Electromagnetic Force Demonstrator

P6-2625

INSTRUCTIONAL GUIDE

Contents

Electromagnetic Force Demonstrator:

- Magnet Rail
- Conductive Aluminum Tube

Required but not included:

- Power source: we recommend the Genecon Hand Crank Generator (**P6-2635**)

Background

Applications of electromagnetic force are all around us. From the first homopolar motor of Michael Faraday, electromagnetic force has been leveraged for endless applications, particularly in motors, generators, and solenoids. Understanding the relationship between electricity and magnetism and how their interaction impacts our lives can be difficult. For this demonstration, Fleming's "Left-Hand Rule for Motors" is a useful mnemonic for determining the direction of force due to induction. Sir John Ambrose Fleming is considered one of the founders of electrical engineering and was a very popular professor. He wrote *Magnets and Electric Currents: An Elementary Treatise for the Use of Electrical Artisans and Science Teachers* which described the purpose and use of the "hand rule." Since then, nearly every lesson on electric motors and generators has included the hand rule.

Introduction

The electromagnetic force demonstrator is a clever device designed to exhibit the relationship between electricity and magnetism as described by Henrik Lorentz. It can be thought of as a section of an unrolled electric motor; electrical energy is converted to mechanical energy. When using the left-hand rule, it is important to consider these two assumptions:

1. The "current" referred to is *conventional* current which flows from positive to negative terminals.

2. The direction of a magnetic field is always oriented from the north pole to the south pole of a permanent magnet.

These two fundamentals are important to understand since they play a part in every electromagnetic interaction.

Investigation

Set up the device so the north side of the magnet is facing up. Connect the power source so the positive terminal is on the left and the negative terminal is on the right. Use Figure 1 as a guide. Be sure to place the demonstrator on a level surface so the tube does not roll before any current is applied.

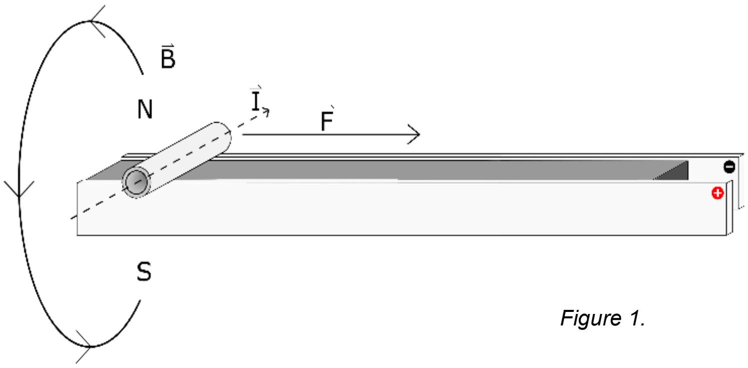

Figure 1.

At this point, try using the left-hand rule to determine the direction the tube will move. Figure 1 shows the direction of the magnetic field (**B**), current (**I**), and force (**F**) for the current setup. Point your index finger along the magnetic field lines (the magnetic field is pointing *up* since the field lines travel from N to S) and extend your middle finger at a right angle to your index finger and point it along the path of the current traveling through the tube. Now stick your thumb out to find the direction of electromagnetic force. Then, send power through the circuit.

1. Did the left-hand rule correctly predict the direction the tube rolled?

2. Now switch the terminals so the negative terminal is on the left and the positive is on the right. Which way did the tube roll? Work through the result using the left-hand rule.

3. Finally, turn the magnet over so the south pole is facing up. What do you expect will happen? Draw a diagram like Figure 1 to show the directions of magnetic field lines, current, and motion.

Discussion

We know through the Biot-Savart Law that a conductor carrying an electric current (like the aluminum tube in this demonstration) generates a magnetic field that surrounds the conductor. We also know that charged particles such as electrons experience a force when traveling through a magnetic field.

With this information, answer the following questions on another sheet of paper:

1. Why doesn't the tube move when there is no current present?

2. Describe the transfer of energy from electrical to mechanical in this system. What forces are present?

3. Describe the interaction of forces in terms of Newton's Third Law of Motion. We see the action of the tube moving, but what is the reaction?