8.2: Magnet

Figure 18.1.1

Some countries are using powerful electromagnets to develop high-speed trains, called maglev, or magnetic levitation, trains. These trains use the repulsive force of magnets to float over a guide way, removing the friction of steel wheels and train tracks. Reducing this friction allows the trains to travel at much higher speeds.

Properties of Magnets

Any **magnet**, regardless of its shape, has two ends called poles where the magnetic effect is strongest. If a magnet is suspended by a fine thread, it is found that one pole of the magnet will always point toward the north. This fact has been made use of in navigation since the eleventh century. The pole of the magnet that seeks the north pole is called the north pole of the magnet, while the opposite side is the south pole.

It is a familiar fact that when two magnets are brought near one another, the magnets exert a force on each other. The magnetic force can be either attractive or repulsive. If two north poles or two south poles are brought near each other, the force will be repulsive. If a north pole is brought near a south pole, the force will be attractive.

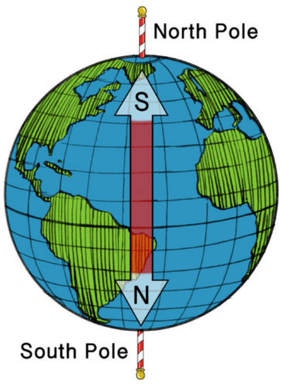


Figure 18.1.2

The Earth's geographic north pole (which is close to, but not exactly at the magnetic pole) attracts the north poles of magnets. We know, therefore, that this pole is actually the Earth's magnetic south pole. This can be seen in the image above; the geographic north and south poles are labeled with barber shop poles, and the Earth's **magnetic poles** are indicated with the double-headed arrow.

Only iron and few other materials such as cobalt, nickel, and gadolinium show strong magnetic effects. These materials are said to be **ferromagnetic**. Other materials show some slight magnetic effect but it is extremely small and can be detected only with delicate instruments.

Ferromagnetic Domains

Microscopic examination reveals that a magnet is actually made up of tiny regions known as **magnetic domains**, which are about one millimeter in length and width. Each domain acts like a tiny magnet with a north and south pole.

Magnetic domains before and after magnetization

Figure 18.1.3

If an object remains a magnet even when removed from the other magnetic field it is called a **permanent magnet**. If alignment is made in the presence of a permanent magnetic field, the object is a **temporary magnet.** If the material is not magnetized in the presence of another magnetic field because the domains are randomly organized so that the north and south poles do not line up and often cancel each other it is **non-magnetic**.

When a ferrous material is placed in a magnetic field, the domains line up with the magnetic field so that the north poles are all pointed in the same direction and the south poles are all pointed in the opposite direction. In this way, the ferrous material has become a magnet. In many cases, the domains will remain aligned only while the ferrous material is in a strong magnetic field; when the material is removed from the field, the domains return to their previous random organization and the ferrous material loses any magnetic properties. These temporary magnets have magnetic properties while in the field of another magnet but lose the magnetic properties when removed from the field.

The formation of temporary magnets allows a magnet to attract a non-magnetized piece of iron. You have most likely seen a magnet pick up a paper clip. The presence of the magnet aligns the domains in the iron paper clip and it becomes a temporary magnet. Whichever pole of the magnet is brought near the paper clip will induce magnetic properties in the paper clip that remain as long as the magnet is near.

Permanent magnets lose their magnetic properties when the domains are dislodged from their organized positions and returned to a random jumble. This can occur if the magnet is hammered on or if it is heated strongly.

Magnetic Fields

When we were dealing with electrical effects, it was very useful to speak of an electric field that surrounded an electric charge. In the same way, we can imagine a **magnetic field** surrounding a magnetic pole. The force that one magnet exerts on another can be described as the interaction between one magnet and the magnetic field of the other magnet. Magnetic field lines go from the north magnetic pole to the south magnetic pole. We define the magnetic field at any point as a vector (represented by the letter **B**) whose direction is from north to south magnetic poles.

Launch the Field Lines simulation below to help you visualize the invisible magnetic field that surrounds the Earth. You can also travel to different planets in the solar system and measure the properties of their magnetic fields. Can you determine which planet has the largest magnetic field? Which planet has no field? Then, try to develop a hypothesis about why this might be.

Summary

- Any magnet has two ends called poles where the magnetic effect is strongest.
- The magnetic pole found at the north geographical pole of the earth is a south magnetic pole.
- The force that one magnet exerts on another can be described as the interaction between one magnet and the magnetic field of the other magnet.
- Magnetic field lines go from the north magnetic pole to the south magnetic pole.

Review

1. The earth's magnetic field
    1. has a north magnetic pole at exactly the same spot as the geographical north pole.
    2. is what causes compasses to work.
    3. is what causes electromagnets to work.
    4. all of these are true.
    5. none of these are true.
2. A material that can be permanently magnetized is generally said to be
    1. magnetic.
    2. electromagnetic.

   3. ferromagnetic.
   4. none of these are true.
3. The force between like magnetic poles will be
   1. repulsive.
   2. attractive.
   3. could be repulsive or attractive.
4. Why is a magnet able to attract a non-magnetic piece of iron?
5. If you had two iron rods and noticed that they attract each other, how could you determine if both were magnets or only one was a magnet?

Explore More

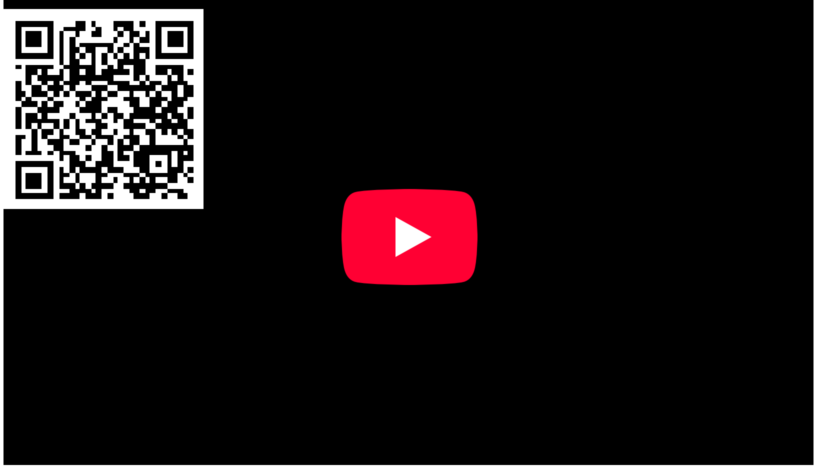
Use this resource to answer the question that follows.

1. In the video, one object rests on top of the magnetic field of another. Compare the friction between these two objects to the friction between a saucer and a table the saucer rests on.

Additional Resources

Study Guide: Magnetism Study Guide

Videos: Introduction to Magnetism - Overview



Real World Application: Levitating Trains