Laboratory 4: Electricity & Magnetism

As Hal said in class, most of the clocks we use now are electromagnetic timers of some kind, so we want to give you a grounding in Electricity and Magnetism. Today you get an experiential encounter with "E&M"; tomorrow brings a more systematic introduction.

A. Electrical Charge

Going all the way back to ancient Greece, people knew that you could give things electrical charge by rubbing certain materials against each other. We have a collection of rods and cloths for you to try that with, and "pith balls" and electroscopes to charge.

Tell us what things you did to establish these basic electrical ideas:

- There are two types of charges.
- Like charges repel, opposite charges attract.
- The electrical force gets weaker as the charges get farther apart.

We have set up two Van de Graaff generators in the back of the room, one that generates positive charge on its dome, one that generates negative charge. Use these to determine the answer to this question: Are the charges on your rods + or – ?

B. Electrical Properties of Material

We describe materials in terms of how well charges can move in them.

- Conductors have mobile charges, and can carry a *current* of electric charges.
- Insulators have immobile charges, and any applied charge stays stationary.

Determine whether the various materials you have are conductors or insulators.

C. Maintaining an Electric Field in Space

A Van de Graaff generator uses the power from the wall socket to build up charge on the dome. We can also use a battery to do a similar thing. Use a battery pack to put + and – charges on two metal plates, then use a charged pith ball to observe that this stores an *electric field* in the region between the plates. We call this a *capacitor.*

D. Permanent Magnets

A compass needle aligns with the direction of the *magnetic field* at that point.
Move a compass near a ferro-magnet and map out the directions of the field in space.
We will make sketches to see that electric and magnetic fields differ geometrically.

E. Electricity Can Produce Magnetism

Now use your battery pack to make current go through a coil of wire. Move a compass near the coil and map out the directions of the field in space. We hope to convince you that in every real way, the coil of wire with current, an *inductor*, stores a magnetic field.

We are going to be working with capacitors and inductors to make clocks. These will operate at frequencies too fast for you to count, so we need a device to measure short time intervals (*i.e.*, high frequencies). To start to explore these frequencies we will introduce you to a function generator in this lab and next week you will work with oscilloscopes, which allow you to visualize these high frequencies.

F. Function Generator

We will help you set up a speaker attached to a *function generator*, which allows you to generate SHM electrical signals at will. These use the electricity and magnetism we just studied to move the speaker cloth back and forth at the frequency of the oscillation.

As you turn the **FREQUENCY** dial, you will hear the pitch of the sound change, observing the pitch ↔ frequency correspondence (higher pitch = higher f).

As you turn the **AMPL** dial, you will hear the loudness of the sound change, observing the loudness ↔ amplitude correspondence (louder = larger amplitude).

Lab Write-up

Explain what you observed about Electricity and Magnetism and what you concluded from your observations. Be as explicit as you can about what methods you used to confirm the electrical and magnetic basics that we were aiming for in this lab.

Finally, put down three questions you have about electricity or magnetism or the last part of the lab, and we will do our best to answer them in classes ahead.