

Homopolar motors : (~30-40 min)

Objectives:

STANDARD III: Students will understand that magnetism can be observed when there is an interaction between the magnetic fields of magnets or between a magnet and materials made of iron.

Objective 1: Investigate and compare the behavior of magnetism using magnets.

- a. Compare various types of magnets (e.g., permanent, temporary, and natural magnets) and their abilities to push or pull iron objects they are not touching.
- b. Investigate how magnets will both attract and repel other magnets.
- c. Compare permanent magnets and electromagnets.

Objective 2: Describe how the magnetic field of Earth and a magnet are similar.

- a. Compare the magnetic fields of various types of magnets (e.g., bar magnet, disk magnet, horseshoe magnet).
- b. Compare Earth's magnetic field to the magnetic field of a magnet.
- c. Construct a compass and explain how it works.
- d. Investigate the effects of magnets on the needle of a compass and compare this to the effects of Earth's magnetic field on the needle of a compass (e.g., magnets effect the needle only at close distances, Earth's magnetic field affects the needle at great distances, magnets close to a compass overrides the Earth's effect on the needle).

EXTENSION:

Students will also verify that there is a relationship between current electricity and magnetism that makes it possible to create motors and generators

Materials Needed:

- 1) D-batteries – (AA batteries suffice, D-batteries have a higher current.)
- 2) Neodymium Cylindrical Magnets ($\frac{1}{4}$ in diameter, $\frac{1}{4}$ in thick)
- 3) 2 in screws (Drywall are easiest and cheapest...) – (Iron nails suffice)
- 4) 4 in thin copper wire.
- 5) Long Bar magnet
- 6) Copper winding coil with a light bulb attached.
- 7) Compass

Strategy:

(designed to follow the electro-magnet demo...)

Classroom Demonstrations:

Review – Winding Coil Demo: (~8 min)

(If the winding is not in the classroom, take some time to help the students remember what they did last time with the electromagnet, and continue with the motor demo. The demo in this section can be used either as an opener, mid-time explanation, or a closing.)

With the electromagnets that were built last time, the students were able to see that electrical current and magnetism were related to each other. Get the students to recall some of the following points. (ask questions or remind them)

- Magnets have two poles
- Magnets can push or pull different kinds of objects
 - Some metals (not every metal)
 - Other magnets
- The earth acts like a big magnet
 - Compasses work because the Earth's magnetic field “pulls” and orients the needle in the compass.
- You can use a magnet to create electricity.
- You can use electricity to make an electromagnet.

Use the winding coil to demonstrate how the light bulb lights up when the magnets is moved into and out of the winding. Ask the students to remember how they were able to pull paper clips with the nail and the winded wire. Show the students the winding and ask them to imagine how the magnet would be affected if you used electricity to make an electromagnet that big... How would the natural magnet react? (It would get pulled or pushed). We can use this property to make different devices. One of this devices is a motor!!!

Homopolar Motor Demo: (~15min)

It is important that you demo the motor first to show the students how this is to be done. Also, ask a student (or do it yourself if you want to) to write the steps on the board.

(Optional... Show the homopolar video on the classroom projector)

Time: (~5 min) We have just mentioned that mass should be conserved. Bring their attention back by asking them to predict what will happen when you mix Alka-Seltzer with water.

- Directions:
- Place the magnet at the head of the screw (or nail)
 - This will magnetize the nail and help it “stick” to the battery)
- “Stick” the tip of the nail to the NEGATIVE pole of the battery
 - (The pole does not matter, but the motor is more stable this way)
- Hold the battery vertical so that the nail and magnet are free-hanging.
- Complete the circuit with the wire by connecting the POSITIVE pole of the battery to the SIDE of the magnet.
- The magnet should spin.

Give time for the students to make their own motors, play with them, see how fast they can get them to

spin, etc. During this time, walk around the students, see their progress and ask a few of the review questions mentioned above.

After some time, gather the attention back from the students: (They may now keep all the materials, and show their parents at home and explain how this device works.)

Simple Explanation: Just like with the winding, the movement of the magnet can be used to move “electrons” and create an electrical current. Likewise, since we have an electrical current, we can use it to move a magnet.

(Extension: Why the side of the magnet? What happens if the wire is connected to the bottom of the magnet? The relationship between electricity, magnetism, and the forces that arise from them are rather peculiar, because the direction matters. This may be shown with the winding also, by not moving the magnet perpendicular to the coil winding.)

Closing:

(As you close, check for understanding) Electricity and magnetism are closely related to each other. Since electricity is not that hard to control (there are switches), we can use it with magnets to help us make many devices. Students should be able to mention quite a few machines that use electrical motors (eg. Drills, mixers, hard drives, trains, toys, some hybrid cars, CD players, etc). In the same manner, since magnetism is also related to electricity, we can use HUGE magnets (and something to move them!!) to produce the electricity that we need.

Performance Assessment:

There are quite a few concepts that the students should have been exposed to by now, check orally for some of these:

1. Magnets have the ability to push, or pull some types of object they are not touching
2. Magnets have two poles
3. Magnets can be used to “magnetize” certain types of objects
4. Compare permanent magnets and electromagnets
5. Electricity and magnetism are closely related to each other
6. By using an electromagnet, and its ability to push and pull just like a magnet, you can create different machines. (like motors)
7. Similarly, with a magnet you can “push and pull electrons” and create electricity. (And thus, make a generator)

Final notes:

*** This behavior between moving electrical charges, and the creation of a magnetic field can be extended to the Earth's magnetic field, hydro-electric plants, Nuclear power plants, generators, motors, alternators, etc. ***