43 Magnetism
Current Balance

Purpose

To investigate how the force on a wire is related to current, length, and the magnetic field.

Required Equipment and Supplies

Basic Current Balance, current loops, and magnet assembly from PASCO
DC power supply, 5 amp
DC ammeter, 5 amp range
balance capable of measuring masses with an accuracy of 0.01 gram (either a quadruple beam balance or an electronic top loading balance)
ring stand
leads with banana plug connectors
Apple II Series computer and *Data Plotter* graphing program (optional)

Discussion

Does a current-carrying wire experience a force in a magnetic field? It depends on the orientation of the wire in the magnetic field. When the wire is perpendicular to the field, the force is a maximum. When the wire is parallel to the field, there is no force. The amount of force depends on current, the length of the wire, and the strength of the field. In this experiment, you will investigate how the force in the wire is related to the current, length, and the magnetic field.

Note: The balances used in this experiment are likely to be calibrated in grams—units of *mass*. The *weight*, *mg*, in newtons is directly proportional to the mass, *m*, in grams. The actual *force* reading in newtons can be calculated by multiplying the mass readings on the scale by 0.0098 newtons/gram.

Part A: Force as a Function of Current

Procedure

Step 1. Mount the main unit of the current balance on a ring stand with a rod of 3/8 inch diameter or smaller as shown in Figure 43.1. Select a cur-

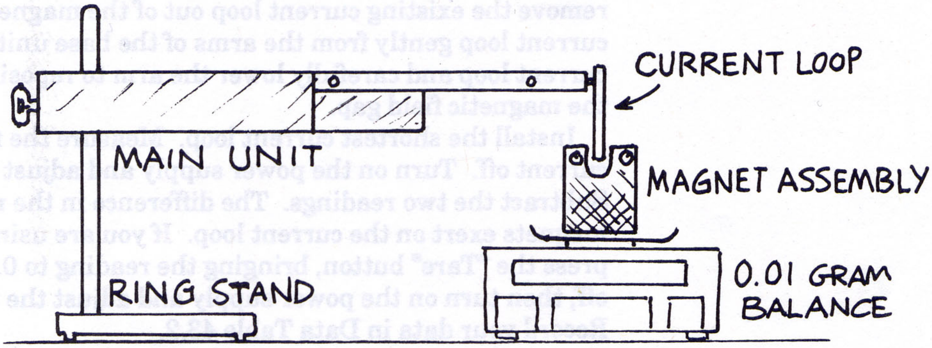

Figure 43.1

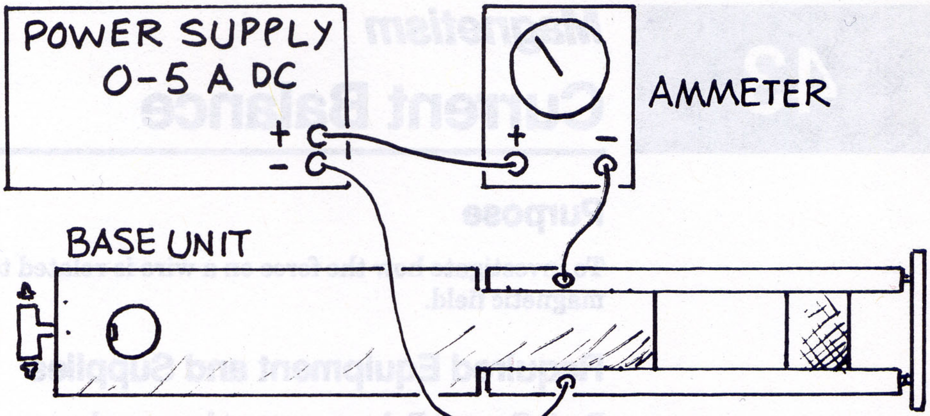

Figure 43.2

rent loop, and plug it into the ends of the arms of the main unit, with the foil extending down. Place the magnet assembly on a balance with at least 0.01 gram sensitivity. Position the ring stand so the horizontal portion of the conductive foil on the current loop passes through the pole region of the magnets. The current should not touch the magnets. Connect the power supply and ammeter as shown in Figure 43.2.

Data Table 43.1

CURRENT (A)	FORCE (N)
0.5	
1.0	
1.5	
2.0	
2.5	
3.0	
3.5	
4.0	
4.5	
5.0	

Step 2. Measure the weight of the magnet assembly with the current off. Turn on the power supply, and adjust the current in the wire to 0.5 amps. Measure the weight of the magnet assembly with the current flowing. With the current flowing, the balance reading will be either higher or lower than with the current off. If you are using a top-loading electronic balance, "Tare" the reading with the magnet assembly sitting on the balance by pressing the appropriate button on the balance. This subtracts the weight of the magnet assembly from the ensuing measurements, so only the force caused by the current is measured. If the reading on the balance is negative when the current is turned on, reverse the leads to the main unit.

Step 3. Increase the current in the loop by 0.5 amps and observe the reading on the balance. Continue until 5 amps and record your data in Data Table 43.1.

Part B: Force as a Function of Length

Step 4. The length of the wire can be varied easily by using one of the six different current loops. Measure the length of the conductive foil of each of the six different current loops. Records these values in Data Table 43.2.

Step 5. Install current loops in the main unit by swinging the arm up to remove the existing current loop out of the magnetic field gap. Pull the current loop gently from the arms of the base unit. Replace it with a new current loop and carefully lower the arm to reposition the current loop in the magnetic field gap.

Install the shortest current loop. Measure the force on the scale with the current off. Turn on the power supply and adjust the current to 2.0 amps. Subtract the two readings. The difference in the readings is the force the magnets exert on the current loop. If you are using an electronic balance, press the "Tare" button, bringing the reading to 0.00 grams with the current off, then turn on the power supply and adjust the current to 2.0 amps. Record your data in Data Table 43.2.

Data Table 43.2

LENGTH	WEIGHT (NO CURRENT)	WEIGHT (WITH CURRENT)	FORCE (DIFFERENCE)

Step 6. Repeat Step 5 using successively longer current loops.

Part C: Force as a Function of the Magnetic Field

The magnetic field in the gap is varied by changing the number of magnets that are mounted on the magnet assembly. It is convenient if the north poles of the magnets are marked "N."

Step 7. Assemble the main unit with the shortest current loop. The magnet assembly should have a single magnet in the center of the holder. Measure the force on the scale with the current off. Turn on the power supply and adjust the current to 2.0 amps. Subtract the two readings. The difference in the readings is the force the magnets exert on the current loop. If you are using an electronic balance, press the "Tare" button, bringing the reading to 0.00 grams with the current off, then turn on the power supply and adjust the current to 2.0 amps. Record your data in Data Table 43.3.

Step 8. Repeat Step 7, adding one magnet to the magnet assembly each time—making sure the north poles are all on the same side of the assembly.

Data Table 43.3

CURRENT LOOP ℓ = ______			
# OF MAGNETS	WEIGHT (NO CURRENT)	WEIGHT (WITH CURRENT)	FORCE (DIFFERENCE)

Data Table 43.4

CURRENT LOOP ℓ = ______			
# OF MAGNETS	WEIGHT (NO CURRENT)	WEIGHT (WITH CURRENT)	FORCE (DIFFERENCE)

Going Further

Step 9. Repeat Steps 7 and 8 with a different current loop. Record your results in Data Table 43.4.

Analysis

1. Why does the balance reading change when the current flows in the loop?

2. Using the data acquired in the data tables, make graphs of force vs. current, force vs. length, and force vs. magnetic field strength. Use *Data Plotter,* if it is available.

3. Describe your graphs. How is force related to current, length, and the magnetic field?

4. Quite possibly your graph of force vs. magnetic field was not *exactly* linear. Can you suggest reasons for that?