A blank spreadsheet template has been provided for you to record and analyze your data.

I. Procedure

A. Preliminary Measurements

1. First, use the alignment knob to insure that the pivots on which the floating wire balances are aligned correctly.

2. Then make sure the two wires are parallel in both the vertical and horizontal directions; if not, get help from your instructor.

3. Then, measure the overlapping length of the wires with a ruler. Also measure the distance from each pivot to the floating wire; call the average, $b$.

4. Use your digital caliper to measure the diameters of the parallel wires.

5. Carefully measure the distance from the mirror to the wall with a 2-meter stick.

6. Record all these data in your spreadsheet.

Be careful, now; if you bump something out of alignment, you’ll have to start over.

7. Now we must measure the center-to-center distance between the two wires. Reflect the laser beam from the mirror onto the wall; this is called an optical lever. Use a piece of masking tape, so that you don’t have to write on the wall, and mark the position of the laser spot. Call this position $y_2$.

**Warning**: Do not let the laser beam shine into your eye or permanent vision damage can result! It is okay to look at the spot where a laser beam strikes a surface so long as the surface is not mirrored or shiny and the beam is not directly reflected into the eye.
8. Now gently place a 100 mg weight on the weight pan on the floating wire, this should be enough to make the floating wire come into contact with the fixed wire. If it isn’t, add another 100 mg. Now, mark the location of the laser spot on the masking tape; call this position $y_1$.

9. Gently remove the weights from the weight pan. The laser spot should go back to $y_2$, if it doesn’t, you’ve bumped something, and you have to start again.

10. As the mirror rotates through an angle $\theta$, the laser beam sweeps through $2\theta$. If $2\theta$ is small, then $\tan(2\theta) \approx \sin(2\theta) \approx 2\theta = |y_2 - y_1|/w$, where $w$ is the distance from the wall to the mirror; this is the principle of the optical lever. Examination of the instrument reveals that the distance between the surfaces of the wires, $s$, is given by $s = b*\theta$, recall that $b$ is the (average) distance from the pivots to the floating wire. To get the center-to-center distance between the wires, add the radius of each wire to $s$: $d = s + r_1 + r_2$.

Look at picture on next page too.
B. Taking Data.

1. Now we are ready to take data. This is easiest if you follow these steps:
   
   i. Add (use tweezers to CAREFULLY place) a small weight to the weight pan on the floating wire and note that the laser spot moves.

   ii. Adjust the current to bring the laser spot back to its original position, $y_2$, and record the weight and the current. Adding weights in increments of 10 or 20 milligrams seems to work most conveniently. Note that your weight set has one 10 mg weight, but several 20 mg weights; this is why the weights in the sample data are not in uniformly increasing order.

   To avoid damaging the equipment, 15 amps is a **STRONG** maximum!
2. Once you’ve taken the data, complete the analysis in your spreadsheet: Calculate the weight and square the current. Then copy the weight column to the right of the current-squared column to facilitate graphing. To help diagnose problems, calculate the magnetic force using the formula you worked out in the homework problem. The magnetic force will not be used for graphing, but it should agree with the weight – Does it?

3. As in the example data, plot the weight as a function of the square of the current. As we learned in the HW problem, the slope should be proportional to find $\mu_0$ use your slope and other measured values to find $\mu_0$ and compare it to the exact value, $4\pi \times 10^{-7}$ T·m/A.

C. Discussion Questions:

1. Clearly, the magnetic force must be equal to the added weight, or else the wire will accelerate. Does your data lead you to believe that $F = i L x B$ is the correct way to calculate the magnetic force between two wires?

2. Does your experimentally measured value for $\mu_0$ agree with the exact value?

D. Lab Report to hand in:


2. Graph from part B3.

3. Discussion from part C.

Don’t forget uncertainties, units, annotations and discussions.
II. Clean-Up

A. Golden Rule: “Do unto others as you desire them to do unto you.”

This applies as much here in the lab as it does in the Fleet. As future Naval Officers, how can you expect your enlisted sailors to maintain a clean work area if your stateroom, work areas, mess area, etc is a “pig sty?” So as officers it is imperative that we clean up after ourselves not only to follow the Golden Rule, but also to lead by example for the enlisted personnel under our charge.

1. End of Lab Checkout: Before leaving the laboratory, please tidy up the equipment at the workstation and quit all running software.

2. The lab station should be in better condition than when you arrived and more importantly, should be of an appearance that you would be PROUD to show to your legal guardians during a “Parents Weekend.”

3. Have your instructor inspect your lab station and receive their permission to leave the Lab Room.

4. You SHALL follow this procedure during every lab for SP212!

Many thanks to Dr. Huddle and Dr. Fontanella for their assistance in producing this Laboratory procedure; specific references can be supplied on request. LCDR Timothy Shivok