Current Balance

Objectives

a. To find the direction of magnetic field, current and the Lorentz force
b. To find the relationship between Lorentz force and current
c. To find the relationship between Lorentz force and length of the current carrying wires.

Apparatus Required

Digital balance	**Current Loops**	**Power Supply**
Connecting wires	**Rotating coil**	

Introduction

A current carrying conductor in a magnetic field experiences a force known as Lorentz force and is usually called as a magnetic force. A wire of length $\boldsymbol{l}$ that carries $\boldsymbol{I}$ current in magnetic field $\boldsymbol{B}$, experience a force $\boldsymbol{F_B}$ which is given by

$$\overrightarrow{F_B} = I(\vec{l} \times \vec{B}). \quad \textbf{(1)}$$

The magnitude of force is

$$F_B = IlBsin(\theta). \quad \textbf{(2)}$$

Where, $\boldsymbol{\theta}$ is the angle between direction of current and the magnetic field.

If the magnetic force $\boldsymbol{F_B}$ pushes a digital balance it reads the force in the form of weight $\boldsymbol{mg}$**,** in a similar manner as we measure our weight.

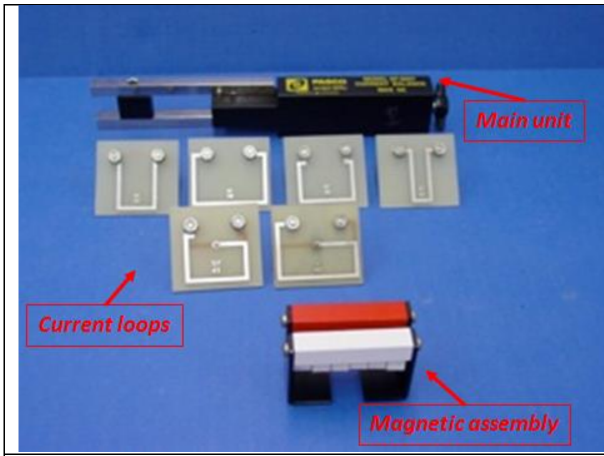
$$mg = F_B \quad \textbf{(3)}$$

Part 1: Finding the directions of the magnetic Force

In this part of the experiment you will be familiar to the direction of the magnetic force.

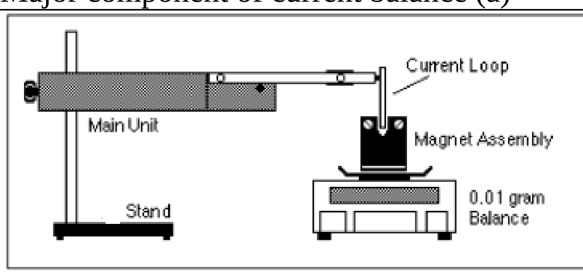
1. You are provided with a digital balance. Connect it to the power source.
2. Put the magnetic assembly at the centre of the digital balance as shown in fig. 1(b).
3. Pick one of the current loops (For example SF-38) and measure the length of the horizontal section. Confirm it from the values provided in the appendix at the end of the write up. Refer to the fig. 1(a).
4. Fix the main unit of current balance to the support unit. Refer to the fig. 1 (c).

5. Connect the loop plate to the top of the support unit through banana connectors. Refer to the fig. 1 (c).
6. Insert the loop plate in between the two poles of the magnet. Make sure the horizontal section of the loop is parallel to the magnets so that the current passing through it is perpendicular ($\theta = 90^0$) to the magnetic field B. Adjust the positon of the magnetic assembly or the main unit to make the horizontal section of the loop inside the magnetic field. Refer to fig. 1(b). **Make sure the loop plate is well inside, well cantered and not touching any point in the magnetic assembly.**

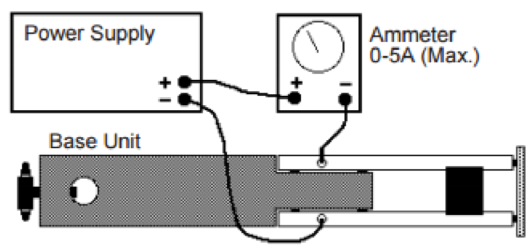


Major component of current balance (a)

Loop in the magnetic field (b)



Current balance set up (c)



Circuit diagram (c)

Fig. 1

7. Connect the current balance to the power supply via ammeter as shown in fig. 1(d). Here you may exclude ammeter from the circuit if the power supply comes with built-in ammeter.
8. Turn all the dials of the power supply to the lowest position by turning them counter-clockwise.
9. Turn on the power supply.
10. Make sure both ammeter and voltmeter reading should read zero. If they are not zero make them zero.
11. Press the zero button on the digital balance. Make sure it reads zero.
12. Slowly rise the current to 1.0 A by adjusting voltage and current nubs. For fine adjustment use fine dial of the power supply.
13. If your digital balance reads negative weight flip the wires in the power supply so that the digital balance reads positive weight.
14. Turn off the power supply.

15. ***With the help of equation (1) identify the direction of magnetic field whether it is from red magnet to white or other way round.***
16. ***You will discuss and learn why the vertical components of the current loops are not important for the magnetic force.***

Part 2: Finding magnetic field B

In this part of the experiment you will vary current (***I***) in a current loop of fix length (***l***) and find the relationship between the current and the magnetic force (F_B). Using this relationship you can measure the magnetic field (***B***).

Procedure:

1. Open excel sheet and design table 1.
2. After part 1 of the experiment now you know that the digital balance is reading positive readings. Repeat steps 8 to 12 for the loop you have used in part1.
3. Record the corresponding weights for currents form 1.0 A to 5.0 A in the excel table. (**Either you can take the measurements for all currents one after other contentiously or you can turn off power supply and repeat all the steps for each current separately)**
4. Turn of the power supply.
5. Using equation 3 find the magnetic force F_B and plot it against the current ***I*** to get the value of magnetic field (in ***T***) from equation (2).
6. Are you getting the curve suggested by equation (2)?

I(A)	***l (m)***	***m (kg)***	***mg (N)***
1			
2			
3			
4			
5			

Table 1

Part 3: Finding the relationship between *l* and F_B

In this exercise you will fix the current (let's say ***I = 4.0 A***) and change the length of the conductor (*l*) by changing the current loops. You will find the relationship between ***l*** and F_B and verify the current from the relationship.

1. Prepare table 2 in another tab of the excel sheet.
2. Record the length and the corresponding weight of each current loop in the excel table for the chosen value of current.

(Till this point students should have developed some skill to take measurements. Therefore, the detail procedure is not provided to discourage monotonous behaviour)

Table 2

I (A) =		
l (m)	***m (kg)***	***mg (N)***

3. Plot $\boldsymbol{F}_B$ v/s $\boldsymbol{l}$ and find the current I from equation (2) by using the magnetic field from part-2.
4. Calculate the experimental value of current from the slope and compare it with the applied current. **Note: Use the value of B that you have got from the part to of the experiment.**

Appendix:

Table: Length of horizontal section of the loop

Current Loop	Length (cm)
SF 40	1.2
SF 37	2.2
SF 39	3.2
SF 38	4.2
SF 41	6.4
SF 42	8.4