Physics: Magnetism part 1

ENGAGE: Magnetism

Like gravitational forces and electrostatic forces, we find that magnetic forces also act at a distance. We will explore this further in this activity. You will probably have some idea about what magnets are. It is very likely you have some on your refrigerator at home holding up pictures and lists.

1. Why don't magnets stick to standard drywalls?


2. Why are magnets attracted to some things and not others?


Many people think magnets are attracted to all metals, but that is not necessarily true.

ANS:

INVESTIGATION 2.9: What is affected by magnets? See appendix for equipment list.

1. You will need the following materials: aluminum foil, pure iron, pure copper, paper clips, copper penny, a nickel or dime (or other “silver colored” coins), stainless steel, brass, minerals (such as quartz, hematite, calcite, pyrite etc.), other materials, including pvc plastic, styrofoam, wood, paper etc.

2. For each material predict what will be attracted to the magnet before you test it. Fill in the table below with your prediction and the actual result:

<table>
<thead>
<tr>
<th>Material</th>
<th>Prediction: Attracted/ not attracted</th>
<th>Reason</th>
<th>Result: attracted / not attracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>aluminum foil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pure iron</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pure copper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>paper clips</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>copper penny</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>nickel or dime</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>stainless steel</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>brass</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>quartz</td>
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<td></td>
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<tr>
<td>pvc plastic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Styrofoam</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wood</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>paper</td>
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</tr>
</tbody>
</table>

3. Separate the items into two piles based on if they are attracted to the magnet or not. What observations can you make about the objects attracted to the magnet?
EXPLORE: Magnets and charge

In investigation 2.8 you explored electrostatic charges. These attract or repel each other. Can these charges interact with magnets in the same way?

INVESTIGATION 2.10: Charges and magnets See appendix for equipment list.
1. Rub a plastic ruler with wool and balance it on a small bottle lid.
2. Now rub a second ruler and bring the rubbed end of this second ruler near to the rubbed end of the first ruler. Observe the result.
3. Rub the first ruler with wool again, and again balance it on the small bottle lid. Bring the wool used to rub the ruler near the rubbed end of the ruler. Observe the result.
4. Now bring a magnet near the rubbed end of the ruler balancing on the bottle lid and observe the result. Try both ends of the magnet.
5. Try rubbing the ruler again with the wool and reintroduce the magnet.

4. (a) What happened when the rubbed end of the second ruler was brought close to the rubbed end of the ruler balancing on the bottle lid?

(b) What can you say about the two ends of the rulers based on this observation?

(c) What happened when the piece of wool was brought close to the rubbed end of the ruler balancing on the bottle lid?

(d) How did the rubbed end of the ruler and the magnet interact?
EXPLORE: More on magnets

Magnets are interesting in that they affect certain materials without actually touching them. Other objects, such as the Sun also affect objects without touching them. In the case of the Sun, gravitational force affects another object. In the case of magnets, it is magnetic force that affects other objects.

5. Magnets have a north (N) and south (S) pole. The diagrams below show various alignments of magnets. Predict how these magnets will behave:

   (a) ________________________________

   (b) ________________________________

   (c) ________________________________

   (d) ________________________________

6. Describe what you would feel if you were to push two south poles together: ________________________________

ANS:
**INVESTIGATION 2.11: Magnetic fields** See appendix for equipment list.

1. Place an index card (or ruled card) in a clear sandwich bag and then place a teaspoon of iron filings into the bag.

2. Lay the sandwich bag down on the bench and gently shake the bag back and forth so there is a thin layer of iron filings on the index card. Sketch what you see in the appropriate box below.

3. Carefully lower the center of the sandwich bag on top of a bar magnet. Sketch what you see in the appropriate box below.

4. Place a second bar magnet under the sandwich bag, lining up the two like poles opposite each other and sketch what you see in the appropriate box below.

5. Finally, reverse the second bar magnet, lining the two opposite poles and again sketch what you see.

- Iron filings with no magnet
- Iron filings with one magnet
- Iron filings with 2 magnets (like poles aligned)
- Iron filings with 2 magnets (opposite poles aligned)

**If you do not have the above materials, watch this link then make observations:** [10 minute amazing MAGNETS, Magnet and iron filings](#)
7. (a) How would you explain the patterns of iron filings you see when there is a magnet in place? __________________________

(b) What do the patterns reveal about attraction and repulsion between the magnets? __________________________

(c) How do the patterns of the iron filings relate to the magnetic field of the bar magnet? __________________________

(d) What happens to the pattern of iron filings when two like poles are placed next to each other? __________________________

(e) What happens to the pattern of iron filings when opposite poles are placed next to each other? __________________________

(f) Can you tell by the patterns where the force of the magnetic field is strongest? Weakest? __________________________

ANS:

> INVESTIGATION 2.12: Strength of a magnetic field See appendix for equipment list.

1. Place a piece of paper between a magnet and a metal paper clip. One at a time, continue placing additional pieces of paper in between the magnet and the paper clip.

2. Record how many pieces of paper can be placed between the magnet and the paper clip before the magnet no longer affects the paper clip.

ANS:

3. (a) Why does the magnet attract the paper clip even though it is not in direct contact with the paper clip? __________________________

(b) How does the magnetic force acting on the paper clip change as you increase the number of pieces of paper between the magnet and the paper clip (what can you say about the effort it takes to pull the magnet and paper clip apart as the number of pieces of paper increased)? __________________________

(c) Would the force on the paperclip change if the paper was removed but the distance between the magnet and paperclip stays the same? __________________________

ANS:
EXPLAIN: Electromagnetism

For a long time, it was believed that electricity and magnetism were completely separate phenomena. After all, as you saw earlier, there is no observable reaction between a charged ruler and a magnet. It wasn’t until Michael Faraday showed that an electric current can create a magnetic field in 1831 that the two phenomena were shown to be related. Together, magnetism and electricity are linked through the theory of electromagnetism.

You have seen that when objects carry opposing charges, they are attracted to each other. However, over time, the charges can dissipate and the objects are no longer attracted to each other.

This occurs because there will eventually be a flow of electrons from the area of high concentration to the area of low concentration until the charges are balanced. This means that the net charge on each object gets smaller and (from Coulomb’s law) if the charges are smaller, then the force will be weaker.

We call a flow of electrons electric current. In nature, most electron flows occur rapidly (static shock) and sometimes violently (lightning).

When we think of electricity, we often think of the electricity we obtain through electric wires to run our everyday appliances (e.g., lights). This electricity is a current, a steady flow of electrons, which originates from a power plant.

Magnetic fields arise from the movement of any charged particles. In most cases these moving charged particles will be electrons. This means that when lightning strikes or a static shock is given, there is a magnetic field. However, since these natural phenomena are virtually instantaneous, so are the magnetic fields. Magnetic fields are more easily observed when there is a continuous flow of electrons. This is why compasses show incorrect readings near any wires carrying currents.

Lightning results from an imbalance in charges between rain clouds and the ground. Electrons begin flowing towards the ground and make contact with positive charges flowing upwards from the ground. When contact is made, electrons flow up at about 1/3 the speed of light between the ground and the cloud, producing a giant spark.

9. Recall in the previous activity a magnet was placed near the charged end of a ruler. Knowing that there is a relationship between electric current and magnetism, can you explain why there was no observable reaction from the ruler to the presence of the magnet?

ANS:

10. Permanent magnets, like the one you used earlier, have (not surprisingly) permanent magnetic fields. However magnetic fields arise from the movement of electrons. Suggest how permanent magnets produce their magnetic field:

ANS:

ELABORATE: Understanding magnetism

The model of the atom you have studied earlier shows several important things:

- Electrons fill an atom’s energy shells with electron shells near the nucleus filled first.
- Electrons have a property called spin, either up or down.
- When orbitals are more than half full, electrons pair up. The spin of the electrons in these pairs is always opposite (i.e. one up one down). It is impossible for both electrons in a pair to have the same spin.
- Electrons are in constant motion around the nucleus.

12. How could the electrons moving around the nucleus produce a magnetic field? 

ANS: