*THE DEMONSTRATION CORNER*

# Lenz's Law with Plumbing Pipes

by

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In the January 1997 issue of *The Physics Teacher*, two articles appeared detailing the use of rare earth magnets to demonstrate Lenz's Law in the classroom. The principle involved is that a permanent magnet falling through a tubular conductor will induce a current in the conductor and hence a magnetic field which will oppose the magnetic field of the permanent magnet and thus slow its rate of fall. This article gives variations of the methods discussed in those papers.

Arbor Scientific (1-800-367-6695) sells two rare earth magnets. The smaller magnets (P8-1123) are 0.5 inch in diameter and 0.25 inch in length and are sold in pairs for $20 U.S. The larger "Giant Neodymium" magnet (P8-1124), which is sold individually, is 2.2 cm in diameter and 2.5 cm in length and costs $35 U.S. We have tried dropping the smaller magnets, individually and in pairs, through .75-inch copper plumbing pipe and also dropping the larger magnet through 1-inch pipe. Although both illustrate Lenz's Law dramatically, unless cost is a limiting factor there is no doubt that the larger magnet provides a much more spectacular demonstration.

We start the demonstration by dropping a non-magnetic "dummy" of the same size as the magnet through a 1-inch Type L copper pipe which is available through local plumbing supply centres. The time to fall through our 1.73 metre long tube is 0.6 s. We use stainless steel because it looks just like the magnet and when the dummy and magnet are held together there is no mutual attraction, and with some verbal distraction, you can convince students that you have two identical pieces of iron (that is, if you want to fool the students and make the demonstration seem even more amazing). The time for the large magnet to fall through the pipe is 15 s. Students are surprised to the point of disbelief!

Be aware that the most common commercial copper pipe is Type M which is thinner walled than Type L and the time taken to fall through a 1.73 meter Type M tube is only 9.2 s. The factor in time of 15/9.2 = 1.6 is to be expected because the wall thickness of Type L is greater than that of Type M by a factor of 1.4 (not equal to 1.6 but close) and the resistance to current should be inversely proportional to wall thickness.

We next use a 0.58-metre section of Type L (one third of the original length) and the time of fall is now 4.6 s, which is only slightly less that one third of the original 15 s. This illustrates that terminal velocity is reached very quickly. We created another variation which allows the students to actually see the magnet falling. A 3/16 inch bit was used to mill a slot along the length of a 0.58 metre length of Type L pipe. The time to fall is only reduced from 4.6 to 3.5 s. This surprises most students because they think that eddy currents must go all the way around the pipe and they expect the magnet will fall through the slotted pipe in much less time.

The fact that terminal velocity is reached very quickly allowed us to create another spectacular variation of this demonstration. Clear plastic pipe of the same inside diameter as the 1 inch copper pipe was used to make a composite tube of alternating lengths of plastic and copper. Our tube has two sections of plastic, each about 30 cm, and two of copper, each of about 40 cm (lengths are not critical). The sections are held together with brass sleeves. The demonstration is most dramatic when the magnet falls through the sections in the order plastic-copper-plastic-copper. The time to fall through the plastic sections is a fraction of a second whereas the total time for the whole tube is between 5 and 6 s. It's the alternation between speeding up and slowing down which the students find most interesting.

## ANYBODY OUT THERE?

Don't forget that I'm always interested in hearing your comments, criticisms, etc.

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