Name: ____ Section: __________ Date: _______________

Worksheet - Exp 19: The Current Balance

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, $\vec{\mathbf{F}}_{\mathbf{B}}$, on a moving charge. The magnitude of $\vec{\mathbf{F}}_{\mathbf{B}}$ is: $F_B = qvB\sin\theta$ where q is the charge, v is the magnitude of the velocity (speed) of the charge, B is the magnitude of the magnetic field strength, and θ is the angle between the direction of the magnetic field 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:

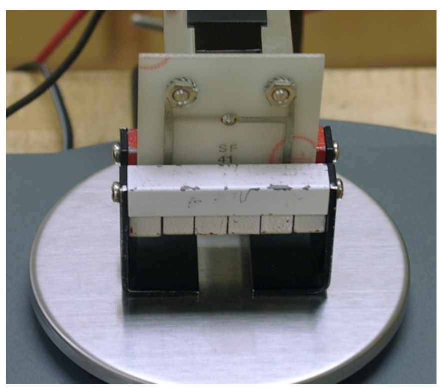
1. Magnitude of the current, I
2. Length of the wire, L
3. Strength of the magnetic field, B
4. Angle between the field and the current, θ

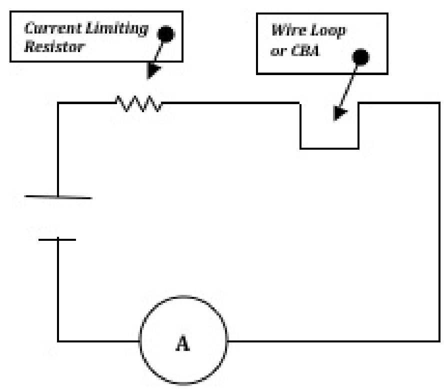
The magnitude of the magnetic force in this case is given by: $F_B = ILB\sin\theta$

The force on the magnet can be determined by measuring differences in the magnet's apparent weight on a scale as the current-carrying wire pushes it up or down. While the scale gives readings of "mass," the associated "weight" or force, F_B, can be calculated: $F_B = mg$

Current, wire length, and angle will be varied one at a time, and magnetic force will be measured in order to determine the magnetic field strength, B, of each magnet. Current and length will be varied for one magnet (B_1), then θ will be varied for a second magnet (B_2).

PROCEDURE





Part 1: Force vs. Current (ΔI)

1. Build the circuit as shown above using the current loop numbered SF 42.
2. Locate the magnet for the wire loops, B_1, and center the magnet on the balance pan. On the digital balance, there is a "Zero" button. Push this button once to "tare" the balance (zero it).
3. Lower the *balance arm* so the wire loop passes through the pole region of the magnet (*i.e.*, the horizontal section of the wire is *just below* the top edge of the magnet, as illustrated above). Note that this will result in the wire loop and the slot of the magnet being parallel.

   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.

   You will need to verify, before each reading, that the wire loop is in the appropriate position.
4. Refer to the above figures and diagram to verify that you have the circuit built correctly. Get instructor approval of your circuit. Be sure the power supply is turned off before you plug it in.

5. Plug in the power supply. Adjust the power until the current is approximately 0.5 A. When the current is on, the magnet should be repelled (deflected downward; positive mass reading). If it is attracted (pulled upwards; negative mass reading), reverse the wires connected to the power supply, turn off the balance, and start again.
6. Measure m and I.
7. Repeat this procedure as you increase the current in 0.5 A increments through 5.0 A.
8. When data collection is complete, turn off the power supply and DMM.
9. Unplug the power supply.
10. Calculate F_B for each current value.

    $F_B = mg$

	I	m	F_B
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

(15 pts)

Part 2: 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, which is already provided in the table.

11. Insert the shortest wire segment (*i.e.*, SF 40) into the balance arm. Always verify that the wire loop is in the appropriate position before recording measurements.
12. Set the current to 2.5 A. Measure m.
13. Repeat for each of the wire loops.
14. Turn off the power supply and the DMM.
15. Unplug the power supply.
16. Calculate F_B.

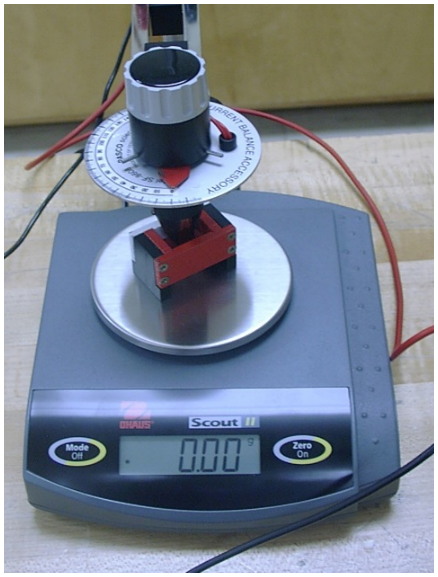
    $F_B = mg$

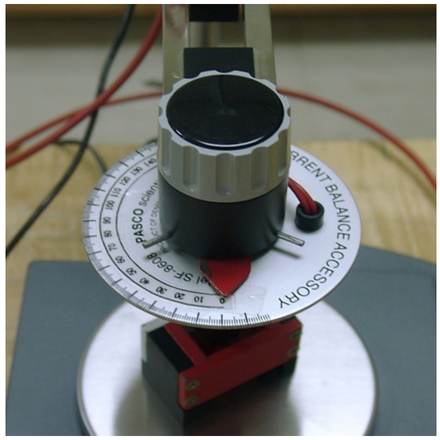
Loop #	Length	m	F_B
SF 40	1.2 cm		
SF 37	2.2 cm		
SF 39	3.2 cm		
SF 38	4.2 cm		
SF 41	6.4 cm		
SF 42	8.4 cm		

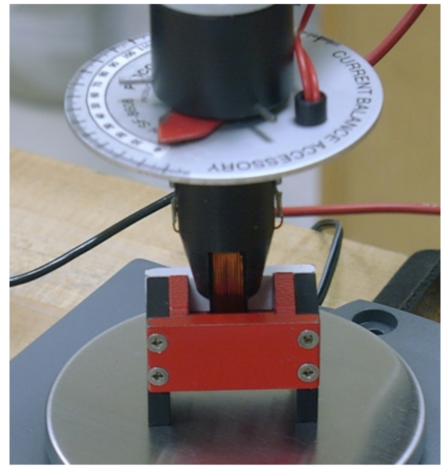
(15 pts)

17. Return the wire loops and magnet to their box. *The balance arm is used for* Part 3 *with the Current Balance Accessory (CBA, Fig. 18.4).*

Part 3: Force vs. Angle ($\Delta\theta$)







18. Center the variable-angle magnet, B_2 (as illustrated above), on the balance pan and tare the balance.
19. Plug the CBA into the balance arm. Adjust the height of the CBA as needed and lower it into the magnet.
20. The horizontal section of the wire loops must be *just inside of*, but not touching, the top edge of the magnet (right figure).
21. Turn the CBA to 0° (center figure).
22. Initially, the horizontal section of the wire loops of the CBA must be parallel to the magnetic field of the permanent magnet. If they are parallel and current is flowing, $F_B = 0.0\ N$, and the mass measurement will not change. If the mass changes when the current is turned on, adjust the alignment by carefully rotating the balance.
23. 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.
24. Return the CBA to 0°.
25. Set the current to 2.5 A.
26. Measure m as you increase θ in 10° increments through 180°.
27. Turn off the power supply and DMM.
28. Unplug the power supply.
29. Calculate F_B for each θ.

Θ	$\sin(\Theta)$	m	F_B
0			
10			
20			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			
130			
140			
150			
160			
170			
180			

(15 pts)

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Extended Worksheet:
Current Balance

Part 4: Analysis

30. Obtain measured data from the Current Balance worksheet. These may be copied on the back of this page if necessary.

31. Plot separate graphs of the following data; one data table with 4 data sets. Determine if (0,0) is a valid data point for each data set. When analyzing your graphs, for B_2 assume that $L = 11.50$ cm. Attach a copy of the graphs to each lab partner's worksheet. (15 pts)

    - F_B *vs.* I
    - F_B *vs.* L
    - F_B *vs.* θ (File ⇒ Settings: Change radians to degrees). Apply a curve fit under Analyze ⇒ Curve Fit (consider Eq. 18.2 when selecting an appropriate fit)
    - F_B *vs.* $\sin\theta$

32. Show that $F_B = qvB\sin\theta$ and $F_B = ILB\sin\theta$ have equivalent units. (5 pts)

33. Is the relationship between current and magnetic force linear? (5 pts)

34. What is the relationship between the length of a wire and magnetic force? (5 pts)

35. What is the shape of the curve for F_B *vs.* θ? How does it relate to $F_B = ILB\sin\theta$? (5 pts)

36. Calculate and compare B_1 values from the first two graphs (you may attach calculations on a separate sheet). (10 pts)

37. Calculate and compare B_2 values from the last two graphs (you may attach calculations on a separate sheet). (10 pts)