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Lab Section H2

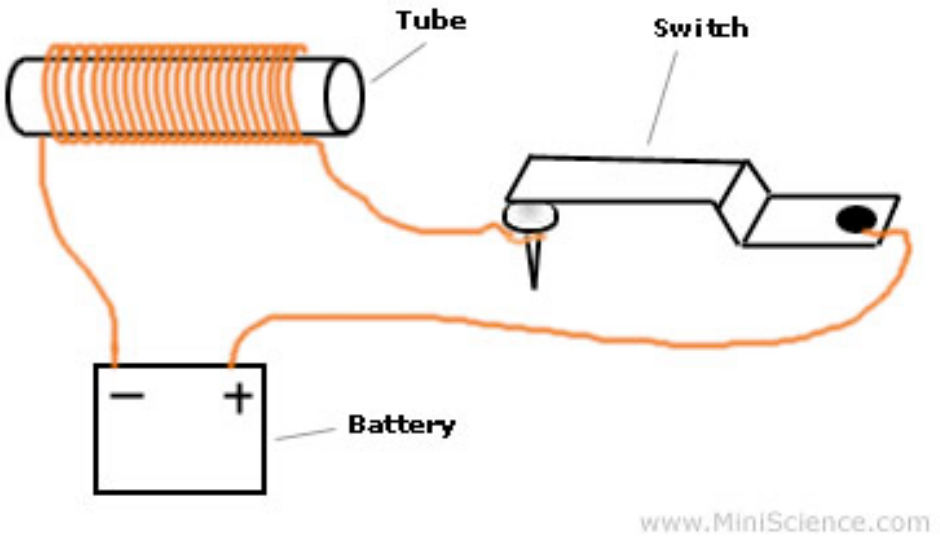
The Solenoid Doorbell and Launcher

This project centers on the successful creation of a device capable of ringing a doorbell or launching a small projectile by simply pressing a button. This device is a removable core solenoid.

A solenoid is simply an electromagnet created by coiling a wire around a metallic core and then running an electric current through it. This electromagnet produces a uniform magnetic field in a certain volume of space depending on certain factors. These factors can be seen in the equation for calculating the magnetic field of a solenoid, $B = \mu_0 (N/l) I$, and are namely the number of coils wrapped around the core, N, the length of the core, l, and the measure of current running through it, I. This project involves a slightly different type of solenoid, one with a removable core. Instead of the wire being coiled around the core directly, it is instead coiled around a hollow plastic cylinder into which a metallic core is placed. The only difference this design yields is one of functionality. When current runs through the wires of the removable core solenoid and when the core is completely inside of the cylinder, an electromagnet is created. When the core is not completely inside of the cylinder, it is pulled through by the magnetic field and then becomes an electromagnet. This pulling force is how the device is able to ring the bell and launch the projectile.

To build the contraption, four D-Cell batteries were first placed into a battery holder. Next, magnet wire was attached to the battery holder from one side and connected to a switch (in this case, a doorbell). The switch was then connected to the solenoid and

the solenoid to the other side of the battery. When the switch is pressed, the circuit is completed and it allows current to flow through the wire, drawing the core into the cylinder. For ideal use of the device, the metallic core, a nail in this case, is left as far out of the cylinder as possible. This allows more time for the field to act on the nail so that it can strike the bell harder, making a louder ring, and so that it can propel the projectile faster. The finished device looks somewhat like the following.



The entire device is setup differently depending on if it is to be used as a doorbell or a launcher. It is held vertically for the doorbell and horizontally for the launcher. The doorbell is held vertically so that the force of gravity can push the nail back down to its starting position after the button is released. This is important because the nail is still slightly magnetized after the current is cutoff and when placed horizontally it either sticks to the bell or is too close to make audible rings in short succession. Alternately, the launcher is held horizontally for ease of propulsion. If held vertically, the projectile, a paper ball, would have a harder time launching because of resistance due to gravity.

Throughout this experiment data measurements were taken so that certain factors could be calculated. Current was to be measured first. After this measurement, the magnetic field of the solenoid was to be calculated using the equation $B = \mu_0 (N/l) I$, where the number of turns, N, was found to be 80 and the length, l, was 3cm. After discovering the magnetic field, the Lorentz force equation was to be used to determine the force on the nail. This force could in turn be used to calculate the theoretical velocity and launch distance of the projectile. However, one key error impeded these calculations. A multi-meter was used to determine the current moving through the wire. Although many measurements were taken, none were consistent with each other. This could be contributed to either the very small diameter of the magnet wire, which hindered measurements to be taken with ease, a possibly faulty multi-meter, or even bad test leads. Without this crucial measurement, the magnetic field of the solenoid could not be calculated. Without this magnetic field, neither the force of the nail on the projectile nor the efficiency of the projectile's launch could be calculated. Furthermore, because of the composition and size of the projectile that was used and because of the cylinder being considerably larger in diameter than the nail, the efficiency of the launch is observably dismal.

Despite a failed measurement leading to the inability to make calculations, the project still works as desired. The doorbell rings consistently and the launcher fires the paper projectile.

References:

http://www.miniscience.com/projects/Solenoid/index.html

http://searchcio-midmarket.techtarget.com/sDefinition/0,,sid183_gci214067,00.html

Whitehead, John B. Electricity and Magnetism. New York: McGraw-Hill Book Company, Inc., 1939.