# General Physics II Lab (PHYS-2021)
# EXPERIMENT ELEC–0:
# E/M Labs Orientation

## 1 Introduction

For this first lab in *General Physics II Laboratory*, you will introduced to a variety of devices that you will use to carry out experiments dealing with electricity and magnetism (E/M). The reason for this *orientation* is that some students have a lot of experience working with devices used in electricity and magnetism, whereas other have no experience what-so-ever. It is for these latter students that your instructor will carry out an overview of the equipment that you will be using for the electricity and magnetism experiments you will be performing during the first half of this course. **There are no specific experimental results to be carried out in today's laboratory session. As such, <u>no</u> lab report will need to be written and turned in for grading.**

In many of the experiments dealing with electricity and magnetism, you will make use of multimeters (see Figure 1) that are used to measure voltages (*i.e.*, potential differences), currents, and resistances. Your instructor will demonstrate the operation of these multimeters.


Figure 1: Examples of multimeters used in this course.

# 2 Electricity Experiments

During the next five weeks, you will be performing the following experiments dealing with electric charges, the laws of electricity, and the manipulation of electrical circuits:

| **Week** | **Experiment Title** | **Exp. #** |
|---|---|---|
| 2 | Electrostatic Charges | ELEC–1 |
| 3 | Ohms Law | ELEC–2 |
| 4 | Resistor Circuits | ELEC–3 |
| 5 | Resistivity | ELEC–4 |
| 6 | RC Circuits | ELEC–5 |

## 2.1 Electrostatic Charges

Experiment *ELEC–1* will make use of a *Faraday Ice Pail* (*i.e.*, cylindrical wire meshes), *electrometers*, and *spherical* and *non-spherical charge distribution* conductors shown in Figure 2 on the next page.

As explained in the *PASCO Electrostatic Charges* instructions for Experiment *ELEC–1*, electric charge is a fundamental property of nature. It comes in two types, called *positive* (+) and *negative* (–). Positive charge is the type of charge carried by protons. Negative charge is the type of charge carried by electrons. For an object to be positively charged, it has to have more protons than electrons. For an object to be negatively charged, it has to have more electrons than protons, disturbing the neutral charge balance.

Opposite charges always attract. Like charges tend to repel. At an elemental level, like charges always repel (electrons repel electrons, protons repel protons), but for macroscopic objects, non-symmetric charge distribution can result in an overall attraction between two objects that carry the same type of overall charge (positive or negative). Non-symmetrical charge distribution always results in an attraction between a charged object and an electrically neutral (overall) object.

All charging processes involve the transfer of electrons from one object to another. In order for an object to become positively charged, it must lose some of its electrons. In order for an object to become negatively charged, it must acquire more electrons. In Experiment ELEC–1, you will carry out the following methods to charge an object: ‘charging by rubbing,’ ‘charging by contact,’ and ‘charging by induction.’

Figure 2: Devices used in the Electrostatic Charge experiment.

## 2.2 Ohm's Law

Experiment *ELEC–2* will involve experiments to verify Ohm's Law:

$$V = I\,R\ ,$$

where $V$ $(= \Delta V)$ is the potential difference (measured in volts, V), $I$ is the current (measured in amperes, A), and $R$ is the resistance (measured in ohms, Ω). In metals and some other materials (in particular, commercially manufactured resistors), one finds experimentally that the voltage drop, $V$, across the material is directly proportional to the current, $I$, through the material (provided the temperature remains relatively constant). The proportionality constant of this relation is called the resistance. Materials that obeys Ohm's Law are called *ohmic* and materials that do not obey Ohm's Law are called *non-ohmic*. Figure 3 on the next page shows an example of the set-up you will use in this experiment.

## 2.3 Resistor Circuits

Experiment *ELEC–3* will also make use of the equipment used in Experiment *ELEC–2*. In this lab, students will investigate the reduction of a combination of resistors into an equivalent resistor and run tests to confirm the results of this reduction. Figure 4 on the next page shows an example of one of the set-ups for the Resistor Circuits experiment. In this

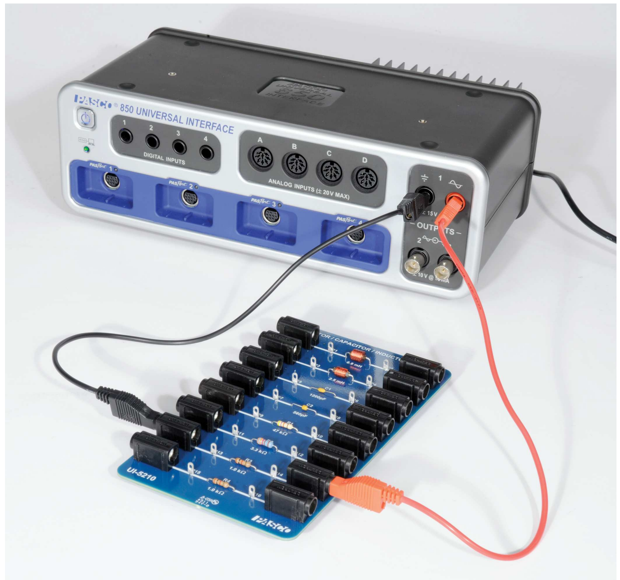


Figure 3: The Ohm's Law Experiment.

experiment you will configure resistors into a combination of resistors connected in series, connected in parallel, and a combination of both of these.


Figure 4: The Resistor Circuits Experiment.

## 2.4 Resistivity

Experiment *ELEC–4* deals with the concept of resistivity. The resistivity of different metals is determined by finding the resistance of wires of a known diameter as a function of their length. It is also shown that the resistance of a wire of fixed length is inversely proportional to its cross-sectional area. Figure 5 below shows the set-up for this experiment.

The equation that describes the resistivity $\rho$ is given by

$$\rho = \left(\frac{R}{L}\right) A \ ,$$

where $R$ (measured in ohms, $\Omega$) is the resistance of the metal wire across its length $L$ (in units of meters), and $A$ (in units of $m^2$) is the cross-sectional area of the wire.

Figure 5: The Resistor Circuits Experiment.

## 2.5 RC Circuits

The final experiment dealing with electricity and electrical circuits is Experiment *ELEC–5*. This experiment will once again make use the same equipment used in the Ohm's Law and Reduced Circuits labs shown in Figures 3 and 4. Here, however, we will also make use of the capacitors on the circuit board. The standard set-up for a resistor-capacitor (R/C) circuit is shown in Figure 6 on the next page. When a circuit like this is fully connected, the battery sends a current through the resistor and charges a capacitor. Once the capacitor reaches a full charge, then the battery can be removed from the circuit and the capacitor can serve as a temporary battery. In this lab, you will explore the characteristics of charging and discharging a capacitor.

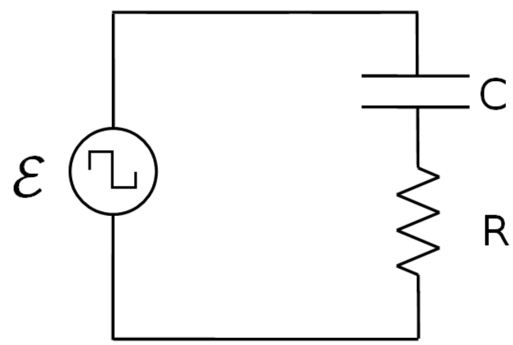


Figure 6: The Resistor-Capacitor Circuit Experiment.

# 3 Magnetism Experiments

There will be two lab experiments dealing with magnetism as shown in the following table:

| **Week** | **Experiment Title** | **Exp. #** |
|---|---|---|
| 7 | Electrostatic Charge | MAGN–1 |
| 8 | Ohms Law | MAGN–2 |

## 3.1 Earth's Magnetic Field

The *MAGN–1* experiment will involve making measurements to measure the intensity and direction of the Earth's magnetic field in Johnson City, Tennessee. The magnitude and direction of the Earth's magnetic field are measured using a Magnetic Field Sensor mounted on a Rotary Motion Sensor. The Magnetic Field Sensor is rotated through 720° in a horizontal plane and then 720° in a vertical plane by rotating the Rotary Motion Sensor pulley by hand. This allows a determination of the horizontal component of the Earths magnetic field, the total field and the dip angle. The Magnetic Field Sensor is zeroed using the Zero Gauss Chamber, the walls of which are made of a highly permeable material which redirects the magnetic field around the chamber. Figure 7 shows example of the set-up used for this experiment.

## 3.2 Magnetic Field of a Coil

Experiment *MAGN–2* studies the magnetic field associated with a coil of wires. In this experiment, the magnetic field of a single coil of wire containing a current is investigated.

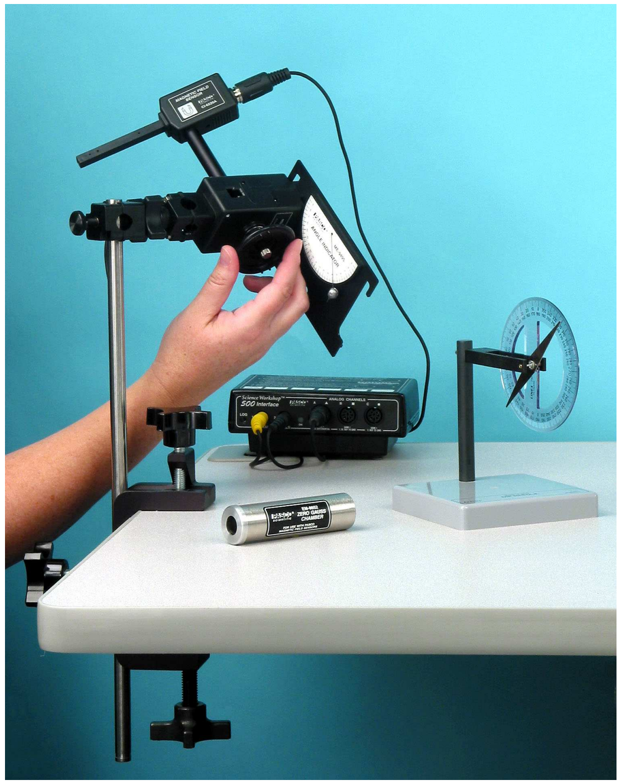

Figure 7: The Earth's Magnetic Field Experiment.

Here the detector will be positioned along the axis of the coil, then along the diameter of the coil. Figure 8 shows the set-ups used for measurements of a single coil with the arranged in these two different orientations.

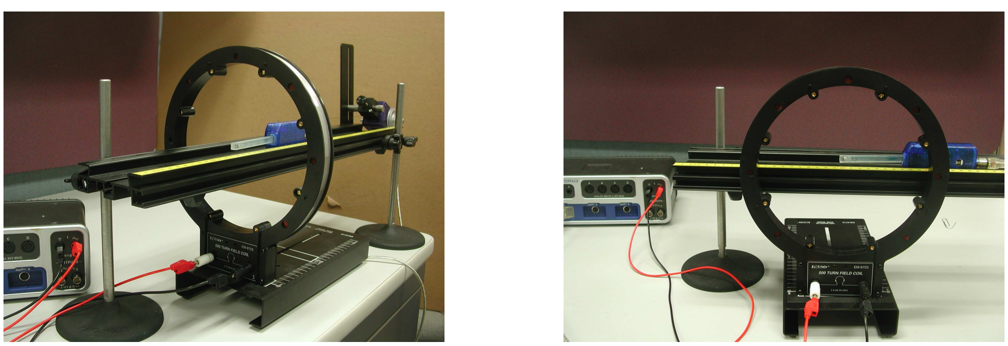

Figure 8: The Signal-Coil Magnetic Field Experiment.