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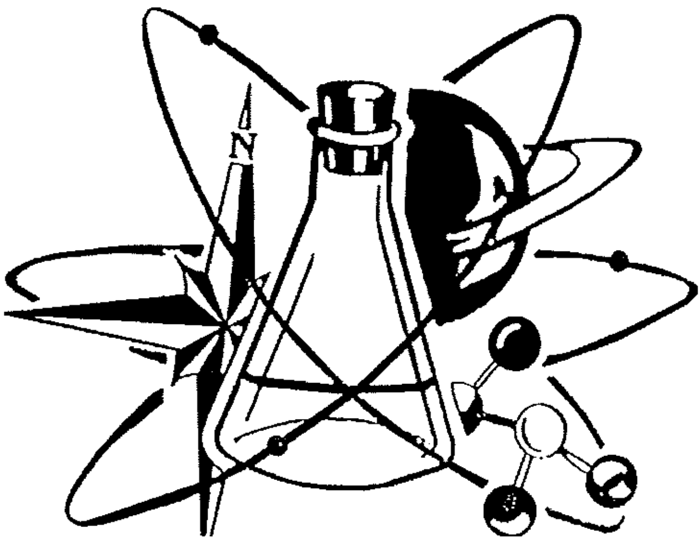

STUDENT TEST KIT
7-1850-1
SOLENOID

DESCRIPTION

The apparatus consists of a black plastic tube 5" long, wrapped with insulated copper wire to form a coil 1 1/4" in diameter and 4 1/4" long. The ends of the coil are attached to mounting posts. The center of the tube is 1 7/8" in diameter, and accepts a steel rod 3/4" in diameter and 6" long. The apparatus is designed to work with a DC voltage source of 6-12 volts.

PURPOSE

This apparatus is designed to demonstrate the effects of an electrically generated magnetic field. By varying the power supplied to the apparatus, and measuring the effects of changes in the configuration of the apparatus, it is possible to derive various physical laws dealing with electricity and electromagnetism.

THEORETICAL BACKGROUND

When a current, I, is passed through a circulars loop of radius r, the magnetic field at the center of the loop is given by:

$$B=\mu_o/4\pi \cdot 12\pi\, r/r^2 = \mu/2 \cdot I/r$$

Where B is equal to the magnitude of the magnetic field at the center of the loop in Telsas, I is the current in amperes, r is the radius of the loop in meters, and μ is a constant equal to $4\pi \cdot 10^{-7}$ N/A^2 (the permeability of free space).

For one of the loops in the solenoid the magnetic field, assuming a current of 6 amperes, would be:

$$\mu_o/2 \cdot I/r$$
$$(4\pi \times 10^{-7}\ \text{N/A}^2)/2 \cdot 6\ \text{amperes}/0.015875\text{m}$$
$$\cdot\ 3\ \text{turns per coil}$$
$$7.12422 \times 10^{-3}\ \text{T}$$

For a solenoid, the magnetic field is equivalent to the sum of the magnetic fields of each of the coils making up the solenoid. For a given solenoid of length b and with the N turns in length l, the magnetic field B is given by:

$$B= \mu_o\,(N/l)I$$

The coil in this apparatus has 22 turns per inch, times 3 layers per turn for a distance of 4 1/4" for a total of 300 turns, which would give a total magnetic field for the solenoid of 7.12422 Telsas.

SUGGESTED EXPERIMENTS
PLEASE NOTE
a VARIABLE POWER SOURCE IS RECOMMENDED FOR THESE EXPERIMENTS

1. Insert the steel rod into the plastic tube, and have the students push it back and forth to see that it moves freely when there is not current applied to the coil.

2. Apply power to the coil and have the students push the steel rod slightly out of position. Notice that the magnetic field has induced a magnetic field of the coil, and that the rod is drawn back to centered position.

3. Attach an ammeter between one of the power leads and the coil. Measure the current draw when the coil and the steel rod are in equilibrium.

4. With the ammeter still in place, move the steel rod out of the center position. Is there an increase in the resistance of the coil?

5. Slowly increase the current supplied to the coil. Does the movement of the steel rod change as the current is increased? What does this say about the strength of the magnetic field. (NOTE: As the magnetic field increases in strength the steel rod should move more freely, to the should move more freely, to the point where the strength of the magnetic field will counterbalance the gravitational force acting on the rod. At this point the rod should "float" in the center of the plastic tube). **INCREASE THE CURRENT SLOWLY, BEING CAREFUL NOT TO EXCEED SAFE LIMITS. OBSERVE THE COIL CLOSELY FOR SIGNS OF HEATING.**

ADVANCE EXPERIMENTS

1. Carefully weigh the steel bar.

2. Adjust the current to the coil to the point where the rod is just "floating".

3. Using the weight of the rod, and the current required to counteract the Earth's gravitational field, calculate the strength of the gravitational field (OR use the strength of an unknown magnetic field). This is a difficult calculation, and is only to be used for advanced studies.

4. Knowing the size of the coil, it is possible to calculate the resistance of the wire used in the apparatus? (HINT: measure the resistance of the coil, using an ammeter, both with and without the steel rod in place).

FURTHER NOTES

The instructor may tailor the use of this apparatus to the level of the class being taught. The more sensitive the equipment available for taking measurements the greater the possibilities for deriving physical law.

It may be pointed out that the principles involved in this apparatus are the same as are used for such applications as automotive starters, door bells, and switches.

The suggestions for the use of this apparatus are designed to show some of the possible uses. There are many other applications which the individual instructor may find useful, and which may be adapted to serve the instructional needs of a particular curriculum. The instructor needs of a particular curriculum. The instructor should feel free to experiment with this apparatus. ALWAYS REMAINING AWARE OF PROPER SAFETY CONSIDERATIONS.

The self-inductance of this solenoid, $L = \frac{\mu N^2 A}{l} = 8 \times 10^{-4}$ H

(A is the cross sectional area.)