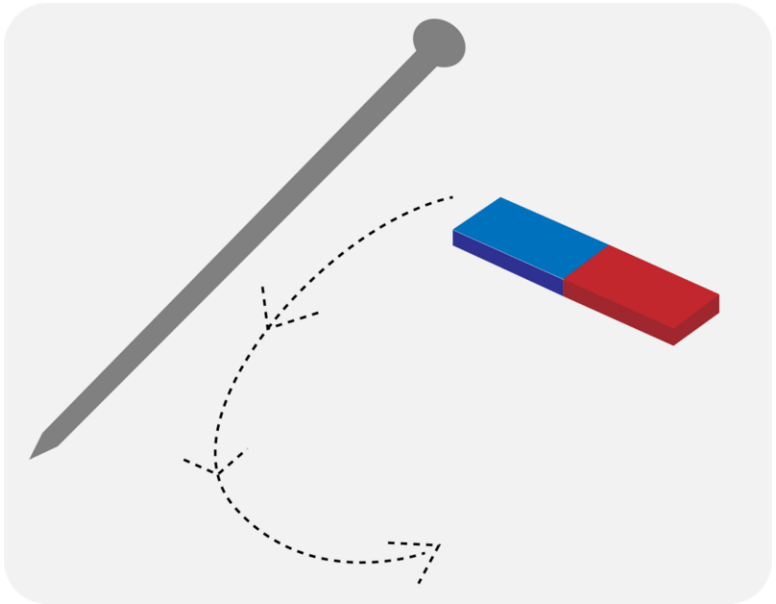


FIGURE 1.3

A: Jarring or heating a magnet moves the magnetic domains out of alignment. When the magnetic domains no longer line up in the same direction, the material is no longer magnetic.

Magnetite

Some materials are natural permanent magnets. The most magnetic material in nature is the mineral magnetite, also called lodestone (see **Figure** 1.4). The magnetic domains of magnetite naturally align with Earth's axis. The picture on the left shows a chunk of magnetite attracting small bits of iron. The magnetite spoon compass shown on the right dates back about 2000 years and comes from China. The handle of the spoon always points north. Clearly, the magnetic properties of magnetite have been recognized for thousands of years.

Chunk of Magnetite Attracting Iron Objects

Early Chinese Magnetite Spoon Compass

FIGURE 1.4

Summary

- Magnetism is the ability of a material to be attracted by a magnet and to act as a magnet. A material can be magnetized if all of its magnetic domains can be aligned. Magnetic domains are regions of matter where north and south poles of atoms line up in the same direction.
- Only certain materials, called ferromagnetic materials, can be magnetized. They include iron, cobalt, and nickel. Materials that have been magnetized may become temporary or permanent magnets.
- Some materials are natural permanent magnets. The most magnetic material in nature is the mineral magnetite.

Review

1. Define magnetism.
2. Why is an atom like a tiny magnet?
3. What are magnetic domains?
4. What is unique about ferromagnetic materials? List three ferromagnetic materials.
5. Explain how you can make a permanent magnet from an iron nail.
6. What is magnetite?

References

1. Christopher Auyeung. Magnetization of domains causes ferromagnetic materials to become magnets . CC BY-NC 3.0
2. User:Havelock/He.Wikipedia. A chain of paper clips held up by magnetism . The copyright holder of this file allows anyone to use it for any purpose, provided that the copyright holder is properly attributed
3. Christopher Auyeung. Objects can become permanently magnetized . CC BY-NC 3.0

4. Left: User:Teravolt/Wikipedia; Right: User:Yug/Wikimedia Commons. Natural magnetic materials such as magnetite have been recognized for thousands of years . Left: CC BY 3.0; Right: Public Domain