MIND TREKKERS
Magnet Down a Metal Pipe Lesson Plan

Amount of time Demo takes: 1-10 min
# times per hr: 15
Container: Large bin

Materials:
1. Aluminum pipe (1) physics has
2. Aluminum right angle (1) physics has
3. Steel ball (2)
4. Strong magnets (3)
5. 3 Copper pipes of different thickness and diameter (3)
6. Stopwatch (1)
7. Small white board to record data (1)
8. place mat (so magnets, and balls don’t roll away as easy)

Set up instructions:
1. Have the materials needed set out on the table.
2. Find a couple of volunteers to help gather data and record. Timer, using the stopwatch, recorder, to write data on white board. In most large expo settings, you will drop the magnet down the pipe rather then having a volunteer.(to ensure it doesn’t roll away)
3. This lesson can be done as a demonstration or as an interactive science experiment. You can choose how you want to do it based on the audience or even go back and forth between demo and experiment.

SAFETY!
1. When working with strong magnets, fingers and skin can get pinched between two strong magnets.
2. Make sure magnets are handled gently, they can break if thrown around on table or if they hit the floor. The magnets can be attracted to something that you may not want them to and cause something to be broken or damaged. These magnets can be a serious health risk to people who have pacemakers.
3. When not in use, store the strong magnets in the proper container

Lesson’s big idea
- Demonstrates magnetic forces and Lenz’s Law, variation of magnetic force fields in different thickness of metal and type of metal. Using the scientific method, recording and comparing data to their hypothesis.
**Instructional Procedure**

1. Demonstrate with different pipes, copper, aluminum and right angle piece of aluminum rolling a metallic ball verses a magnetic ball. It is easier to see with the right angle what is happening as the magnet rolls, verses a pipe. Discuss Lenz’s Law, electromagnetic fields.

2. Hold a magnetic ball and a non-magnetic metallic ball in your hands and ask the volunteer which ball will drop first if you dropped them at the same time, or would they fall at the same speed. We know that gravity acts on objects the same, and if you drop the balls from the same height and distance they will fall at the same rate. Try the same experiment but drop the balls through a pipe this time. The non-magnetic ball will fall at the typical speed, with only gravity acting on it. The magnet will create a magnetic force as it drops through the tube. The force of the magnetic field going from N to S or positive to negative “brakes” the magnet as it drops causing a decrease in the speed it travels down the pipe. See the figure below, the illustration (fig. 1) shows a magnet with a S and N pole, and shows the change in magnetic force as the magnet drops through the pipe.

3. Set up an experiment to test your volunteers hypothesis. Coach them on some possible ideas to test. For example, Does the thickness of pipe affect the speed of the magnet falling? Does the diameter of the pipe affect speed of the magnet falling?

On the white board diagram the pipe numbers, steel ball and magnet. Have a volunteer record times and another start and stop the stop watch. Make sure they start and stop at the correct times.

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Steel Ball (sec)</th>
<th>Magnet (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
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<td>3</td>
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<td>4</td>
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</tbody>
</table>

4. What is happening inside the pipe?
Current inside a closed loop creates a magnetic dipole moment, i.e. an accelerating current creates a magnetic field in the interior of the loop, Figure 1. Keep in mind the magnetic field in Figure 1 is created by the current flowing in the closed loop.

**Lenz’s Law** - A change in the magnetic flux inside a closed conducting loop induces a current inside the loop that opposes the changing magnetic fields. An induced current is always in such a direction as to oppose the motion or change causing it!

In the case of the magnetic dropping down the aluminium pipe, the falling magnetic is the source of the changing magnetic field and the aluminium pipe the close loop (think of taking just a small slice of the pipe at any point in time.)

**Figure 2:** The induce current tries to stop the magnet from falling.
**Assessment**
1. What is happening inside the pipe?
2. What conditions caused the pipe to go through the pipe the slowest? Why?

**Conclusion**
Lenz’s law, magnetic fields, and gravity. What forces are acting on the ball and magnet as they fall and what is different between the two.

**Clean Up**
Clean up between demonstrations if needed. When completely finished gather all materials listed for this demonstration and make sure everything is accounted for. If something was used up, broken or damaged. Let someone know so it can get replaced or fixed. Magnets should be stored separately.

**References**
http://www.coolmagnetman.com/magpipes.htm
http://www.practicalphysics.org/go/Experiment_425.html
http://en.wikipedia.org/wiki/Lenz's_law

**National Science Standards**
K-4 Content Standard B, Physical Science, Light, heat, electricity and magnetism
5-8 Content Standard B, Physical Science, Transfer of energy, Motions and forces
9-12 Content Standard B, Physical Science, Motions and forces, Interactions of energy and matter
K-12 Content Standard A, Science as inquiry

**Magnet Down a Metal Pipe lesson plan bullet points**
- Demonstrates magnetic forces and Lenz’s Law, variation of magnetic force fields in different thickness of metal and type of metal. Using the scientific method, recording and comparing data to their hypothesis.
- The non-magnetic ball will fall at the typical speed, with only gravity acting on it.
- The magnet will create a magnetic force as it drops through the tube. The force of the magnetic field going from N to S or positive to negative “brakes” the magnet as it drops causing a decrease in the speed it travels down the pipe.