Physics II
Lab 6 – Experimental Determination of the Force on a Current- Carrying Conductor in an External Magnetic Field [1]

NAME:

SECTION:

BACKGROUND: 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 current (I); the length of the wire ($\vec{L}$); the magnetic field ($\vec{B}$); and the angle between the field and the wire (θ). This magnetic force can be described mathematically by the vector cross product: $\vec{F}_m = I\vec{L} \times \vec{B}$, or in scalar terms, $F_m = ILB \sin\theta$. In this experiment you will vary three of the variables in the equation – the current, the length of the wire and the strength of the magnetic field – and measure the resulting magnetic force. By adding the Current Balance Accessory, you will also vary the angle between the wire and the magnetic field, thereby performing a complete investigation into the interaction between a current-carrying wire and a magnetic field.

PROCEDURE:

Part I: Force *vs.* current

1. Set up the apparatus. The instructor will demonstrate how to do this.

2. Determine the mass of the magnet holder and magnets with no current flowing. Record this value in the column under "Mass" in the table below.

Current (amps)	"Mass" (grams)	"Force" (grams)	Current (amps)	"Mass" (grams)	"Force" (grams)
0.0			3.0		
0.5			3.5		
1.0			4.0		
1.5			4.5		
2.0			5.0		
2.5					

[1] Important: Read this in its entirety before doing the lab.

Set the current to 0.5 amp. Determine the new "mass" of the magnet assembly. Record this value under "Mass" in the table.

3. Subtract the mass value with the current flowing from the value with no current flowing. Record this difference as the "Force". [2]

4. Increase the current in 0.5 amp increments to a maximum of 5.0 amp, each time repeating steps 2-4.

5. Plot a graph of Force (vertical axis) versus Current (horizontal axis).

QUESTION

1. What is the nature of the relationship between these two variables?

Part II: Force *vs.* length of wire

1. Set up the apparatus. The instructor will demonstrate how to do this.

2. Determine the length of the conductive foil on the current loop. Record this value under "Length" in the table below.

Current Loop	Length
SF40	1.2 cm
SF37	2.2 cm
SF39	3.2 cm
SF38	4.2 cm
SF41	6.4 cm
SF42	8.4 cm

[2]Note: In these instructions, we use the balance reading in grams as our measure of force. Most students will realize that the mass reading is proportional to the actual force, which is given by the equation $F = mg$. If you wish to use the actual force value, simply multiply each reading in grams by 0.0098 newtons/gram to arrive at a force in newtons, or by 980 dynes/gram to arrive at a force in dynes.

"Mass" with $I = 0$: _____

Length (mm)	"Mass" (grams)	"Force" (grams)

3. With no current flowing, determine the mass of the Magnet Assembly. Record this value on the line at the top of the table.

4. Set the current to 2.0 amps. Determine the new "mass" of the Magnet Assembly. Record this value under "Mass" in the table.

5. Subtract the mass that you measured with no current flowing from the mass that you measured with the current flowing. Record this difference as the "Force".

6. Turn the current off. Remove the Current Loop and replace it with another. Repeat steps 2-5.

7. Plot a graph of Force (vertical axis) versus Length (horizontal axis).

QUESTION

1. What is the nature of the relationship between these two variables?

Part III: Force *vs.* magnetic field

1. Set up the apparatus. The instructor will demonstrate how to do this. Use the shortest length current loop.

2. Mount a single magnet in the center of the holder.

3. With no current flowing, determine the mass of the Magnet Assembly. Record this value in the first column under "Mass" in the table below on the appropriate line.

	"Mass"				"Mass"		
Number of magnets	$I = 0$ grams	$I \neq 0$ grams	"Force" grams	Number of magnets	$I = 0$ grams	$I \neq 0$ grams	"Force" grams
1				4			
2				5			
3				6			

4. Set the current to 2.0 amps. Determine the new "mass" of the magnet assembly. Record this value in the second column under "Mass" in the table.

5. Subtract the mass you measured when there was no current flowing from the value you measured with current flowing. Record this difference as the "Force".

6. Add additional magnets, one at a time. (Make sure the north poles of the magnets are all on the same side of the magnet assembly.) Each time you add a magnet, repeat steps 3-5.

7. Plot a graph of Force (vertical axis) versus Number of Magnets (horizontal axis).

QUESTIONS

1. What is the nature of the relationship between these two variables?

2. Is it reasonable to assume that the strength of the magnetic field is directly proportional to the number of magnets?

3. What would happen if one of the magnets were put into the assembly backwards, with its north pole next to the other magnets' south poles? If there is time, try it.

Part IV: Force *vs.* angle

1. Set up the apparatus. The instructor will demonstrate how to do this.[3]

2. Determine the mass of the magnet assembly with no current flowing. Record this value in the table on the appropriate line.

[3]When doing this part *do not* exceed a current of 2 A through the coils.

"Mass" with $I = 0$: _____.

Angle (deg)	"Mass" (grams)	"Force" (grams)	Angle (deg)	"Mass" (grams)	"Force" (grams)
0					
5			-5		
10			-10		
15			-15		
20			-20		
25			-25		
30			-30		
35			-35		
40			-40		
45			-45		
50			-50		
55			-55		
60			-60		
65			-65		
70			-70		
75			-75		
80			-80		
85			-85		
90			-90		

3. Set the angle to 0° with the direction of the coil of wire approximately parallel to the magnetic field. Set the current to 1.0 amp. Determine the new "mass" of the magnet assembly. Record this value under "Mass" in the table.

4. Subtract the mass measured with no current flowing from the mass measured with current flowing. Record the difference as the "Force".

5. Increase the angle in 5° increments up to 90°, and then in $-5°$ increments to $-90°$. At each angle, repeat the mass/force measurement.

6. Plot a graph of Force (vertical axis) versus Angle (horizontal axis).

Questions

1. What is the nature of the relationship between these two variables?
2. What angle produces the greatest force?
3. What angle produces the least force?

Turn in

- This sheet of instructions (write your name and section number on it) with tables filled in.
- Part I – graph and answers to questions (properly referenced). Use a computer to do your graph and type your answers.
- Part II – graph and answers to questions (properly referenced). Use a computer to do your graph and type your answers.
- Part III – graph and answers to questions (properly referenced). Use a computer to do your graph and type your answers.
- Part IV – graph and answers to questions (properly referenced). Use a computer to do your graph and type your answers.