Experiment 18: The Current Balance

Figure 18.1: Current Balance Arrangement for Varying Current or Length

From Left to Right: Power Supply, Current Balance Assembly, Ammeter (20A DCA scale, 20A jack). North pole of magnet is red; south pole of magnet is white (standard). The magnetic field is from north to south (red to white).

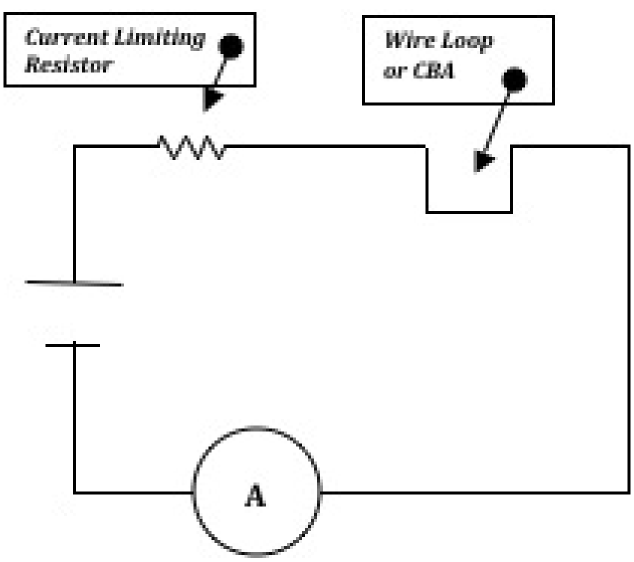

Figure 18.2: Schematic for Current Balance (The current limiting resistor may be internal to the power supply, as shown in Fig. 18.1)

Equipment

Pasco Current Balance Apparatus
Digital Balance
Large Power Supply
Current Limiting Resistor
(If new power supply, no resistor)
Ammeter (20A jack, 20A DCA)
(6) Wire Leads
Rod
Clamp

Advance Reading

Text: Magnetic force, magnetic field.

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:

$$F_B = qvB\sin\theta \tag{18.1}$$

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:

$$F_B = ILB\sin\theta \tag{18.2}$$

In this experiment, a current-carrying wire will be placed between the two poles of a magnet. When current is flowed perpendicular to the magnetic field, the wire and the magnet will either push or pull on each other in the vertical direction. We quantify the force on the wire using Eq. 18.2; by Newton's Third Law, the force exerted on the *magnet* will be equal and opposite.

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:

$$F_B = mg \tag{18.3}$$

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).

Consider Eq. 18.2. At what angle is F_B at a maximum value? At what angle is F_B at a minimum value?

When we investigate the force due to either a change in current or a change in the length of wire, we will want the maximum force. This allows us to compare 2 values for the magnetic field strength, B. We must, therefore, be certain that the current carrying wire and the magnetic field of the magnet are perpendicular to each other (90°). Refer to Fig. 18.1.

When we investigate the force due to a change in angle, we must find a way to be sure of our initial angle, 0°. What will F_B equal if the wire and the magnetic field are parallel? With this arrangement, a non-zero current will result in a force of 0.0 N. If the balance has a non-zero mass reading, we know that the wires and the field are not parallel.