Physics 215 - Experiment 12
The Current Balance

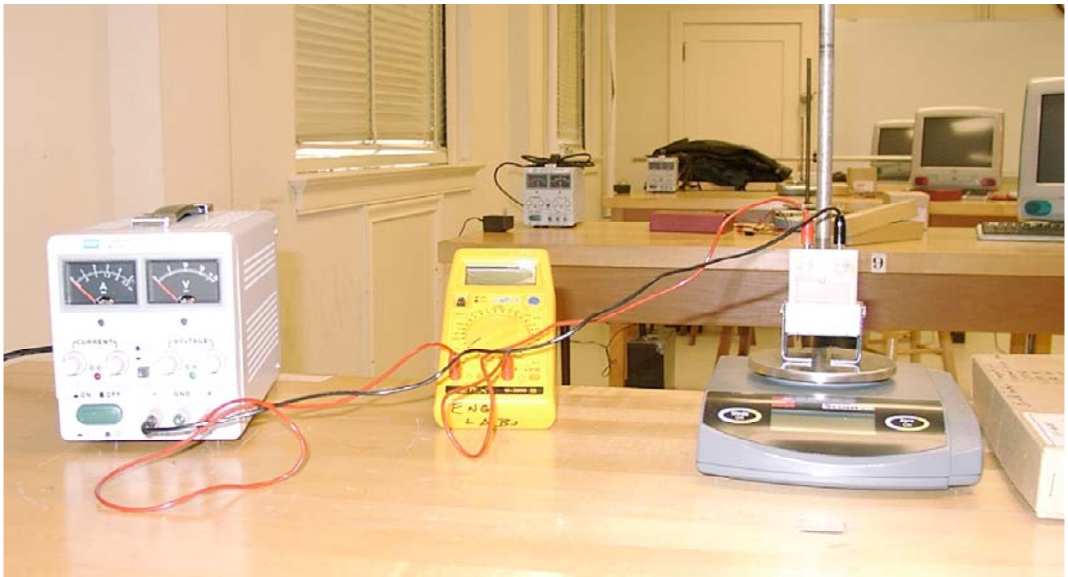

Fig. 12-1 Current Balance Arrangement for Varying Current or Length

From Left to Right: Power Supply, Ammeter (DMM - 10A or 20A Jack and Scale) Loop Assembly (Balance Arm/Wire Loop/Magnet),

Note: North pole of magnet is red; south pole of magnet is white.

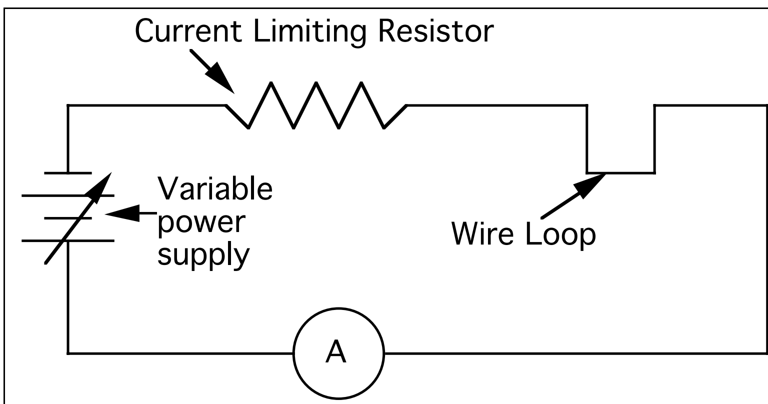

Fig. 12-2 Schematic for Varying Current or Length

Equipment:

Pasco Current Balance Apparatus
Digital Balance
Power Supply
3 Connecting Wires
Ammeter

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Advance Reading

Urone- (Chapter-section) 21-3, 21-4 and 21-7.

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

Theory: A magnetic field exerts a force, $\mathbf{F_B}$, on a moving charge. The magnitude of $\mathbf{F_B}$ is:

$$F_B = qvB\,sin(\theta) \qquad \text{(Eq. 12-1)}$$

where q is the charge, v is the magnitude of the velocity of the charge, B is the magnitude of the magnetic field strength, and θ is the angle between the magnetic field direction and the direction of the charge velocity.

Current is a collection of charges in motion, thus a magnetic field also exerts a force on a current carrying conductor.

The magnitude and direction of this force is dependent on four parameters:

1) magnitude of the current, I
2) length of the wire, L
3) strength of the magnetic field, B
4) angle between the field and the current, θ

The magnitude of the magnetic force in this case is given by:

$$F_B = ILB\,sin(\theta) \qquad \text{(Eq. 12-2).}$$

To determine the strength of the magnetic field, we will measure the "mass" (effective mass) when current is flowing through a wire that is placed inside a magnetic field. The "mass" is due to the magnetic force. We will vary three of the four parameters.

Procedure

Force vs. Current (ΔI)

1. Arrange the equipment as in Fig. 12-1 and Fig. 12-2, using the current loop numbered SF 42. The magnet for the wire loops is in the box with the wire loops. Arrange the equipment away from the computer. On the digital balance there is a "Zero" button. Push this button once to zero the balance. Center the magnet on the balance pan.

The wire loop should pass through the pole region of the magnet (i.e., the horizontal part of the wire is just below

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the top of the magnet). Refer to Fig. 12-3.

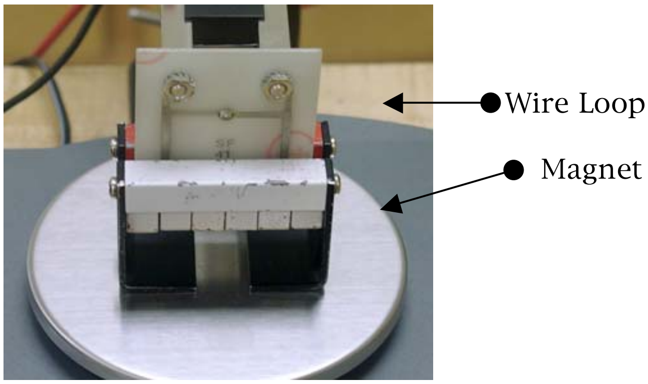

Fig. 12-3 Wire Loop Arrangement

Once you begin this experiment do not move the equipment on the table, although you will raise and lower the balance arm to change attachments.

2. Measure and record the mass of the magnet with the current off. Calculate the weight, F_g.
3. Tare the balance (push the zero button).

Before plugging in the power supply, your instructor must check the circuit. Make sure the power supply is turned off before plugging it in.

4. Plug in the power supply. Adjust the power until the current is approximately 0.5 A. When the current is on, the magnet should deflect downward (positive mass reading). If it is pulled upwards (negative mass reading), reverse the wires connected to the power supply.
5. Measure and record the "mass" and current; calculate F_B.
6. Increase the current in 0.5 A increments through 5.0 A. Record the current, "mass", and F_B for each increment.

Force vs. Length of Wire (ΔL)

Note: For this part of the experiment you will need to know the effective length of the wire loops. They are listed in Table 12-1.

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

Table 12-1

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7. Insert the shortest wire segment (SF 40) into the balance arm. Always check for contact between the wire loop and the magnet before recording your data.
8. Adjust the power supply until the current is 2.0 A. Measure and record the "mass". Calculate F_B.
9. Repeat for each of the wire loops.
10. Turn off, then unplug, the power supply. Return the wire loops and magnet to their box. The balance arm will be used for the Current Balance Accessory (CBA, Fig. 12-4); adjust the height as needed.

Fig. 12-4 Current Balance Accessory (CBA) Arrangement for varying θ.

Fig. 12-5: Top view of CBA

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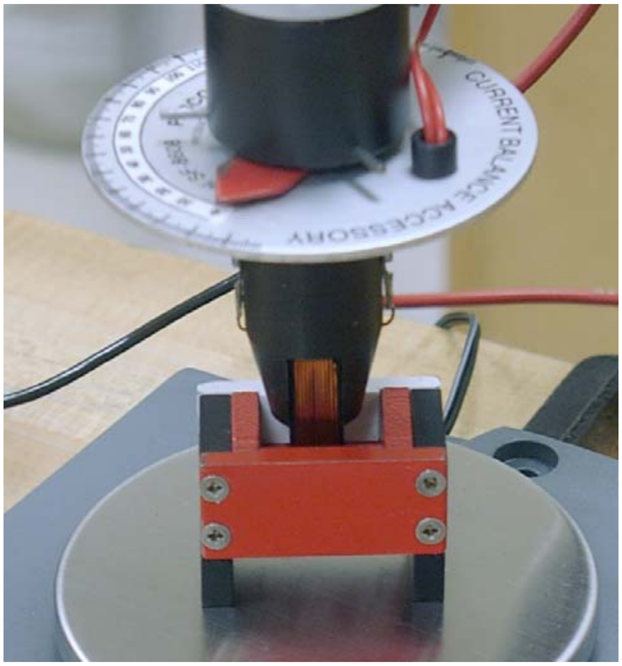

Fig. 12-6 Close-Up of CBA: Wire Loops Inside Magnet.

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Equipment Notes:

- Center the magnet (from the CBA box) on the balance pan.
- Plug the CBA into the balance arm and lower it into the magnet. The horizontal section of the wire loops must be *just* inside of, but not touching, the magnet (Fig. 12-6).
- Turn CBA to 0° (Fig. 12-5).
  - Initially, the wire loops of the CBA must be parallel to the magnetic field of the permanent magnet. If they are parallel and the current is on, F_B = 0 T, and the mass measurement will not change. If the mass changes when the current is turned on, adjust the alignment by carefully rotating the magnet. When you have the correct arrangement, turn the CBA from 0° through 180°, checking to see that it will not hit the magnet at any point.

Force vs. Angle ($\Delta\theta$)

11. Referring to the *Equipment Notes*, set up the CBA arrangement.
12. Before plugging in the power supply, measure and record the mass of the magnet. Calculate F_g. Tare the balance.

13. Set the angle to 0°, with the direction of the wire coil parallel to the magnetic field. Set the current to 2.0 A. Measure and record the "mass". Calculate F_B.
14. Increase θ in 10° increments through 180°.
15. Calculate F_B for each θ.

Graphing

16. Plot separate graphs of the following data; include the data point (0,0) on each graph.

- F_B vs. I
- F_B vs. L
- F_B vs. θ

17. Calculate B from the graphs of

- F_B vs. I
- F_B vs. L
- F_B vs. θ

(Assume that for the CBA L = 11.5 cm.)

18. Compare the values of B that you obtain from the graphs of F_B vs. I and F_B vs. L.

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Questions

1. What is the relationship between current and magnetic force?

2. What is the relationship between the length of a wire and magnetic force?

3. What is the shape of the curve for F_B vs. θ? How does it relate to Eq. 12-2?

4. Show that Eq. 12-1 and Eq. 12-2 are dimensionally equivalent.

5. There is a magnet at the end of the Dial-O-Gram balance arm. The arm has an aluminum plate in the magnetic gap. What is the purpose of this magnet system? (Refer to *Urone* Chapter 22, Section 22-4 and http://demoroom.physics.ncsu.edu/html/demos/163.html)