Center of Science and Industry

Magnets are Fun

GRADE LEVELS: 1st through 3rd grade

CONCEPTS:

- Magnets have two poles – north and south.
- The poles have attractive and repulsive properties
- Magnets can be used for practical purposes, such as transportation
- The earth is a very weak magnet
- Neodymium magnets are incredibly powerful

OBJECTIVES: Participants will be able to:

- Explain poles and show how they react to each other
- Create a maglev train and test it with modifications
- Race the trains without touching them (using magnetic forces)
- Explain electromagnetic forces and how they relate to the Ring Launcher

CONTENT STANDARDS:
Science: Physical Sciences: 1.1, 1.3, 1.5, 1.6, 1.7
Science: Physical Sciences: 3.1, 3.2, 3.3, 3.4

VOCABULARY WORDS:
Magnetic force -The push or pull exerted by a magnet
Magnetic field - The region around a magnet where the magnetic force acts.
Magnetic poles - Either of two regions of a magnet, designated north and south, where the magnetic field is strongest
Electromagnetic - magnetism produced by electric charge in motion
Levitate - to be suspended in the air, as if in defiance of gravity
Compass - A device used to determine geographic direction, usually consisting of a magnetic needle or needles horizontally mounted or suspended and free to pivot until aligned with the earth's magnetic field.
Attract - exert a force on an object causing it to approach or prevent it from moving away. To cause to draw near or adhere by physical force.
Repulse - cause to move back by force or influence

Neodymium - A metallic chemical element, atomic number 60, Neodymium belongs to the rare-earth group of elements. Alloyed with iron and boron, neodymium is the basis for powerful permanent magnets.

EXTENSIONS AT COSI:

Gadgets

- Magnetic Gear Table – Try to make the gears go up the side of the center post and still rotate. What kind of problems do you have? How much force can the magnets withstand? Do you notice that when you have too many gears the magnets allow the gears to slide so they are no longer touching? Take two of the gears and try to line up their bottoms exactly and stick them together. Can you do it? Why or why not?
- Magnetic Balancing Act – Which of the substances were magnetic?
- Crazy TV – How does the magnet in the end of the stick affect the picture on the television screen?
- See the Light – Try spinning the handle and making the light come on. The handle is attached to a magnet. As you spin the handle you are also spinning the magnet. Like all magnets this one has a magnetic field. The moving magnetic field creates an electrical current. That current then travels through wires to the light bulb. The faster you spin the handle the stronger electrical current is produced making the light bulb brighter.

Gadgets Café

- Take Apart Café – As you take apart the computer you can find several magnets. Take out the speaker, leaving the wires attached. Ask an attendant to show you how the magnet inside is used to make the noise that a speaker produces.
- Science Menu – Chose *Get your Motor Running* from the menu. Follow the directions provided to explore how motors work.

Science ala Carte

- Electromagnetism – A team member will lead you threw experiments demonstrating how a magnetic field can generate an electrical current, and how an electrical current can create a magnetic field.
- Ring Thrower – A team member will demonstrate how electrical currents and magnetic fields can be used to throw the ring into the air.

ADDITIONAL RESOURCES:

http://www.pbs.org/wgbh/nova/einstein/lrk-hand-maze.html
http://pbskids.org/zoom/activities/do/funnyfamilyfridgemag.html
http://www.howmagnetswork.com/history.html

SAMPLE TEST QUESTIONS:

1. Two magnets have poles at each end. One end is the positive pole marked with a plus sign (+). The other end is the negative pole, marked with a negative sign (-).

Which of the following is true?

A. The negative ends of the magnets will be attracted to each other.
B. The positive ends of the magnets will be attracted to each other.
C. The positive end of one magnet will be attracted to the negative end of the other magnet.
D. The negative end of one magnet will repel the positive end of the other magnet.

2. Jimmy drew a picture of his dog and attached it to the refrigerator with a magnet. Which of the following is true?

A. The refrigerator is plastic.
B. The paper Jimmy drew his picture on is magnetic.
C. Jimmy's dog does tricks.
D. The refrigerator is metal.

3. You can create an electromagnet by wrapping copper wire tightly around a nail and attaching each end of the wire to opposite ends of a battery. Which of the following is not true?

A. The flow of electrons threw the copper wire creates a magnetic field.
B. The electromagnet stops gravity and begins to float.
C. The electromagnet can be turned on and off.
D. An electromagnet can be very strong.

Magnets-Pre Visit Activities

Magnetism Hunt

OBJECTIVE: The learner will learn that not all metals are magnetic.

MATERIALS:

- Large nail
- Bar magnet (1 per student)
- Small tacks
- Metal paper clips

INSTRUCTIONS:

1. Give each student a bar magnet and tell them they're going to experiment with magnets and various objects. Classify "Do's' and 'Don'ts." (don't try this at home, especially with computer and TV screens, iPods, computer disks, audio cassette tapes, film etc.)
2. Have the students write down the name of each object, what material it's made of and their predictions on Worksheet 1.
3. After experimenting, have them write down their findings on the worksheet. Then have them answer the remaining question on the worksheet.
4. As a class, discuss the findings.
5. Next, split the class into small groups and give each group 3 magnets and several metal paper clips.
6. Have the students predict how many paper clips they think one magnet, then two, then three will pick up and record their predictions on Worksheet 2.
7. Have the students test out the magnets and record the number of paper clips picked up with one, two and three magnets and whether their prediction was correct. Then have them answer the two remaining questions on the worksheet.

.

ACADEMIC CONTENT STANDARDS:

Science

Physical Sciences: 1.5, 3.3

Scientific Inquiry: 1.1, 2.10, 3.2, 3.5, 5.2

Magnetism Hunt

Name:____

WORKSHEET # 1

Name of Object	Material of Object	Attracted to Magnet?	
		Yes	No

Write two sentences telling what you found out about magnets.

Magnetism Hunt

Name:____

WORKSHEET #2

# of Magnets	Number of Paper Clips Picked Up		Was your prediction correct?
	Prediction	Actual Results	
1			
2			
3			

Were you surprised by the results? Why or why not?

Write two sentences telling what you found out.

Magnetisphere

OBJECTIVE: The learner will understand magnetic fields

MATERIALS: (enough for teacher and each group)

- Strong polarity bar magnet
- Plastic wrap/Contact paper
- Iron Filings
- Plastic salad tray or Aluminum tray
- Spoons
- Straws
- Safety goggles
- Worksheet
- A small button

INSTRUCTIONS:

1. Tell the students that before you discuss magnetism that you have a question for them: What purpose does our skin serve? Field some answers. Hopefully someone will say that it keeps harmful things out of our bodies (protective).
2. Next talk about how the magnetosphere does the same thing for Earth that our skin does for our bodies.
3. Ask the students if they can tell you what a magnetic field is. Try to steer them towards properties such as: invisibility, surrounding the magnet, etc)
4. Now tell them that they are about to do some experiments showing magnet fields and compare the lines of force of the magnet to the lines of force of the magnetosphere.
5. *VERY IMPORTANT* Make sure the students wear their safety goggles and follow directions carefully so as not to get filings in their eyes nor breathe filings in.
6. Now separate the students into smaller groups and give each group their safety goggles, a bar magnet, wrap/contact paper, iron filings, a tray, a spoon, straws (one per student), and worksheets (one per student).
7. MAKE SURE everyone has their goggles on. To keep the bar magnet clean, wrap it in plastic wrap with tape around it, or put contact paper around it (it may be easier to prepare the magnets ahead of time).
8. You can do the whole experiment first and then have the students repeat it on their own or you can do one step at a time, showing them first and then having them

repeat each step. Of course you know your class best, and you may just want to perform the experiment for them and have them observe. Place the bar magnet under a plastic salad tray or aluminum tray.

9. Sprinkle some iron filings onto the tray from a distance of about 10 inches. Observe the pattern made by the iron filings held in place by the forces between the opposite poles of the magnets. Tell the students to draw this force on their worksheets.
10. The Earth's magnetosphere can be modeled by blowing *SOFTLY* through a straw towards the magnetic field lines. Make sure that everyone has their goggles on and is standing back from tray. Also make sure to emphasize that you should only be blowing air through the straw, not taking breaths through the straw. A squishing of the field lines on one side of the model shows how the magnetosphere looks. Have the students draw the model of the magnetosphere on their worksheets.
11. Ask the students if they know what solar wind is. And ask them what do they think will happen when solar wind approaches Earth or how do they think the magnetosphere protect the Earth.
12. It's time to find out. Place the bar magnet under a plastic tray or aluminum tray. Place a small button directly above the center of the magnet to model the earth. Sprinkle the iron filings along the edge of one side of the tray covering the magnet.
13. Softly blow the filings toward the button through a straw. Caution the students again to blow carefully so that no iron filings get into eyes or mouth. Depending on the force used in blowing, the filings will be trapped in the magnetic lines of force. Compare this to the trapping of the solar particles by the Earth's magnetosphere.
14. Have the students draw the model of the effects of the solar wind on the earth's magnetosphere on their worksheet.

W HAT HAPPENED? WHAT IS GOING ON?

Scientists call the region surrounding the Earth where its magnetic field is located, the Magnetosphere. When the solar wind sends streams of hot gases (plasma) towards the Earth, the magnetosphere deflects most of this gas.

ACADEMIC CONTENT STANDARDS:

Science: Physical Sciences: 1.5

MAGNETIC FIELDS

MAGNETOSPHERE

EFFECT OF MAGNETOSPHERE ON SOLAR WIND

Take me to the (magnet) races

OBJECTIVE: The learner will understand that opposites attract and similar poles repel in magnets

KEYWORDS:

- Linear Induction
- Magnetic Force Field
- Repel
- Attract

MATERIALS:

- Bar Magnets (2)
- Chalkboard
- A variety of magnetic and non-magnetic objects (rubber bands, pennies, paper clips, screws, small magnets, tacks, popsicle sticks, etc)
- Small matchbox- or hot wheels–type cars (one for each group)
- Enough sets of 2 magnets for each group (the circular "donut" shaped ones work well)
- Rubber bands (4 for each group)
- Masking tape to create a small drag strip or racetrack (or an actual racetrack if you have access to one)

INSTRUCTIONS:

1. Ask the students for the definition of a magnet/what a magnet does.
2. After fielding some answers ask what would happen if you put a magnet up to something made of metal. Field some predictions and write them on the chalkboard, and then try it out. Make sure to try a variety of metals (some magnetic, some non-magnetic).
3. Now ask what would happen if you put two magnets near each other? Field some predictions and write them on the board, and then try it out (Place the two magnets together so that they attract one another.)
4. Explain to the class that magnets have North and South poles and that opposite pole attract, like they just saw. If opposite poles attract, what do they think will happen when you put two like poles together?
5. Place the magnets so that North touches North. Reiterate that like poles repel

and opposite poles attract.

6. Break up the students into smaller groups. Hand each group a little car, 2 magnets and 4 rubber bands. Challenge them to find some way to make the car move without touching or blowing on it. After a few minutes check their progress and make sure everyone's "on the right track."
7. Take the groups to the drag strip or racetrack and have them race against each other. Ask if there are any reasons why some cars go faster than others.

WHAT HAPPENED? WHAT IS GOING ON?

Magnetism, like gravity, is a force that cannot be seen. Every magnet, however, has an area in which it exerts its force. This area or space is called the magnetic force field. The size of this field depends upon the strength and size of the magnet. All parts of a magnet do not show equal strength. The areas of greatest strength or attraction on a magnet are called the poles. If you suspend a bar magnet horizontally by a loop of thread, you will find that when the magnet stops swinging, one end will point north. This end is the north-seeking pole, or simply North Pole. The other end is the south seeking, or South Pole. Magnets are usually marked with an N for North Pole and an S for South Pole. If you place similar poles together (N-N or S-S), the magnets will repel each other. If you place opposite poles together (N-S), the magnets will attract and stick to each other.

If two magnets are brought close enough together, their fields will begin to interact in the following ways:

- If the magnets' north poles are brought together, the magnets will repel one another (like poles repel).
- If the north pole of one magnet is brought to the south pole of the other magnet, the magnets will attract one another (opposite poles attract).

ACADEMIC CONTENT STANDARDS:

Science: Physical Sciences: 1.5, 1.6, 3.3

Magnets-Post Visit Activities

Dangling Magnet

Key Words:
Magnet
Magnetic field
Liquid
Solid

Materials:
- Round donut magnet
- 500 mL beaker (a mason jar will also work)
- Water
- Soda
- Salt Water
- Metal paper clips
- Six-sided pencil
- 8 inch piece of string
- Water
- Scissors
- Tape
- Paper upon which to write predictions/hypotheses and observations/conclusions
- Pen/Pencil

Instructions:
1. Tape the end of the string to the middle of the pencil so that it will wind as the pencils turns. Tie the other end of the string to the magnet. Spin the pencil so that the magnet is wound all the way up to the top.
2. Place the paper clip inside of the beaker and hold the pencil on top of the beaker so that the magnet is hanging inside the beaker. (If you want to take some silly putty/clay and put 2 little pieces on either side of the pencil by the rim (to keep the pencil from rolling away), that's an option). Ask the students to write on their paper

what they think will happen when you lower the magnet into the beaker. Then field a few answers from the class and write some answers on the board.

3. Slowly turn the pencil so that the magnet is lowered into the center of the beaker. Keep unwinding until the paperclip is attracted to the magnet. Tell the students to record their observations on their papers. (For example: what happened to the paper clip? How strong is the magnetic attraction?)
4. This time, do the same thing but with the beaker half full of water. Before you do the experiment ask the students what they think will happen and write up their options on the board. You can also ask them to vote for which option they think will most likely happen.
5. Go ahead and lower the magnet.
6. Have students record their observations on their papers now. Pay particular attention to any changes.
7. This experiment can be repeated several times, each time using a different liquid and observing changes. Try using salt water, clear soda, juice, etc.
8. Split the students into smaller groups. Ask them to create a way to quantify the results. One way is to mark the string in equal units, and observe the magnet in different liquids.

Academic Content Standards

Science: Physical Sciences: 1.5, 3.3
Science: Scientific Inquiry: 1.1, 3.2, 3.5

Center of Science and Industry

Magnetic Pendulum

Key Words:
Magnet

Materials:
Ring Stand or Clamp
4 to 6 Magnets
Fishing Line

Instructions:

Assembling the Magnetic Pendulum:

1. Put all the magnets together in a stack so that they stick together magnetically. By doing this, you are orienting the magnets so that all of the north poles point in one direction and all of the south poles point in the other direction. Mark the top of each magnet with paint, tape, or correction fluid, thus identifying all the matching poles.
2. Use the string or fishing line to hang one magnet from the ring stand so that it is a free-swinging pendulum. You can hang the magnet in any orientation.
3. Arrange the other magnets on the ring stand base in an equilateral triangle measuring a couple of inches on a side. Position the magnets so that they all have the same pole up.
4. Adjust the length of the pendulum so that the free-swinging magnet will come as close as possible to the magnets on the ring stand base without hitting them or the base itself. You can accomplish this either by changing the length of the string or by adjusting the position of the clamp.

Experiment:

1. Give the pendulum magnet a push, and watch!
2. Vary the location and poles of the magnets to develop other patterns. You can arrange the magnets so that all of them have the same pole up, or you can mix them up. Notice that a tiny change in the location of one of the fixed magnets or in the starting position of the pendulum magnet may cause the pendulum to develop a whole new pattern of swinging.

Possible Interactive Questions:

- What do you notice about the pendulum? Can you make a hypothesis about what will happen after you provide motion to the magnet?
- Is there an observable pattern to the movement of the pendulum?

What's Going On?

The force of gravity and the simple pushes and pulls of the magnets act together to influence the swinging pendulum in very complex ways. It can be very difficult to predict where the pendulum is going to go next, even though you know which magnets are attracting it and which are repelling it.

This sort of unpredictable motion is often called chaotic motion. Strangely enough, there can be a subtle and complex kind of order to chaos. Scientists try to describe this order with models called strange attractors.

Further Exploration:

Experiment with various magnets and variations in magnetic power. Does changing the magnets cause fluctuations in the outcome?

Academic Standards:

Science: Physical Sciences: 1.5, 3.3

Light combinations

Key Words:
Diamagnetic

Concepts:
Both the north and south poles of a strong rare-earth magnet repel a grape. The grape is repelled because it contains water, which is diamagnetic. Diamagnetic materials are repelled by magnetic poles.

Materials:
Per Group:
- Two Large Grapes
- Drinking Straw with a small hole in the center (see below for details)
- Film Canister w/ Lid
- Pushpin
- Small Knife or Razor Blade
- Neodymium Magnet

Instructions:
1. Insert the pushpin through the underside of the film canister lid and put the lid on the canister so that the point of the pin is sticking out.
2. Find the center of the drinking straw and use the knife to cut a small hole, approximately 0.5 cm x 1 cm. (You can also use the hot tip of a soldering gun to melt a hole.)
3. Push one grape onto each end of the straw. Balance the straw with the grapes on the point of the pushpin; the point of the pin goes through the small hole on the straw.
4. Now that you have your device, bring one pole of the magnet near the grape. Do not touch the grape with the magnet.
5. The grape will be repelled by the magnet and begin to move slowly away from the magnet.
6. Pull the magnet away and let the grape stop its motion.
7. Turn the magnet over and bring the other pole near the grape. The other pole will also repel the grape; both poles of the magnet repel the grape.

Possible Interactive Questions:

- What happens when you bring the magnet closer to the grape? Why do the grape move further away from the magnet?
- Can you make the device spin? How fast can you make it go?

What's Going On?

Ferromagnetic materials, such as iron, are strongly attracted to both poles of a magnet.

Paramagnetic materials, such as aluminum, are weakly attracted to both poles of a magnet.

Both poles of a magnet, however, repel diamagnetic materials. The diamagnetic force of repulsion is very weak (a hundred thousand times weaker than the ferromagnetic force of attraction). Water, the main component of grapes, is diamagnetic.

When an electric charge moves, a magnetic field is created. Every electron is therefore a very tiny magnet, because electrons carry charge and they spin. Additionally, the motion of an orbital electron is an electric current, with an accompanying magnetic field.

In atoms of iron, cobalt, and nickel, electrons in one atom will align with electrons in neighboring atoms, making regions called domains, with very strong magnetization. These materials are ferromagnetic, and are strongly attracted to magnetic poles.

Atoms and molecules that have single, unpaired electrons are paramagnetic. Electrons in these materials orient in a magnetic field so that they will be weakly attracted to magnetic poles. Hydrogen, lithium, and liquid oxygen are examples of paramagnetic substances.

Atoms and molecules in which all of the electrons are paired with electrons of opposite spin, and in which the orbital currents are zero, are diamagnetic. Helium, bismuth, and water are examples of diamagnetic substances.

If a magnet is brought toward a diamagnetic material, it will generate orbital electric currents in the atoms and molecules of the material. The magnetic fields associated with these orbital currents will be oriented such that they repelled by the approaching magnet.

A law of physics known as Lenz's Law predicts this behavior. This law states that when a current is induced by a change in magnetic field (the orbital currents in the grape created by the magnet approaching the grape), the magnetic field produced by the induced current will oppose the change.

Further Exploration:

Try fruits other than grapes; a fruit such as watermelon, which has high water content, works well. Cut the fruit into grape-sized chunks.

Ohio Science Standards:

Science: Physical Sciences: 1.5, 3.3