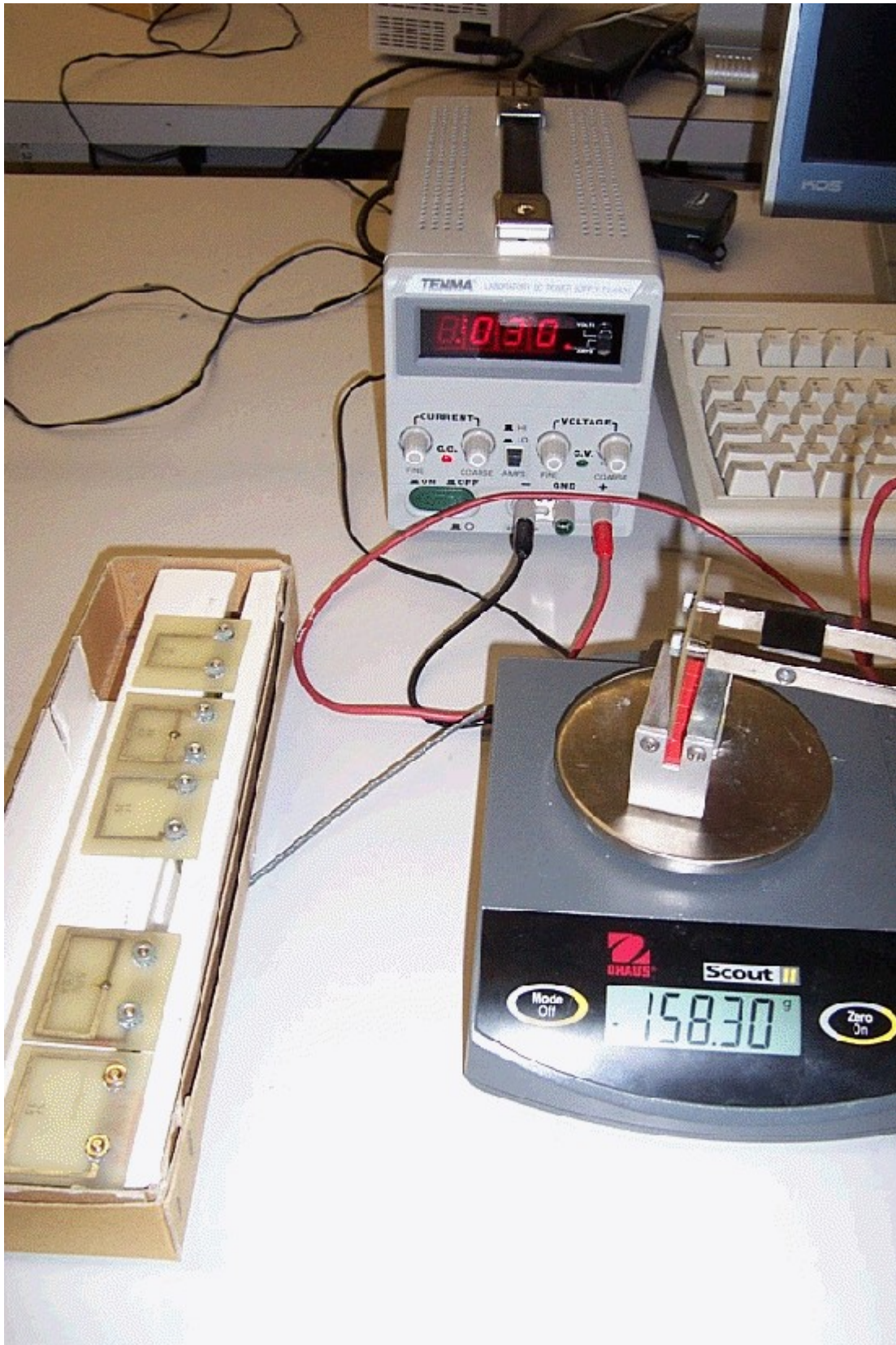


LAB 4: MAGNETISM

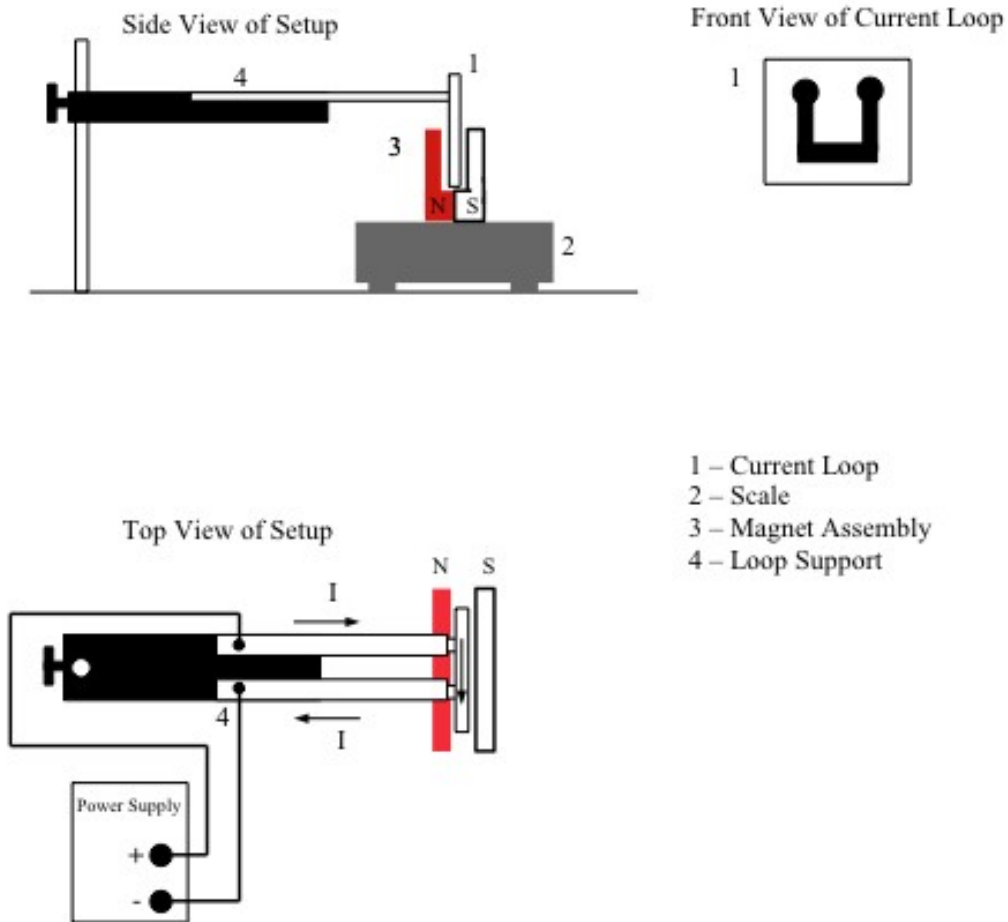


Force on a magnet due to a current carrying wire

In this lab you will investigate the interaction between a permanent magnet and a current carrying wire.

You have a horseshoe magnet whose poles are known (Red: North, White:South), a scale, various current loops, a voltage source and connecting wires.

A sketch of the experimental setup is shown below.



Setup Figure

Part I: Qualitative testing of the right-hand rule

Choose any one of the current loops and assemble the system precisely as shown in the Setup Figure. That is, connect the power supply and keep the orientation of the magnets exactly as shown in the figure. Do not, however, turn on the power supply yet.

DO NOT ZERO THE SCALE before you place the magnet assembly on it. In addition, you should place the center the current loop well within the groove of the

magnet assembly, however, do not let the current loop fiber board touch the magnet assembly.

a) Based on your setup, how should the apparent “weight” of the magnet assembly (when the power supply is ON and current is flowing through the current loop) compare to the true “weight” of the magnet assembly (when the power supply is OFF and there is zero current flowing through the current loop)? Explain your reasoning in terms of the right-hand rule. *Hint: Your answer will depend on the direction of the magnetic force exerted on the magnetic assembly by the current loop. You may find it easier, however, to first determine direction of the magnetic force on the horizontal portion of the current loop due to the magnet assembly and then, using Newton's 3rd Law, determine the direction of the magnetic force on the magnetic assembly.* Draw free-body diagrams of the horizontal portion of the current loop and the magnet assembly as part of your explanation.

b) Turn on the power supply, put both COARSE and FINE Voltage knobs to mid-position and increase the current to the maximum possible allowed by the power supply. Describe what happens to the reading of the scale. Does the result agree with your prediction?

c) Turn off the power supply and reverse the electrical connections on the loop support. How should the apparent “weight” of the magnet assembly compare to the true “weight” of the magnet assembly now? Again, explain your reasoning in terms of the right-hand rule. Draw free-body diagrams of the horizontal portion of the current loop and the magnet assembly as part of your explanation.

d) Turn on the power supply and increase the current to the maximum possible allowed by the power supply. Describe what happens to the reading of the scale. Does the result agree with your prediction? How does it compare to the reading from part b)?

e) In the preceding analysis we have ignored the interaction between the magnet assembly and the two *vertical* portions of the current loop. (Did you notice this?) Explain why the vertical portions of the current loop do not contribute to the magnetic force between the current loop and magnet assembly.

Part II: Investigate (quantitatively) how the force exerted by a magnet on a current carrying wire depends on the magnitude of the current. Determine the magnetic field of the the magnet assembly.

Select one of the current loops and record the length of the horizontal portion. (You may use the current loop that you're already using!) Reassemble the apparatus as in the Setup Figure. Record the magnetic force for 4 different “positive” values of the current over the full range of current. Note: The magnetic force is the *difference* between the apparent “weight” and the true “weight”. Also, remember that the scale measures mass in grams. You must properly convert this mass to force. **REMEMBER NOT TO ZERO THE SCALE – JUST RECORD THE BASE VALUE AND NOTE THE DIFFERENCE BETWEEN THE SCALE READING AND THIS BASE VALUE.**

Reverse the electrical connections on the loop support and record the values of the magnetic force for 4 different “negative” values of the current over the full range. Note: The magnetic force will be negative in this situation.

- a) What is the equation that relates the magnetic force to the current through the loop and other quantities? Is the relationship between the magnetic force and current linear? Is it quadratic? Is it exponential?
- b) Plot the magnetic force vs. the current using Graphical Analysis (GA). Make sure your plot has a title, axes labels with units, and a best fit. Use your plot and the equation you wrote down in part a) to determine the magnitude of the magnetic field of the magnet assembly. Show your work.

Part III: Investigate (quantitatively) how the force exerted by a magnet on a current carrying wire depends on the length of the wire. Determine the magnetic field of the the magnet assembly using a second method.

Select one of the current loops and record the length of the horizontal portion of the current loop. Assemble (again) the apparatus as in Setup Figure. Turn the current to its maximum possible value (record this value of current) and record the magnetic force.

AGAIN, REMEMBER NOT TO ZERO THE SCALE – JUST RECORD THE BASE VALUE AND NOTE THE DIFFERENCE BETWEEN THE SCALE READING AND THIS BASE VALUE.

Repeat this procedure using the same current for at least 4 more, different current loops.

- a) Plot the magnetic force vs. the length of the current loop using GA. Make sure your plot has a title, axes labels with units, and a best fit. Use your plot and the equation you wrote down in Part II: a) to determine the magnetic field of the magnet assembly. Show your work.
- b) How do your two measurements of the magnetic field compare to each other? Which method do you think is more accurate? A typical refrigerator magnet has a magnetic field on the order of 100 Gauss. How do your measurements compare?