

PHYSICS 171

UNIVERSITY PHYSICS LAB II

Experiment 8

Magnetic Force on a Current Carrying Wire

Equipment: Electronic balance, Power supply, Ammeter, Lab stand

Supplies: Current Loop PC Boards, Magnet assembly (long and short), Current Balance Accessory Unit.

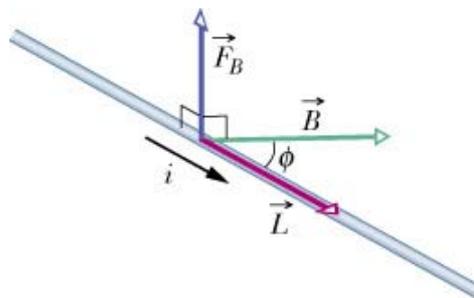
A current-carrying wire in a magnetic field experiences a force that is usually referred to as a magnetic force. The magnitude and direction of this force depend on four variables: the magnitude of the current ( $i$ ), the length of the wire ( $L$ ), the strength of the magnetic field ( $B$ ), and the angle between the field and the wire ( $\phi$ ). The magnetic force can be described mathematically by the vector cross product:

$$\vec{F}_B = i \vec{L} \times \vec{B}$$

or in scalar terms

$$F_B = iLB \sin(\phi),$$

where  $\phi$  is the angle between the directions of  $\vec{L}$  and  $\vec{B}$ . The direction of  $\vec{F}_B$  is that of the cross product  $\vec{L} \times \vec{B}$  because we take current  $i$  to be a positive quantity. The force  $\vec{F}_B$  is always perpendicular to the plane defined by vectors  $\vec{L}$  and  $\vec{B}$  as shown in the Figure below.



If a wire is not straight or the field is not uniform, we can imagine the wire broken up into small straight segments and apply the above equation to each segment. The force on the wire as a whole is then the vector sum of all the forces on the segments that make it up. In using the above equation bear in mind that there is no such thing as an isolated current-carrying wire segment of length  $L$ . There must be always a way to

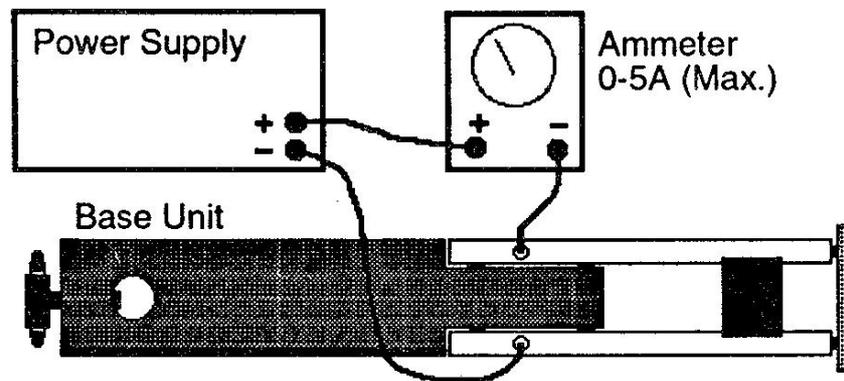
introduce current into the segment at one end and take it out at the other end.

In the present experiment we will vary three of the variables in the above equation: the current, the length of the wire, and the angle between the wire and the magnetic field. The force on the wire will be measured with an electronic balance.

Procedure - Experiment 8

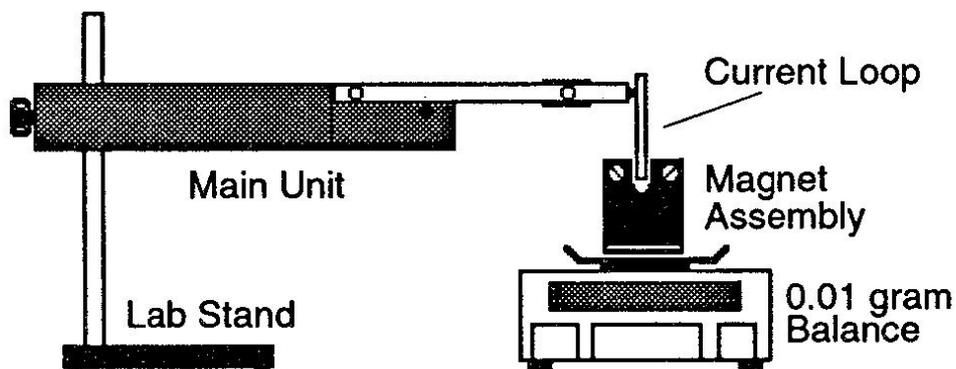
A. Force versus Current

Use a Current Loop of length 6.4 cm (#SF 41) and plug it into the ends of the Main Unit, with the foil extending down. Connect the Power Supply and Ammeter as shown in the Figure below.



Place the long Magnet assembly on the balance and tare the reading by pressing the appropriate switch on it. This subtracts the weight of the Magnetic assembly, so only the force caused by the current will be measured.

Position the Lab stand so the horizontal portion of the conductive foil on the Current Loop passes through the pole region of the magnets as shown below. The Current Loop should not touch the magnets.



Turn the current on. If the reading is negative, reverse the leads where they plug into the arms of the Main Unit. The measured weight is directly proportional to the force caused by the current moving through the magnetic field created by the Magnet Assembly.

Note: In this experiment we use the balance reading in grams as our measure of force. The mass reading is proportional to the actual force, which is given by the equation  $F=mg$ . To use the actual force value, each reading in grams should be multiplied by 0.0098 Newtons/gram to arrive at a force in Newtons.

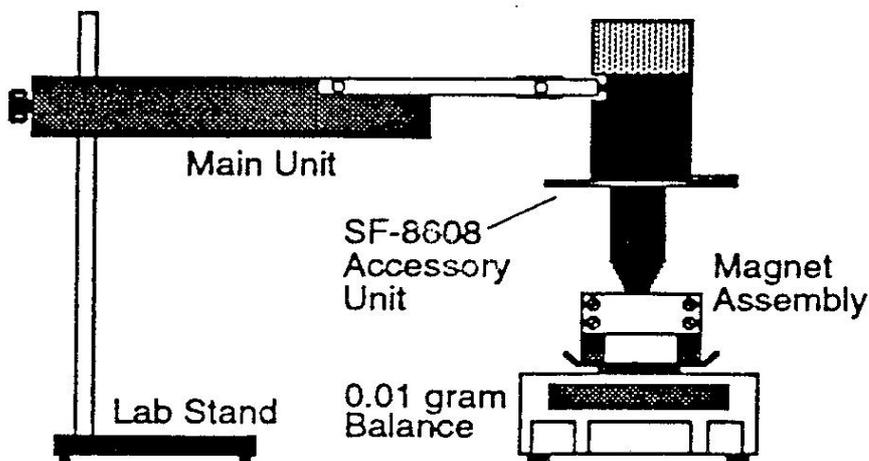
Set the current to 0.5 A. Determine the new “mass” and calculate the corresponding force in Newtons. Record their values. Increase the current in 0.5 A increments to a maximum of 3.0 A, each time recording the corresponding “mass” and force readings. Plot a graph of Force (vertical axis) versus Current (horizontal axis). While doing the experiment, try to find what is the nature of the relationship between these two variables ?

B. Force versus Length of Wire

Start with the Power Supply turned off and a Current Loop of length 1.2 cm (#SF 40) plugged into the ends of the Main Unit. Place the long Magnet assembly on the balance and tare the reading by pressing the appropriate switch on it. Turn the Power Supply on, and adjust the current to 3.0 A. Insert the Current Loop into the pole region of the magnets. Record the “mass”/force readings. Turn the power supply off. Repeat with Current Loops of length 2.2 cm (#SF 37), 3.2 cm (#SF 39), 4.2 cm (#SF 38), 6.4 cm (#SF 41) and 8.4 cm (#SF 42). Each time record the corresponding mass/force reading. Plot a graph of Force (vertical axes) versus Length (horizontal axis). Again, while doing the experiment try to find what is the nature of the relationship between these two variables ?

C. Force versus Angle

Set up the apparatus as shown below.



Place the short Magnet assembly on the balance. With no current flowing, press TARE button, bringing the reading to 0.00 g. Set the angle to  $0^\circ$  with the direction of the coil of wire approximately parallel to the magnetic field. Set the current to 2.5 A. Record the "mass"/force value. Increase the angle in  $10^\circ$  increments up to  $90^\circ$ , and then in  $-10^\circ$  increments to  $-90^\circ$ . At each angle, repeat the mass/force measurement. Plot a graph of Force (vertical axis) versus Angle (horizontal axis). Think on the following questions: What is the relationship between these two variables? How do changes in the angle between the current and the magnetic field affect the force acting between them? What angle produces the greatest force? What angle produces the least force?

Name:

Section:

A. Force versus Current

Current (Amps)	Mass (gram)	Force (Newton)
0.0		
0.5		
1.0		
1.5		
2.0		
2.5		
3.0		

From the data in the table and/or from the plot you made could you tell what is the relationship between the strength of the current and the force acting on the wire carrying the current ? Write you answer below:

B. Force versus Length of Wire

Length (mm)	Mass (gram)	Force (Newtons)
12		
22		
32		
42		
64		
86		

From the data in the table and/or from the plot you made could you tell what is the relationship between the length of the current-carrying wire and the force acting on it ? Write your answer below:

C. Force versus Angle

Angle (deg)	Mass (grams)	Force (N)
0		
10		
20		
30		
40		
50		
60		
70		
80		
90		
-0		
-10		
-20		
-30		
-40		
-50		
-60		
-70		
-80		
-90		

From the data in the table and/or the plot you made could you tell what is the relationship between these two variables ? How do changes in the angle between the current and the magnetic field affect the force acting between them ? What angle produces the greatest force ? What angle produces the least force ?

Write your answers below:

