

Teacher's Guide for "The Mysteries of Magnetism"

ACTIVITY 1 (10-15 min)

The goal of the first activity is by experimenting with magnets, compasses, and iron filings, to have students characterize the magnetic force, and the source of the magnetic force. This is a very open-ended inquiry-based activity.

Students should work in small groups to write descriptions and draw sketches of comparing magnetism to the other forces you have studied so far in your class.

Available sources of magnetism can be various non-electric magnets.

They can use either compasses or iron filings to map the direction of the magnetic force. At the end, you can have students share and compare their drawings. Using a variety of equipment (magnets, iron filings, compasses) across the classroom will generate a variety of answers and foster better discussion. However, limit an individual group to only one option.

Segment 2: The idea of poles is introduced in this segment. Then, the concept that these poles cannot be separated is introduced. Some complicated demonstrations are performed on the video, such as breaking a magnet in half. A demonstration where magnetism is disrupted by extreme heat, and another by extreme shock is performed.

ACTIVITY 2 (10 minutes to build [optional], 10 minutes to experiment, 5 minutes to discuss)

Through this activity the students will explore the idea of domains. The students will use an approximately 1" long piece of drinking straw filled with iron filings to act as a magnet. The ends of the straw can be sealed with a hot glue gun. One end of the straw is sealed with glue. After it cools, then fill the straw with iron filings. Then seal the other end. Depending on the type of iron filings you use, there may be some settling. I suggest using the low temperature hot glue guns.

You can either have the students build these straws or build them yourself in advance depending on the amount of time allotted and if you have enough hot glue guns. You can also have one glue gun station and let the students take turns.

The goal is for students to realize they can magnetize the straws by exposing them to an external field, and demagnetize the straws if they shake them. You can use bar magnets to magnetize the straws. Holding the straws horizontally, slowly pass the straws parallel to the bar magnet. A better option is to use circular ceramic magnets. Holding the straws horizontally, if you pass the straws slowly through the holes in the middle of the circular magnets they will gain a strong magnetization. This can be tested by bringing the straws near a compass.

Students should describe what happens to the straw magnet and how this relates to a natural magnet. They should draw a sketch of what they think is happening in a bar magnet. Explain the demonstrations from the video based on what you have learned from the activity.

Segment 3: The idea of domains is discussed in terms of the activity and the demonstrations. The idea of magnetic field lines is introduced.

ACTIVITY 3 (10 min)

Using either compasses or iron filings on a piece of paper or cardboard, the students will sketch a diagram of the field lines around a magnet. The magnet is placed under the paper and the iron filings on top. It is nice to have a variety of magnets available so different student groups will have different sketches, which they can share and compare.

The materials for this can be as simple as bar magnets, and either iron filings OR compasses. Or even better, give some groups iron filings, and some groups compasses.

Pieces of Plexiglas if available might also give greater insight than simple paper.

This can also be done three dimensionally using small soda bottles, filled with oil and iron filings, and a test tube with a magnet. You first fill the $\frac{1}{2}$ liter soda bottle with any kind of clear oil (mineral oil or

vegetable oil). Then add some iron filings. Then place a bar magnet inside of a test tube. Slip the test tube into the soda bottle. This works best when the lip of the test tube is bigger than the lip of the soda bottle so it does not fall in. The iron filings will flow through the oil to map the lines.

Segment 4: The shape of field lines is discussed. Then, electromagnets are introduced in a variety of toys and devices.

ACTIVITY 4 (10-15 min)

Although not intended for this lesson, it is always fun to have the students make electromagnets from nails and insulated wire and have them pick up things.

Have the students draw a sketch of the field lines due to a solenoid or a coil of wire with a constant DC current. Students could optionally make their own coils or the teacher can prepare coils. Coils can be made large using toilet paper rolls, or small using steel bolts. Students can use both iron filings and compasses to map the fields. The power supply could be plug in supplies or batteries. You must be very careful with the plug in power supplies.

Try to nudge the students to place their compasses everywhere relative to the coils. Above, below, left, right, inside outside etc.

To affect the iron filings a stronger field like the nail and tight coil is nice. The toilet paper roll coil is nice because you can place a compass inside the coil.

Students should compare their electromagnet sketches to that of the natural magnets, and find many similarities. Try to encourage a variety of methods.

Segment 5: In this segment I review what the field lines of a coil look like. Then I do a demonstration of the field line of a single wire. The students are asked to think about the relationship between the coil and the single wire.

ACTIVITY 5 (10 min)

Have students start out by drawing the field of a single wire. Bend wire into a square loop and explain the drawing. **This is a modeling exercise.** You can have the students simply draw the picture on paper. Or give the students cardboard cutouts of arrows to represent field vectors and place them around the wire or the loop. This could also be done with magnetic cardboard cutouts that students stick to the board to share ideas.

The goal is to hope that the students see that the field circles the wire, and when this wire is bent into a loop it creates the field we see with an electromagnet.

Segment 6: The connections between the field of a single wire and the field of a loop are reviewed. With the understanding of the magnetic fields of wires, the students are asked to make the connection to the field of a natural magnet.

ACTIVITY 6 (10 min)

Students should discuss their ideas in small groups and then share and collaborate in the large group. The goal is to have students synthesize everything they have learned in this lesson. The idea being there are domains. Each domain is a small magnet. You may have to remind the students that atoms contain moving charges such as electrons. So each domain has moving charges. So the goal is to get students to realize what is the source of magnetism. And the motion of electrons in atoms is the source of magnetism in rocks.

An oversimplified view would be to use the Bohr model of the atom and that electrons are “orbiting” the nucleus and it is this motion, which causes the field. Although this is **not correct**, this might be the easiest thing for students to visualize. Unless your students are ready to discuss probability clouds and quantum mechanics and spin, you may want to keep things at the level that there is a connection between moving charges on the atomic level and magnetism in natural objects.