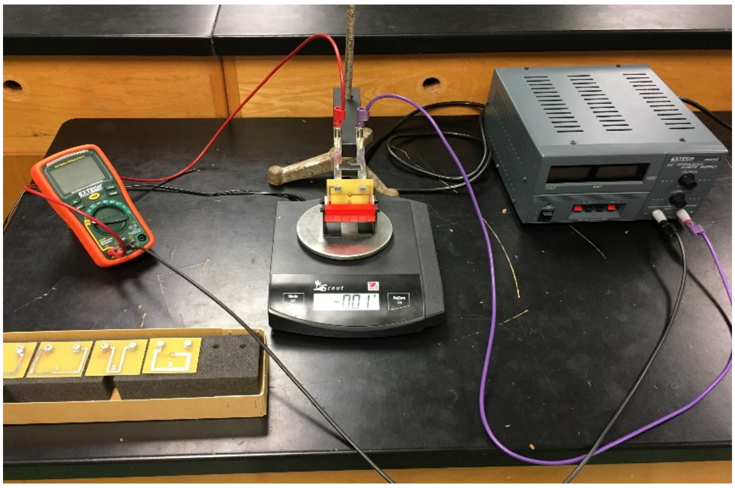
PHY 152/252
The Current Balance – Laboratory 5



Objective:
The objective of this lab is to measure the effects of a magnetic field on a current carrying conductor.

Theory:
A magnetic field **B** exerts a force $\mathbf{F_B}$ (bold letters denote vectors) on any moving charge that is given by the vector cross product:

$$\mathbf{F_B} = q\mathbf{v} \times \mathbf{B}$$

Where q is the charge, **v** is the velocity of the charge, and **B** is the magnetic field strength. The magnitude of this force is given by $F_B = qvB\sin\theta$, where θ is the angle between the velocity vector and the magnetic field vector.

Since a current is a collection of charges in motion, a magnetic field should also exert a force on a current carrying conductor. The magnitude and direction of this force is dependent upon four factors: (1) the strength of the magnetic field; (2) the length L of the wire; (3) the magnitude of the current i; and (4) the angle between the field and the wire. The magnetic force $\mathbf{F_B}$ in this case is given by the vector cross product:

$$\mathbf{F_B} = I\mathbf{L} \times \mathbf{B}$$

The magnitude of the above expression can be found from $F_B = ILB\sin\theta$, and if the magnetic field is entirely perpendicular to the current carrying wire, the force on the wire is simply $F_B = ILB$. We will use this equation to find the magnitude of a magnetic field.

Procedure Part 1: Force vs. Current

1. Mount the wire loop holder device on a ring stand, just above an electronic balance. .

2. Connect the power supply, ammeter, and wire loop holder in series. Note that the arms of the wire loop holder have connectors that fit the standard connector wires. On the meter,

use the 10A and COM ports only. Turn the large multimeter knob to the 10A position. Your instructor may need to help with this. Note: you may use the ammeter on the power supply for this experiment instead. It is accurate enough at the relatively large currents we will use.

3. Place the wire loop holder designated SF 42 in the end of the mounting arms. Be careful when inserting and removing these holders. They will break easily.

4. Place the magnet at the center of the balance pan. The wire loop holder device should then be lowered so that the holder passes through the pole region of the magnet. Adjust the wire loop holder such that it is just above the bottom of the magnet's slot (but not touching it) and midway between the sides of the slot (but not touching them).

5. Measure the mass of the long magnet with no current flowing and calculate its weight in Newtons. *This is your zero force, F_0, or zero weight, W_0.* Once the experiment starts, do not move the setup. It is also important to keep all metal objects and wires away from the magnet. These could affect the data.

6. Before turning on the power supply, have your instructor check the circuit. After it has been approved, turn the voltage control knob (upper knob) fully clockwise, turn the current limit control knob fully counterclockwise, and turn on the power supply, Turn current limit control clockwise until the meter reads approximately 1.0 A. *When the current is turned on, the magnet should be deflected downward*. Read the new mass from the balance and convert the mass to weight F in Newtons. Use g = 9.81 m/sec^2 when making this conversion. The weight must be greater than it was when no current was flowing. If the balance reads less than before, either turn the magnet around on the balance pan to reverse the direction of B, or you can swap the power supply wires. The difference in the weight with the current on and with the current off is the force due to the magnetic field, F_B. (i.e. $F_B = F - F_0$). Calculate this force in Newtons.

NOTE: You may have an electronic balance that will allow you to zero it with the magnet on it. If so, do it as needed during the experiment.

7. Increase the current in 0.5 ampere steps until 3.0 amps is reached. Record the current and the magnetic force at each current value. Put these data in a table.

Procedure Part 2: Force vs. Conductor Length

8. For this part of the lab, you will need to know the effective lengths of the wire loops, which are given in the table below: Note that the "SF numbers" on the loops do not signify the length of the wire. Insert the shortest wire segment (SF 40) into the holder arms and reposition the loop into the magnet's slot. Make certain that the balance still reads the zero-current mass. If not, re-zero the balance. Also note that the holder arms swing upward to facilitate the removing and adding of the loops. Again, be careful when changing the loops.

SF 40	1.2 cm
SF 37	2.2 cm
SF 39	3.2 cm
SF 38	4.2 cm
SF 41	6.4 cm
SF 42	8.4 cm

9. Adjust the current-limit control on the power supply until the ammeter reads 2.0 amps. Determine and record the resulting magnetic force.

10. Repeat this process for all 6 wire loops. Turn off the power supply with the off/on switch when removing and adding a wire loop. As you reposition each loop into the

magnet's slot, make certain that the zero-current balance reading remains the same. If not, re-zero it. Record the current and the magnetic force for each loop and put these data in a table.

Calculations:

1. Using Excel (or any other graphical analysis program) and the results from Step 7, plot magnetic force vs. current and determine the best-fit straight line. From the slope of this line, determine the value of the magnetic field strength of your magnet. In what unit is the magnetic field strength measured?

2. Using Excel and the results from Step 10, plot magnetic force vs. wire length and find the best-fit straight line. From the slope of this line, determine the value of the magnetic field strength of your magnet.

3. Determine the percent difference in the magnetic field strengths as found in Calculation #1 and in Calculation #2.