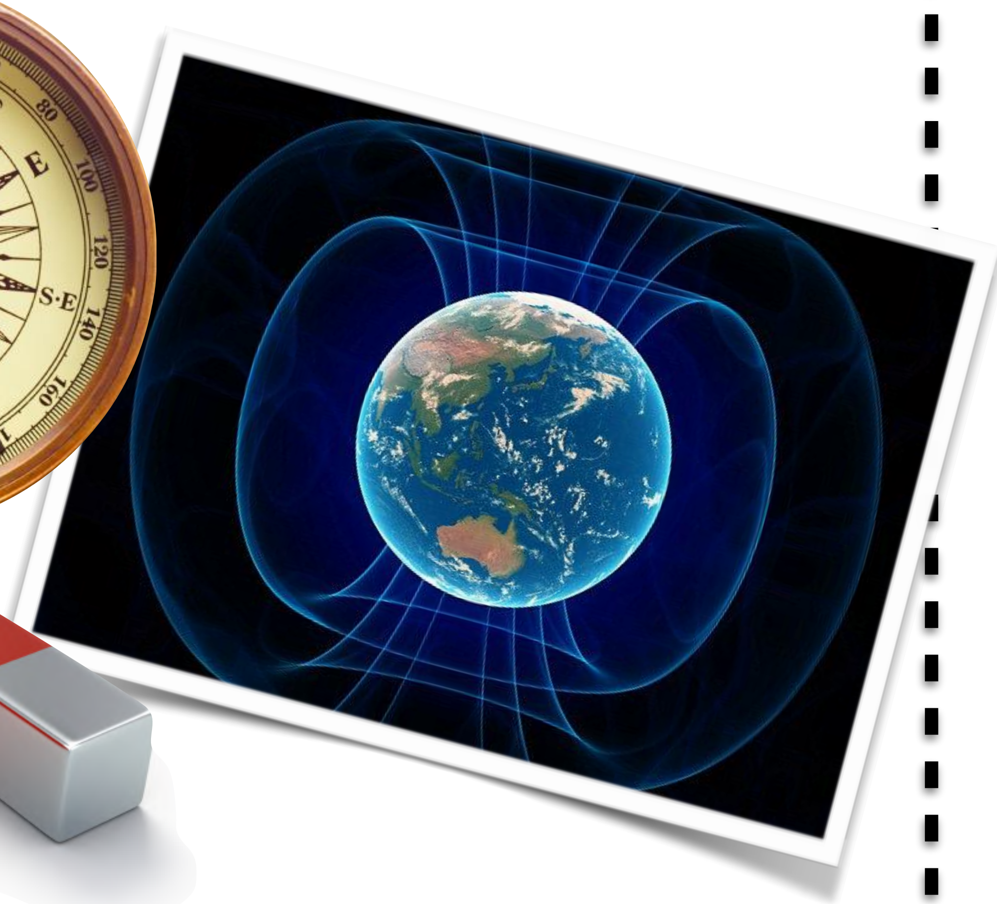
Magnets



In this packet, we will be learning the basic physics behind magnets work and how we utilize them in the US Navy. We are then going to practice these principles in easy and fun activities that can be done in the classroom or at home.

Contact the National Museum of the U.S. Navy for Field Trip and School Visit opportunities!

*This packet is intended for elementary schools, to be used in groups of three or fewer and/or individually.

What is a magnet?

A magnet is a rock or a piece of metal that can pull certain types of metal toward itself. The force of magnets, called **magnetism**, is a basic force of nature, like electricity and gravity. Magnetism works over a distance. This means that a magnet does not have to be touching an object to pull it.

Magnetism happens when tiny particles called **electrons** behave in a certain way. All objects in the universe are made up of units called **atoms**. **Atoms** in turn are made up of **electrons** and other particles (neutrons and protons). The electrons spin around the atom's nucleus, which contains the other particles. The spinning electrons form tiny magnetic forces. Sometimes many of the electrons in an object spin in the same direction. In these cases, all the tiny magnetic forces from the electrons add up to make the object one big magnet.

It is possible to make a magnet by taking an existing magnet and rubbing another piece of metal with it. The new piece of metal must be rubbed continuously in the same direction. This will make the electrons in that metal start to spin in the same direction.

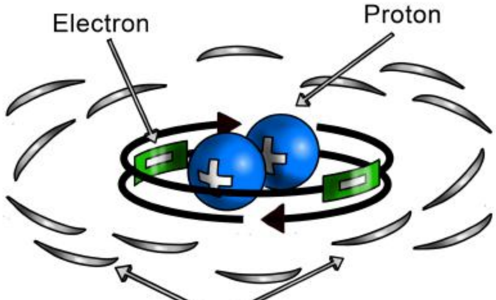
Electricity can also create magnets. Electricity is a flow of electrons. As electrons move through a piece of wire they have the same effect as electrons spinning around the nucleus of an atom. This is called an electromagnet.

Because of the way their electrons are arranged, the metals iron, steel, nickel, and cobalt make good magnets. Once these metals become magnets, they can stay magnets forever. Then they are called **hard magnets**. But these metals and others can also act like magnets temporarily, after they have been near a hard magnet. Then they are called **soft magnets**. Most other materials—for example, water, air, and wood—have very weak magnetic properties

Magnets strongly attract objects that contain iron, steel, nickel, or cobalt. Magnets also attract or repel (push away) other hard magnets. This happens because every magnet has two opposite poles, or ends: a north pole and a south pole. North poles attract the south poles of other magnets, but they repel other north poles. Likewise, south poles attract north poles, but they repel other south poles.

The magnetic forces between the two poles of a magnet create a magnetic field. This is the area affected by the magnet. A magnetic field surrounds all magnets.

Britannica School, s.v. "Magnet and Magnetism,"



Did you know?

If you cut a bar magnet in half (seen below), you create two smaller magnets!

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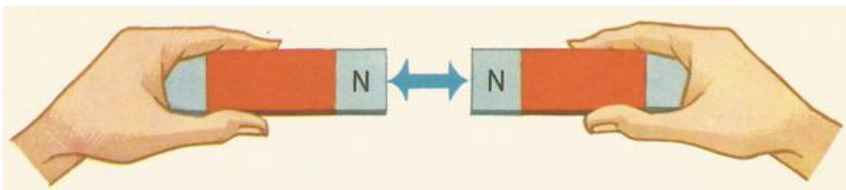
How do magnets work?

In a bar magnet, magnetism is strongest at the ends, or poles. The north pole always points north. The south pole always points south. Magnets attract other magnets. Unlike poles attract each other. The north pole of one magnet **attracts** the south pole of another magnet. But poles that are alike **repel**, or push away from, each other.

Magnets are strongest at there ends. The north pole of one magnet will attract the south pole. Unlike poles of a magnet attract each other. Like poles repel each other.



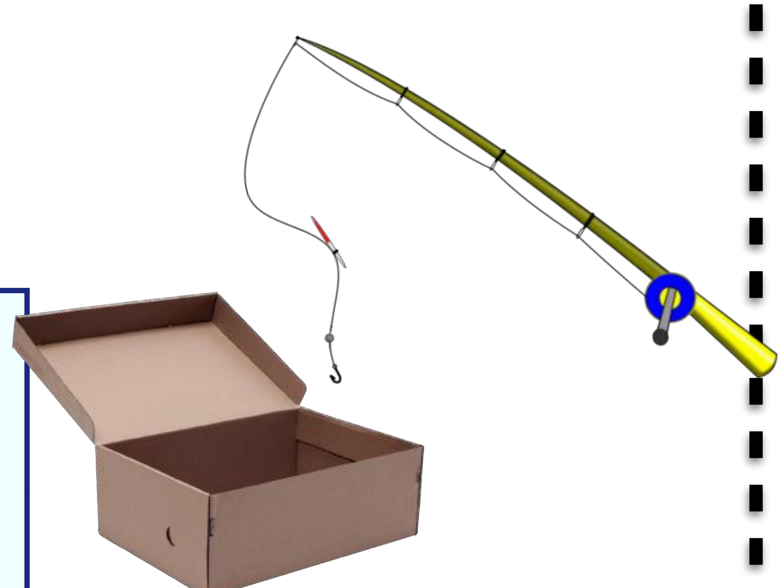
Let's try it out!

Take two magnets and match two opposite ends and two like ends. What happens?

Hard Magnets/Soft Magnets Activity

Permanent magnets keep their magnetism long after they have been magnetized. For this reason, they are known as **"hard" magnetic materials**. Many strong permanent magnets are alloys (mixtures) of iron combined with nickel, cobalt, or a group of metals known as lanthanide elements. Among the most common magnetic alloys are a group of compounds containing a mixture of aluminum, cobalt, copper, iron, nickel, and possibly titanium.

Temporary magnets are made of such materials as steel and nickel. These materials are known as **"soft" magnetic materials** because they usually do not retain their magnetism. For example, a magnetized steel nail loses its magnetism if it is removed from a magnetic field.



Let's try it out!

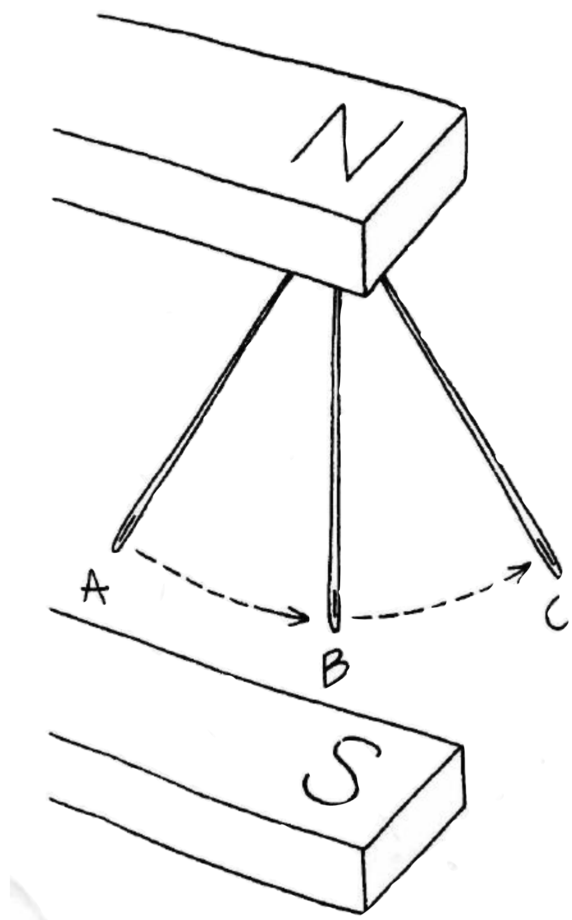
Move to the "fishing" station and see how various materials react to the magnet at the end of the fishing pole! Then, on the diagram, list which materials are hard or soft magnets. Are any materials not magnet at all? What do they have in common?

Magnetism vs. Gravity

Station A

What You'll Need
2 Bar Magnets
1 Sewing Needle

1. Place the first magnet on a non-metallic table.
2. Hold the second magnet about 2 inches above the magnet laying on the table. Position the two magnets so the opposite poles are facing each other.
3. Touch the point of the sewing needle to the bottom of the top magnet.
4. Lower the top magnet so the hanging needle is close to, but not touching, the magnet laying on the table.
5. Use your finger to push the bottom of the needle to one side, and release needle if swinging a pendulum.
6. Observe, how long does it swing?



Further exploration:

- Would standing the needle on the lower magnet affect its swing? Repeat the experiment, placing the point of the needle on the lower magnet. Observe any changes in speed and time.
- Would a larger or smaller needle affect the results? Repeat the original experiment twice, first using a smaller needle then a larger needle. Observe any changes in speed and time.

Did you Know?

The Earth is like one big bar magnet. It has a magnetic north and a magnetic south, which is what the needle on a compass points to. However, this is geographically different than the actual north and south poles. Invisible magnetic field lines run from the north to south poles.

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Shielding Magnetic Force

Station B

What You'll Need

Scissors
Ruler
Poster board
2 Pencils
Masking Tape
Bar Magnet
10 Paper Clips
Non-metallic Cake Server
or Spatula

1. Cut two 8 inch by 4 inch poster board pieces.
2. Put the pencils between the poster board pieces, shown in the image below.
3. Tape the ends of the cardboard pieces together to secure the poster board, looking a little like a sandwich.
4. Tape the magnet near the edge of the top piece of the poster board.
5. Place all 10 paperclips on a non-metal table.
6. Hold the poster board sandwich high above the paperclips.
7. Slowly lower the poster board sandwich until it is just above, but not touching, the paperclips on the table.
8. Are the paperclips moving?
9. Without moving the poster board, slowly insert the cake-server between the pieces of poster board.
10. Now, has anything changed in the movements of the paperclips?

Write your observations below:

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Permanent Magnets

Station C

What You'll Need
Iron Nail
Paper Clip
Bar Magnet

1. Touch the nail to the paper clip to make sure they are not attracted to each other.
2. Lay the nail on a non-metal table.
3. Hold the south-pole end of the magnet on top of the center of the nail.
4. With the south-pole end of the magnet, stroke the nail toward its point over 30 times. (I know, that's a lot!) Be sure to lift the magnet away from the nail when returning to the starting point for each stroke.
5. Touch the pointed end of the nail to the paper clip.
6. What happens?

Did you Know?

Iron and other metallic materials act as if they have millions of tiny magnets inside of them, but they all point toward different directions. **Permanent Magnets have all of the tiny magnets facing the same point, making them strong and magnetic.** By stroking and touching the end of the nail, you have shifted the tiny magnets to all face the same way!

Try stroking the nail with the north pole of the magnet. Repeat the entire experiment with the north pole of the magnet and see how that affects the result. What happens? Why?

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Compasses

Before we used GPS, like the one on smart phones today, Sailors in the US Navy used **compasses** and the stars to navigate the waters which works at all times of the year, in all weathers, and in most places. When a piece of magnetized iron (think of the experiment at Station C) is placed on a splinter of wood and floated in a bowl of water, the wood will swing until the iron is pointing north and south. Any other direction can then be found.

A compass works because Earth is a huge magnet. A magnet has two main centers of force, called poles—one at each end. Lines of magnetic force connect these poles. Bits of metal near a magnet always arrange themselves along these lines. A compass needle acts like these bits of metal. It points north because it lines up with Earth's lines of magnetic force.

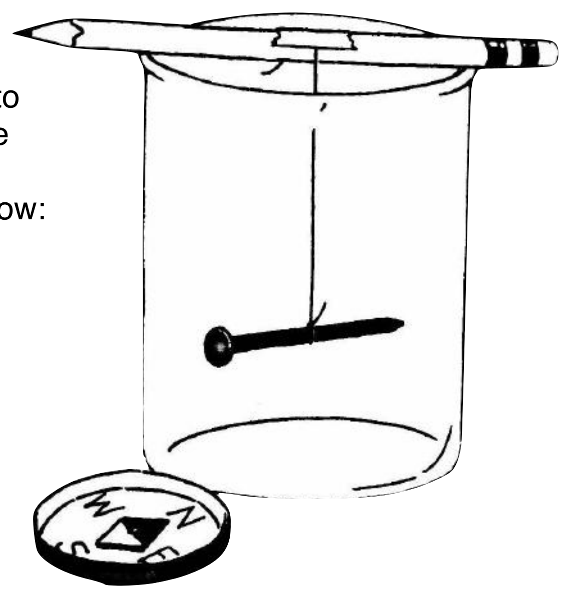
Earth's magnetic poles are not the same as the geographic North and South poles. The geographic poles are located at the very top and bottom of a globe. The magnetic poles are nearby but not at exactly the same places. A compass points to the magnetic North Pole, not the geographic North Pole. Therefore, a compass user has to make adjustments to find true north.

A special kind of compass called a gyrocompass does point to true north. The gyrocompass uses a device called a gyroscope, which always points in the same direction. Today large ships carry both magnetic compasses and gyrocompasses.

"Compass." Britannica School, Encyclopedia Britannica

Homework Activity

Try to make your own compass at home! Start by repeating the experiment from Station C (page 6) to create a magnetized iron nail. Now, tie a piece of thread to the center of the nail. Tape the other end of the thread to a wooden pencil and lay the pencil across a glass shown to the right. Place a compass next to the glass to see if the nail is accurately pointing the magnetic field of the north pole of Earth. What happened? Write your thoughts below:



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Vocabulary

Atom- the basic unit of a chemical element. Consists of electrons, neurons, and protons.

Attract- to draw by a physical force causing or tending to cause to approach, adhere, or unite.

Compass- an instrument for determining directions, as by means of a freely rotating magnetized needle that indicates magnetic north.

Electrons- a stable sub-atomic particle with a charge of negative electricity, found in all atoms and acting as the primary carrier of electricity in solids.

Hard Magnet- an object made from a material that is magnetized and creates its own magnetic field.

Magnetism- a physical phenomenon produced by the motion of electric charge, resulting in attractive and repulsive forces between objects.

Repel- To drive or force back or away.

Soft Magnet- Materials that act like magnets temporarily, after they have been near a hard magnet.

Fill in the following sentences with the vocabulary words you just learned.
Use <u>context clues</u> to help:

________________ is the phenomenon where _____________ within the __________ align. Strongest at their poles, these magnets ____________ the opposing poles and ____________ like poles. Materials that have their own magnetic field permanently are called ______ __________ while some materials, known as _______ __________, can become magnetized but not permanently. The US Navy uses hard magnets to make _______________, helping them to navigate the waters by finding Earth's north pole.