Magnets & Motors

Focus: Physics **Grades:** suggested for grade level 3 and up (adaptive, interesting for adults)

Background:

The purpose for this demo is to interest students in magnetism and the applications of magnetism in the form of electromagnets and motors. This is a very hands on demonstration. Individually the students will handle magnets, magnetize and demagnetize paper clips, use magnetism detectors, and solve the puzzle of why "refrigerator magnets" stick to steel but not to either side of a magnet. In teams (there are 12 kits to loan) the student perform experiments with electromagnets and motors. The student will learn from experimentation that the motor's speed depends on the magnets gap and strength and the number of batteries connected.

Objectives:

- ✓ Students will be able to explain basic magnetism.
- ✓ Students will demonstrate the effects of electrical current to magnetism.
- ✓ Students will be able to speculate what will happen to the motion of a motor when magnet polarity or electric current direction change and when magnetic or electric current magnitudes change.

Learning outcomes:

Learning outcomes from this lesson parallel the 4th grade Ohio proficiency test.

- ✓ Select instruments, make observations and/or organize observations of an event , object or organism.
- ✓ Identify and/or compare the mass, dimensions and volume of familiar object in standard and/ or non-standard units.
- ✓ Analyze a series of events and/or simple daily or seasonal cycles and predict the next likely occurrence in the sequence.
- ✓ Evaluate a simple procedure to carry out an exploration.
- ✓ Identify and/or discuss the selection of resources and tools used for exploring scientific phenomena.
- ✓ Demonstrate an understanding of safe use of materials and/or equipment in science activities.
- ✓ Identify characteristics of a simple physical change.

Lesson:Overview

Discovery of simple magnet's properties
Discuss what is happening inside a magnet, spinning electrons
Discovery how the magnetic force changes with distance
Learn the mystery of refrigerator magnets, a complex magnet
Learn to make a magnet (magnetize) and unmake a magnet (demagnetize)
Learn the relationship between moving magnets and moving electrons
Experiment with an electromagnet's design, strength, and polarity
Experiment with an electric motor's direction, and speed by changing magnets, direction of electron flow, and number of batteries.

Activity

Setup. Pass out pack containing two donut magnets, two "refrigerator" magnets, and WOW magnetic view film, plus pass out gift pencil to each student. Magnets are ceramic, they break, if you do break some we are not upset, but ask to avoid dropping them.

Observing attraction and repulsion between magnets. Students experiment and recognize like colors attract and unlike repel. Note as convention red is North seeking and Blue or White is South Seeking. Ask if our geographic North Pole, which is close to our earth magnet pole should be painted Red or Blue? The answer is Blue because our Geographic North pole is a South Seeking magnet pole. Tip is not to drop the word seeking, as we all tend to do.

Symbolic balls on sticks, Ferromagnetic Materials; to understand magnets we are back to our electrons. But here we are concern not with imbalance of their numbers but their motion. Electrons are always in motion but in some materials they have more freedom than others. Show how electrons spin in a ferromagnetic material and how they can become a permanent magnet. Student should find materials that magnets attract (pencil eraser holder, paper clips, and desk parts. (Advanced - this is not exactly correct, we now know the electron is spinning on axis and in domains is the correct view, but this gives a good mental picture they can correct in college – your call, also for the advance mention paramagnetic and diamagnetic materials).

Observe how a magnets Repel on a Pencil. Stack two magnets on pencil with like poles facing each other. The magnets levitate. Press down on the top magnet and sense the force against your finger relative to the gap between magnets. Ask how much force increases every time you half the distance. The correct answer is quadruple. Note this is the same relationship found in electric force and gravity force. This is (coulomb's law) called a square law relationship, advanced – Force is proportional to magnetic strength divided by distance squared.

Refrigerator Magnets. Test students reasoning. Show how refrigerator magnets stick to ferromagnetic materials. Show how they stick to each other. Show how they are not attracted very well to either north or south seeking poles of donut magnet. And show how they ripple when pulled across each other. Ask how they think the poles are arranged. Have students look at donut magnets and refrigerator magnets with view film. Answer: strips of alternating N and S. Explain ripple as hold-repel-hold sense. Ask students how magnetic fields change when two magnets fields intersect each other. Have student place donut magnet under refrigerator magnet while viewing refrigerator magnet field and see increase and decrease in width of field. **Collect refrigerator magnets kit or they may be damage by experiments to come.** Students retain donut magnets.

Paper Clips become magnetized. Place the two paperclip's fat side on blue/south of magnet. Now paperclips are weak permanent magnets with narrow side south. On your desk show how narrow attract fat end of paper clip. Take one of the paper clips and put the fat end on the red side. Now find that fat attracts fat ect. Will these paper clips always be magnets? (Heat or demagnetize, explain how alternately magnetize at lower are lower levels is demagnetization.)

(Optional) Flux Detector. Pass out flux detectors. Warn students not to put magnets on refrigerator magnets, can damage flex magnets. Or better collect refrigerator magnets. (Dots are arrow points and X's are arrow tails) Use large version to show how flux wraps from north to south. **Show how rotating magnetic field (by rotating donut magnet) can rotate the flux detector magnet. Collect or students will be distracted from further experimentation.**

Lenz Law. Demonstrate that copper is not ferromagnetic. Drop down copper tube and find a slow fall. Why? Think of copper tube as a series of copper loops or rings. A moving magnetic field through the loop causes electrons to flow in loop. Electrons flowing in a loop create a magnetic field. The field has to oppose motion (if it aided motion the magnet would shoot out and defy conservation of energy).

Have students get into groups. Pass out electromagnet bags and motors on battery packs.

Electromagnet. For the time being forget about the motor on the battery pack. Explain the battery pack. Hook up the electromagnet black to black and plug to first red jack. Put close to end of electromagnet and momentary press button and notice flux direction by which side of the donut magnet is attracted or repelled. Switch plugs and check on flux direction. Explain right hand rule. How does magnet strength change – Ask- cause conversation to include number of turns, current and core material. Measure strength by picking up washers. (Could do statistics of number of washers picked up against # or batteries and # of turns – of course one variable at a time)

Motor. The principle of motors is changing the field at the right time to cause continuous motion. Take off permanent magnets and use flux detector to determine the polarity of the armature magnet. Plug in first jack. Now check out stator magnets. Select stator arrangement to make it go in the direction you want, say clockwise. Switch magnet. Add donut magnets. Increase voltage with number of batteries in series