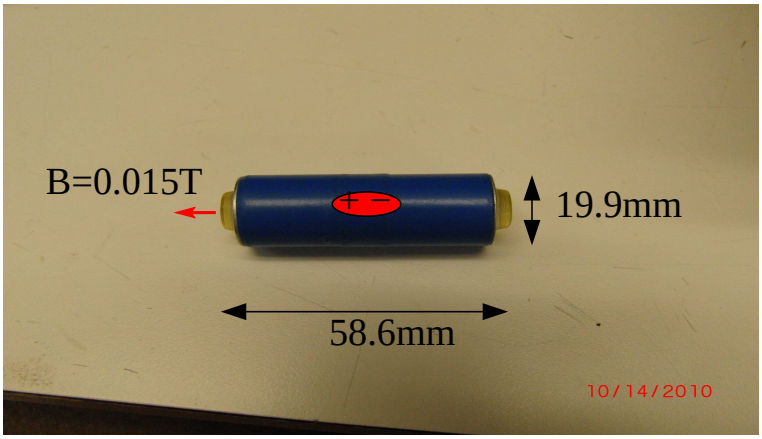

FIG. 1: The magnet as photographed by Jeff Cady, with measures and illustrations added.

CPL challenge

Pipe dreams (or: magnetic breaking in an aluminum pipe)

In our last meeting we played around with an Aluminum pipe, and a magnet. We let the magnet in from one side, and waited for it to come out in the other side. The travel time through the pipe was 7s roughly.

The goal of this challenge is to calculate the time of going through the pipe. Here is the information, courtesy of Jeff Cady and in his words: "The tube is made of Al and has dimensions of 26.7mm x 21.3mm (O.D. and I.D. respectively) and is 153cm long (sorry for mixing units). The magnet is a disc magnet sandwiched between 2 aluminum cylinders with rubber bumpers on each end forming another cylinder with an overall length (including the rubber bumpers) of 58.7mm. The diameter is 19.9mm. A field of 150Ga along the axis of the cylinder was measured at the end of the bumper. The mass of the magnet is 54.7g. This value neglects the buoyant force of air and any internal energy effects that may cause an apparent change in the gravitational mass."

Some reconnaissance shows that the specific resistance of Al is $\rho = 2.8 \cdot 10^{-8}\Omega \cdot m$. I think it is safe to assume that the magent consists of a small dipole at the center of the cylinder, whose picture is attached. Also, if you need a refresher on the magentic field due to a dipole magnet, some more reconnaissance led to:

http://en.wikipedia.org/wiki/Dipole

Where it is indicated that the field is:

$$\vec{B} = \frac{\mu_0}{4\pi} m \frac{3(\vec{d}\cdot\vec{r})\vec{r} - \vec{d}r^2}{r^5} \tag{1}$$

with md the magnetic moment, $\vec{r}$ the radius vector, and $\mu_0 = 4\pi 10^{-7} smT/C$ in SI units.

As always in the CPL, do as many violent approximation as you feel comfortable with. Let your conscience be your guide. Feel free to use Mathematica or any other analysis program, although it is not quite necessary. Similarly, any reference book is fair game.