**102 LAB PROTOCOL**

**LAB I - Capacitance**

**Objective:** Students will learn empirically how the capacitance between two plates depends on the area, distance and dielectric between them by measuring them with an Arduino.

**Material**

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| Individual Station (15 in total) | Collective Station (5 in total) |
| * 1 Laptop * 1 Utility case (Arduino inside) * 1 Set of plastic sheets * 1 Set of paper sheets * 1 Set of aluminum sheets * 1 pair Banana-Banana cables * 30 cm ruler | * Aluminum Foil * Block of wood * Small weights (To fix the sheets) * Extra pairs of Banana-Banana * Micrometer (To measure the width of the sheets) * Multimeter (To verify capacitance) |

**Procedure**

Students will play around aligning their aluminum sheets with a dielectric between them and connecting the electrodes from the utility case to measure the capacitance. We expect there will be some short-circuits during the measurement, but the Arduino is built to withstand them. Therefore, we don’t expect anything to break but the plastic or paper sheets. By varying the area of the aluminum sheets and the distance between them we expect them to obtain a linear regression of the capacitance (C) or (1/C) respectively.

**LAB II – RC Circuits**

**Objective:** Students will learn how to measure the time constant of an RC circuit using a PASCO 850 and will then build their own RC circuit with a predetermined time constant.

**Material**

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| Individual Station (15 in total) | Collective Station (5 in total) |
| * 1 Laptop * 1 PASCO 850 Universal Interface * 1 (100 kΩ) Rheostat Utility Case * 5 (10 microF) capacitors * 5 (50 Ω) resistors * 2 pairs Banana-Banana * 1 PASCO 850 Input Voltage interface. | * Assorted Resistors * Assorted Capacitors * Capacitance and Resistance Multimeter |

**Procedure**

Students will measure the time constant of the circuit by sending a square wave through the PASCO’s analog 1 output port and measuring the voltage through the effective capacitor with the analog input port A of the Pasco. They will then find the time constant of the circuit by using the PASCO built-in fitting functions for their data. During the second sessions students will create their own circuit in a breadboard with a fixed number of resistors and capacitors for a given time constant. They will then repeat the procedure above to verify their result and justify the linear dependence between the resistor, capacitance and the time constant. We expect some students will blow up some capacitors, so we should have extras just in case.

**LAB III – Magnetic Field of Solenoids and Coils**

**Objective:** In the first session students will measure the magnetic field of a solenoid as a function of distance and current, and in the second session students will utilize an electric motor setup to measure frequency as a function of magnetic field and current.

**Material**

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| --- |
| Individual Station (15 in total) |
| * 1 Laptop * 1 IOLab * 1 Ramp same as 101 Lab - * 1 Solenoid 1.9 cm radius, 550   turns, 15 cm of length   * 1 Solenoid 3 cm radius, 560 turns and 15 cm of length * 1 Compass * 1 Graphing paper (11 in x 17 in) * 1 Electric Motor Setup * 1 Digital Oscilloscope * 2 pairs Banana-Banana |

**Procedure**

Students will start by using the compass and the IOLab to measure direction and magnitude respectively of the magnetic field to draw the field lines around the solenoid. After, the students will use the ramp to move the IOLab at a fixed axis from the solenoid to obtain the dependence of the magnetic field on position. Finally, during the second session they will measure the frequency of the turning coil in the electric motor setup with the use of a photodiode detector (included in the setup) and an oscilloscope as a function of the distance between the magnet and the coil and the current through it. We expect them to find a linear dependence in this part of the experiment. Although we are giving them clear limits regarding what voltages to use and how the connection should be setup we know previous runs of this labs have had the electric motor setup malfunction.