

Lab 5 – The Current Balance

Objectives:

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

Theory:

A magnetic field \mathbf{B} exerts a force \mathbf{F}_B (bold letters denote vectors) on a moving positive charge that is given by the vector cross product:

$$\mathbf{F}_B = q\mathbf{v} \times \mathbf{B}$$

Where q is the charge, \mathbf{v} is the velocity of the charge, and \mathbf{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 $F_B = iLB$.

Procedure Part 1: Force vs. Current

1. Connect the power supply, ammeter, and wire loop SF 42 in series.
2. Place the long magnet on the center of the balance pan. The wire loop should then be arranged so that it passes through the pole region of the magnet (i.e. the horizontal part of the wire is just below the top of the magnet).
3. 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.
4. Before plugging in the power supply, have your instructor check the circuit. After it has been approved, plug in the power supply and adjust the dial until the ammeter reads approximately 1.0 A. *When the current is turned on, the magnet should be deflected downwards.* Read the new mass from the balance and calculate the weight F in Newtons. It should be greater than it was when no current is flowing. If the balance reads less than before, reverse the wires on the arm of the current balance. 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.

5. Increase the current in 0.5 A increments until 3.0 A is reached. Record the current and the magnetic force for each step.

Procedure Part 2: Force vs. Length of Wire

6. For this part of the lab, you will need to know the effective length of the wire loops, given in the table below:

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

Note that the numbers on the loops do not signify the length of the wire.

Insert the shortest wire segment (SF 40) into the holder. Measure the mass of the magnet holder and the magnets again and determine its weight (it should be the about the same as before).

7. Adjust the power supply until the ammeter reads 2.0 A. Determine the magnetic force. Repeat for all 6 wire loops.

Calculations:

1. Using Excel (or any other graphical analysis program) and the results from Step 5, plot magnetic force vs. current and determine the best-fit line. From the slope, determine the value of the magnetic field for your magnet.

2. Using Excel and the results from Step 7, plot magnetic force vs. wire length and find the best-fit line. From the slope, determine the value of the magnetic field for your magnet.