Tucson Electric Power

Eddy Current Tube

Inventory:

1 L-type copper pipe

1 M-type copper pipe

1 pvc pipe

neodymium (rare-earth) magnets

1 small pebble

Directions:

1) Hold the pvc pipe vertically and off the table or ground a few inches.
2) Drop the small pebble through the pvc pipe and observe what happens.
3) Repeat steps 1-2 dropping the pebble through each one of the copper pipes.
4) Now drop a magnet through the pvc pipe and observe what happens.
5) Next, drop a magnet through each of the copper pipes as you hold them vertically and observe what happens.
6) With a partner, drop identical magnets through the two types of copper pipe releasing them at the same time and observe what happens.
7) Drop two magnets stuck together down the same tube and make observations about similarities and differences between this experiment and the previous one. (BE CAREFUL – two strong magnets are attracted by a lot of force and can easily pinch you!)
8) Play with different variables and continue to make observations about what is happening.

What do you notice?

What do you wonder?

Short Science Story (S^3) – the electromagnetism side

As the magnet falls through the copper tube, it pushes electrons around the tube creating an electric current. The moving electrons (electric current) create their own magnetic field which repels the falling magnet, slowing it down. There are two types of copper pipe – L-type has a thicker wall than the M-type. You will note the different masses. The L-type copper pipe slows the magnet down more because the thicker wall means it has less electrical resistance. The lower resistance means the falling magnet is able to create a larger electric current, which in turns means a stronger magnetic field to repel the magnet as it falls, which slows it down more than when it falls through the M-type copper pipe.

Short Science Story (S^3) – the energy side

The magnet starts with a particular amount of potential energy. Without the copper tube, this energy would be converted into kinetic energy (energy of motion), causing it to speed up as it falls. When the magnet is dropped through the tube, some of the initial potential energy is converted into electrical energy (energy given to the moving electrons). Because some of the magnet's original energy has been given to the moving electrons, it doesn't gain as much kinetic energy and therefore moves slower.

Safety and Pedagogical Hints and Tips

- **WARNING:** Rare-earth neodymium magnets are strong enough to erase the magnetic strip on credit cards and damage the electronics of a cell phone. **DO NOT PLACE THEM NEAR YOUR WALLET OR ELECTRONIC DEVICES OF ANY KIND!**
- Students love to watch the magnet as it falls through the copper pipe. They can hold the pipe below eye level and peer down through the pipe as the magnet falls.
- Neodymium magnets are brittle. Carefully let them come together without slamming into each other. Be wise about letting students take the magnets apart and put them together based on age. It is very easy to pinch a finger and even draw blood from the pinch.
- To get two magnets apart, slide them horizontally and then pull them apart.
- If you lose one of the magnets, check the metal chair and table legs near the demonstration area. The magnet has generally attracted toward and attached to one of them.

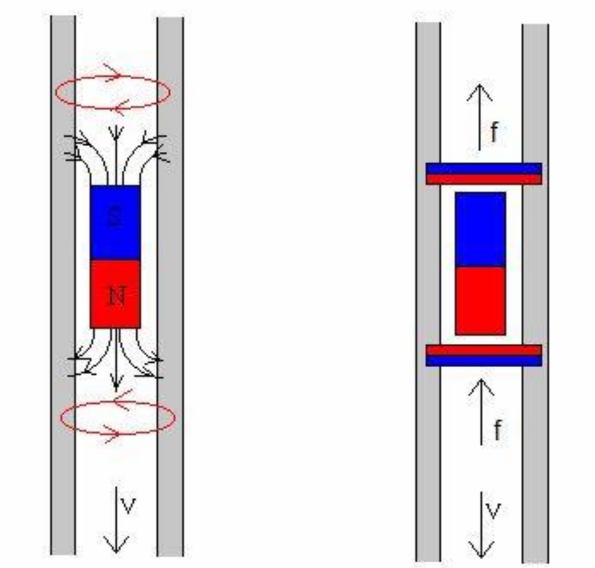
What the heck?

Eddy currents are an electric phenomenon that is produced when a conductor (metal) passes through a variable magnetic field. The relative movement causes a circulation of electrons, or induced current within the conductor. These circular Eddy currents create electromagnets with magnetic fields that oppose the effect of the applied magnetic field.

The **Eddy currents** and the generated contrary fields will be stronger

- when the applied magnetic field is stronger, or
- with higher conductivity of the conductor, or
- with higher relative speed of movement.

For a practical demonstration of the **Eddy Currents**, cylindrical magnets are used that fall vertically in a copper or aluminum tube. It can be experimentally proven that the force that opposes the weight is proportional to the speed of the magnet. The experience is illustrated in the attached drawing:



Let's suppose that the cylindrical magnet descends with its North pole (color red) in front and its South pole (color blue) behind. On a magnet, the magnetic field lines are outgoing at the North pole and incoming at the South pole.

During the descent of the magnet, the flow from the magnetic field increases in the region near the magnet's North pole. An induced current originates in the tube, **Eddy Current**, which opposes the increased flow, in the direction that is indicated in the first figure.

In the following figure, the equivalency between currents (spirals or solenoids) and magnets is shown, in such a way that the induced current ahead of the North pole equals a magnet of opposing polarity, by which they repel each other. However, the induced current behind the magnet has the same polarity by which they attract each other. Both currents generate a force (f) that stops the falling movement of the magnet.

Source: http://www.regulator-cetrisa.com/eng/magnetism.php?section=foucault

Conservation of Energy Story

The magnet has gravitational potential energy when at the top of the tube. When you drop it outside the tube, the potential energy is converted almost completely into kinetic energy. When you drop it inside the tube, some of the potential energy is converted into electrical energy (the energy required to move the electrons in the conducting tube). Because some of the original energy is converted to the electrical energy while the magnet is falling, it won't have as much kinetic energy when it reaches the bottom of the eddy current tube.