Use the plotting tool to graph the displacement \((d)\) vs. current. If the current was stable, enter error bars to the displacement only (“y” direction).

http://www.ic.sunysb.edu/class/phy141md/doku.php?id=phy131studio:labs:plottingtool. If you do not have access to the plotting tool during the measurement, use the graph papers at the end of this lab manual to graph your result. The data points should be approximately on a straight line.

Repeat the measurement with a 10g weight and graph the result with the plotting tool. Use smaller steps in the current (e.g. 0.50A or 0.33A). This time the wire will hit the end of the magnet before 4.0A is applied.

**Answer these questions:**

1. According to the graph, what is the relationship between current and the displacement?
2. Look at the parameter “\(a\)” that the plotting tool provided for the two measurements (one with 20g weight and the one with 10g weight on the copper wire). How does this parameter depend on the weight you applied?
3. Look at the error of the parameter “\(a\)” in the two measurements. Which one has a larger error? What can be the source of a systematic error in this measurement?
4. Assume that the magnetic field rapidly drops to zero outside of the volume that is in between the two magnets. If that is the case, what quantity corresponds to the parameter \(\epsilon\) in Eq. (2)?
**Determine the Magnetic Field**

Draw a free body diagram of the wires with the relevant forces. Assume that there is no friction and the bending of the wire requires such a small force that we can neglect it. Derive the following expression for the displacement of the wire:

\[ d = \left( \frac{L}{4mg} \right) F \]  \hspace{1cm} (3)

where \( L \) is the distance between the top end of the wire and the upper of the two contacts at the bottom and \( m \) is the mass hanging on the wire. Combined with Eq. (2) we get

\[ d = \left( \frac{L}{4mg} \right) l \cdot B \]  \hspace{1cm} (4)

or

\[ d = (L \cdot \frac{l}{4mg}) \cdot l \]  \hspace{1cm} (5)

therefore we can identify the parameter "\( a \)" in the plotting tool as

\[ a = \frac{LB}{4mg} \]  \hspace{1cm} (6)

and

\[ B = \frac{4amg}{L} \]  \hspace{1cm} (6)

The size of the magnets is 0.50” by 0.50” by 2.00” and this is known with such a precision, that its error is negligible. Similarly, we can neglect the error in the weight.

Calculate the magnetic field from the measurement when the 20g was used. Repeat the calculations with the measurements using the 10g weight. Estimate the errors by using the error of “\( a \)” and the error of “\( L \)”.

Compare the results. Compared to the Earth’s magnetic field, how many times stronger is the magnet?