G: Magnetic Force on a Current-Carrying Wire

GOAL

- To measure the magnetic force on a current-carrying wire in a magnetic field.
- To determine the magnetic force dependence on the current.
- To determine the magnetic force dependence on the length of the wire.

EQUIPMENT

- Horseshoe magnet
- Current balance apparatus
- Different lengths of wire segments
- DC Power supply (5 A)
- DC Ammeter

THEORY

The force on a wire of length L carrying current I in a magnetic field $\vec{B}$ is given by

$$\vec{F} = I(\vec{L} \times \vec{B}) \qquad \text{Eqn. 1}$$

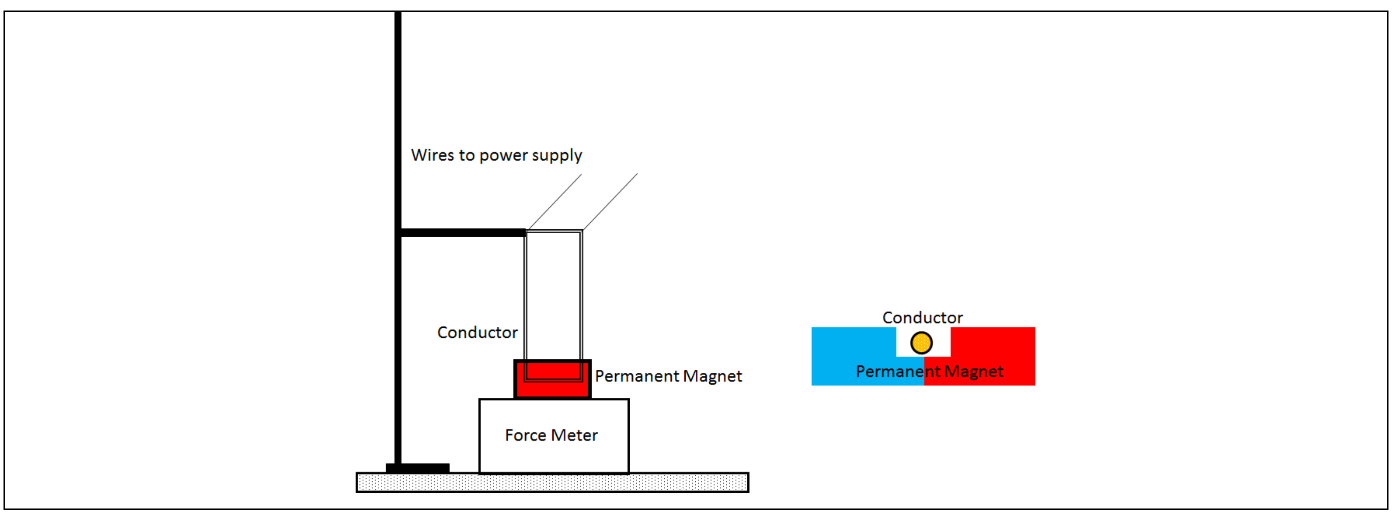
where $\vec{L}$ is in the direction of I. In terms of the magnitude of the force we have

$$|\vec{F}| = ILB \sin \alpha \qquad \text{Eqn. 2}$$

with α the angle between the direction of the current and the direction of the field.

EXPERIMENT

Consider the setup shown below



Experimental Setup

Weight balance (force meter):

1. Remove the magnet from the balance and turn it on.
2. Put the magnet at the center of the balance, take note of its weight and then zero (tare) the balance so that it reads 0 g.

Circuit:

1. With the power supply off, use wires to connect the 8-cm-long wire segment to the power supply.
2. Put the wire segment in the horseshoe magnet (as shown in the figure above), making sure that they are well aligned and not touching.
3. With the power supply off, connect the black ammeter to the circuit in order to measure its current (use the 20A input). **Be sure to use it correctly! This is your last chance to show that you learned how to measure current.**

Force vs. Current

Keeping the conductor unchanged, vary the current (do not exceed 4.9 A!). Record your data and answer the questions that follow.

1. Before you turn on the power supply, trace the direction of current in the conductor by observing that current should flow from the positive terminal to the negative terminal of the power supply. Based on the direction you traced, obtain the direction of the magnetic force that will be generated on the current-carrying wire.
2. Now turn on the power supply and verify your observations based on the change in reading of the force meter. Provide an explanation that either confirms or disproves your prediction.
3. Fill out table 1 below (you can also fill out this table in excel if you prefer) by varying the current between 0 and 4.9 Amps in roughly equally spaced intervals. Take 8 to 10 data points.
4. Plot in excel (or any other software available to you) a graph with current on the horizontal-axis and Force on the vertical-axis. By fitting it to a straight line, record the slope and *y*-intercept of the graph. Print and attach to your report.
5. What does the slope represent? (Hint: See Eqn. 2.)
6. What does the *y*-intercept represent? What is its expected value?
7. Repeat steps 1-3 with the direction of current reversed.
8. How should the slopes obtained (based on directions of current) compare?
9. From your calculations, estimate the field strength of the horseshoe magnet.

Force vs. Length

Set the direction of the current so that you have an attractive force between wire and magnet. Set to current to 1 Amp and vary the length of the wire segment by replacing it with a different one after each observation. Use a ruler to figure out the length of each segment and record your data in table 2 and answer the questions that follow.

1. Plot a graph with length on the horizontal-axis and Force on the vertical-axis. Fit the data and record the slope of the graph. What does the slope represent? Print your plot and attach.
2. Based on your data, calculate the field strength of the horseshoe magnet. Is your result consistent with what you obtained previously?

Table 1

Current (A)	Scale reading (g)	Force (N)	Current (reversed)	Scale reading (g)	Force (N)

Table 2

Length (m)	Scale reading (g)	Force (N)