



LAPLACE'S LAW DEMONSTRATOR

LLDE01

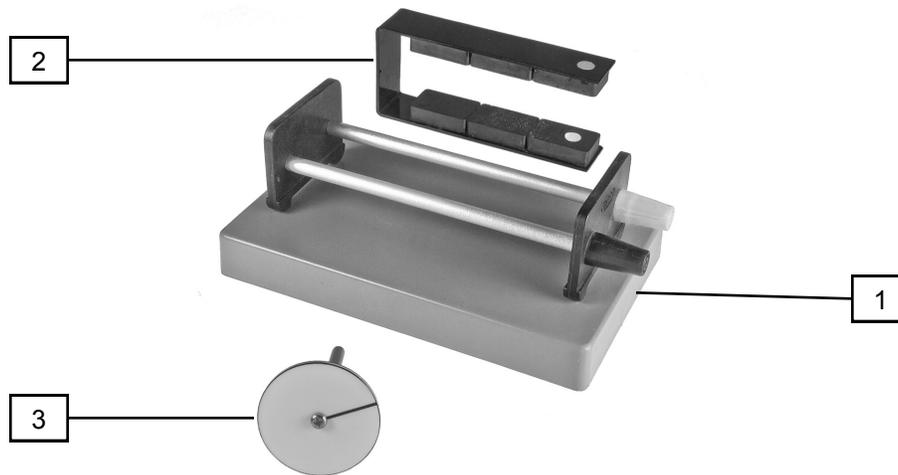


Figure 1

DESCRIPTION

"Laplace's Law" refers to the Biot -Savart formula that describes the magnetic field generated by a current-carrying conductor. For a a long, straight wire,

$$B = kI/a$$

where B is the magnetic field strength at a distance a from the wire, I is the current strength, and k is a proportionality constant whose value depends on the system of units chosen. If such a wire is placed in an external magnetic field, it will experience a force due to the interaction of the magnetic fields. The LLDE01 Laplace's Law Demonstrator verifies the existence of this force and shows its direction in relation to the directions of the electric current and the external magnetic field.

The demonstrator consists of a base with two separate, parallel conductors (1, *Figure 1*), a large U-shaped magnet (2) that fits between the parallel conductors, and a conducting rod (3) attached to a plastic disc with an indicating line to show the rod's orientation. In use, the magnet is placed between the conductors to provide a vertical external magnetic field, and the rod is balanced across the parallel conductors, bridging them and creating a complete conducting path between the two binding posts on the ends of the rods.

When a current is passed through the rods, a force is exerted on the rod with the disc which causes it to roll along the parallel rods. This phenomenon is also known as the *Motor Effect*.

SPECIFICATIONS

| | |
|----------------------|----------------------------|
| Current requirement: | 2–5A d.c. |
| Voltage: | <6V |
| Usable rod length: | 12 cm |
| Dimensions: | 21 x 12 x 9 cm (l x w x h) |
| Weight: | 670 g |

BACKGROUND

A charged particle moving in a magnetic field experiences a force perpendicular to the directions of both the field and the motion, the *Lorentz Force*:

$$\mathbf{F} = q(\mathbf{v} \times \mathbf{B})$$

where q is the magnitude of the charge and \mathbf{F} , \mathbf{v} and \mathbf{B} are vectors representing the force, the charge's velocity, and the magnetic field respectively.

Consider a current of positive charges moving at the same speed in a tube. If an external magnetic field and the charges' direction of motion are mutually perpendicular, we have:

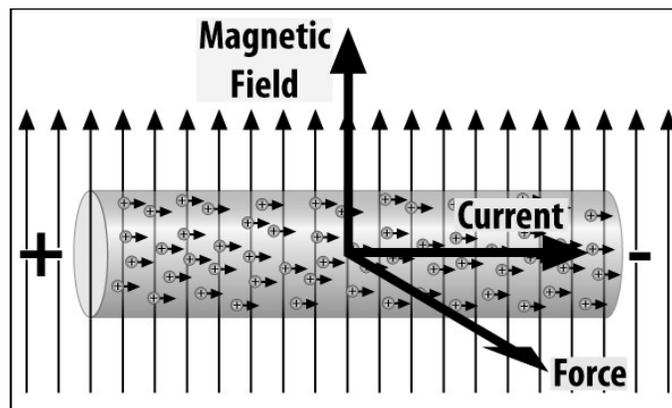


Figure 2

In *Figure 2*, the current and magnetic field directions are in the plane of the diagram, and the resulting force on the charges is in the direction of the observer, in accordance with the law of vector products. If the charges are negative (electrons) instead of positive and the tube is a metallic wire, the direction of their motion is reversed, but so also is the sign of the charge q , so the direction of a conventional electric current and the resulting force on the wire carrying it are the same as in *Figure 2*.

FLEMING'S LEFT HAND RULE

A mnemonic for the spatial relationship shown above was devised by John Ambrose Fleming in the late 19th century. It involves spreading the thumb and first two fingers of the LEFT hand at right angles to each other, as shown in *Figure 3*.