# Experiment 22 The Current Balance

#### Advanced Reading: (Serway) Chapter 29, sections 29-1 through 28 -4 Equipment: 1 Pasco Current Balance apparatus 1 Dial-o-gram balance 1 power supply 3 double-banana plug wires. 1 Kelvin DMM

## Objective:

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

## Theory:

A magnetic field  $F_B$  exerts a force on a moving positive charge that is given by the vector cross product:

$$\mathbf{F}_{\rm B} = q\mathbf{v} \times \mathbf{B}$$

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:

$$F_B = |q| vB\sin\theta$$

where  $\theta$  is the smaller angle between the velocity vector **v** and the magnetic field vector **B**.

Since a current is a collection of charges in motion, a magnetic field should also exert a force on a current



figure 22-1





carrying conductor. The magnitude and direction of this force is dependent upon four factors: (1) the length of the wire, (2) the strength of the magnetic field, (3) the magnitude of the current, and (4) the angle between the field and the wire. The magnetic force  $\mathbf{F}_{\text{B}}$  in this case is given by the vector cross product:

$$\mathbf{F}_{\mathrm{B}} = \mathbf{i}\mathbf{L} \mathbf{x} \mathbf{B}$$

where **I** is the current, **L** is the length of the wire, and **B** is the strength of the magnetic field.

### Procedure:

#### Part 1: Force vs. Current

1. Set-up the apparatus as it appears in figure 21-1 and figure 21-2 using the current loop numbered SF 42. The circuit consists of a power supply, an ammeter (DMM) and the wire loop all connected in series.

Before placing the magnet on the digital balance, the balance should be zeroed. Push the "zero" button once.

2. Place the long magnet on the center of the balance pan. The wire loop should 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). See Figure 21-3 below



Figure 22-3

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 DMM reads approximately 1.0 amps. . 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 1.0 amp increments until 5.0 amps is reached. Record the current and the magnetic force for each step. Using **Graphical Analysis** plot magnetic force vs. current and determine the best-fit line. *Record the number on the side of the wide magnets.* From the slope you will determine the magnetic field of your magnet.

#### 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. They are as follows:

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 about the same as before).

7. Adjust the power supply until the DMM reads 2.0 amps. Determine the magnetic force. Repeat for all six wire loops. Plot magnetic force vs. wire length. . From the slope you will determine the magnetic field of your magnet.

#### Part 3: Force vs. Angle

8. Plug the Current Balance Accessory into the arm of the current balance. Replace the long magnet assembly with the small "square" magnet. See Figure 21-4. Measure the mass. This is your zero current mass.

9. Set the angle to  $0^{\circ}$  with the direction of the coil wire parallel to the magnetic field. See Figure 21-5. Set the current to 2.0 amps. Re-measure the mass. If the mass changes, slightly vary the angle of the magnet setup so that the mass is as close as possible to the zero current mass. Determine the force. This force is your zero (angle) force,  $F_0$ .

10. Increase the angle in 10<sup>0</sup> increments up to 180<sup>0</sup>. At each angle repeat the magnetic force measurement. Plot magnetic force vs. angle. From this plot, determine the strength of the "square" magnet.

#### Questions/Conclusions:

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

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

3. What is the shape of the curve in part 3? Sketch the shape of the curve if you could rotate the current balance accessory a full 360 degrees.

4. Show  $F=qvBsin\theta$  and  $F=iLBsin\theta$  are dimensionally equivalent.

5. Calculate the field strength of the wide magnets using the slope of the graph in part 1. Write the number of the wide magnet you had. Your lab instructor has the correct values.



Figure 22-4



Figure 22-5