

## ORIENTATION

Many of the components presented in the mechanics lab (Physics 180L) orientation are still pertinent for the Physics 181L laboratories. You may wish to consult the orientation section for Physics 204 (pg. 8) for a review of the following topics:

- i) Units and dimensions. (particularly dimensional analysis).
- ii) Theory of measurement and experimental uncertainty.
- iii) Graphing and graphical analysis.

As you can see from the contents of the lab manual Physics 205 labs will concentrate for the most part on electrical charge. The study of stationary distributions of electric charge is called **ELECTROSTATICS**. Charge is measured in **Coulombs (C)**. The charge on an electron is  $1.6 \times 10^{-19}$  C.

CAN YOU THINK OF, OR HAVE YOU DISCUSSED EXAMPLES OF  
“EVERY-DAY” EXPERIENCES OF ELECTRIC CHARGE?

CAN YOU DESCRIBE ELECTRIC CHARGE?

Charge moving in an electrical circuit is current. Electric current has dimensions of charge per unit time. Current is measured in Coulombs per second (C/sec) or Amperes (A).

If charge always moves around a circuit in the same direction this is called **DIRECT CURRENT (DC)**.

If the direction of the charge moving around the circuit changes this is called **ALTERNATING CURRENT (AC)**.

Generally electrical circuits will resist the flow of current. To initiate and maintain the flow of charge around a circuit requires a source of **ELECTROMOTIVE FORCE (emf)**. Examples of sources of emf are batteries (i.e. flashlight or watch batteries), and power supply units. **Emf is measured in Volts (V)**. Volts have dimensions of potential energy per unit charge. Volts are identical to Joules per Coulomb.

An understanding of electricity and magnetism is essential to explain even the simplest household appliance. Charge impulses are what stimulate all our voluntary and involuntary movements. Almost all contemporary measurement techniques in science and engineering involve the use of some electronic instrumentation.

In several experiments this semester you will be using instruments such as digital multi-meters, power supplies, signal generators, and computers. The purpose of this orientation is for you to familiarize yourselves with the vocabulary and instrumentation associated with electrostatic and electrical circuit measurements. In particular you should consider their limitations in terms of stability, sensitivity, accuracy, and how the instruments might disturb the circuit or system being analyzed.

The most common instrument is the Digital Multi-Meter, (DMM). Some of you may have used one to test the electrical system of your car, or trouble-shooting an electrical circuit. It is called a multi-meter because it is “multi-functioned”. It can measure amps (current), volts (voltage ac and dc), and ohms (resistance).

**Reading Resistors**

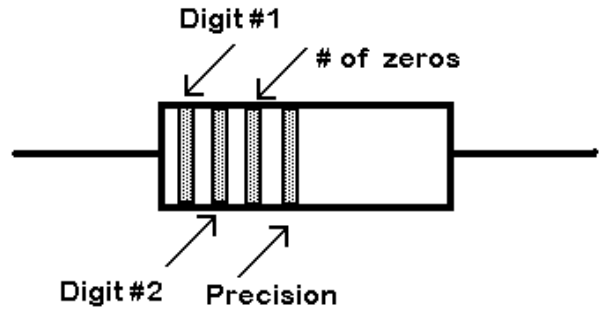
To read, start at the end where the colors start. Then the first two bands give the first two digits while the third gives the number of zeros following these digits. The fourth band gives the precision.

Example: Gray - Green - Red - Silver means 8500 ohms, and approx. 10% precision.

The final parameter, which defines a resistor, is the amount of power it can dissipate. This is determined to a large extent by its physical size.

**Color Code:**

Black	0	Gold	5%
Brown	1	Silver	10%
Red	2	No Band	20%
Orange	3		
Yellow	4		
Green	5		
Blue	6		
Violet	7		
Gray	8		
White	9		



Exercise:

**Give Numerical Values of Resistors and their Precision.**

- 1) Red - Green - Brown - Silver \_\_\_\_\_
- 2) Yellow - Blue - Red - Gold \_\_\_\_\_
- 3) Blue - Orange - Brown \_\_\_\_\_
- 4) Brown - Red - Black - Gold \_\_\_\_\_
- 5) Gray - Violet - Orange - Silver \_\_\_\_\_

**Give Color Code Values of Resistors to nearest values.**

- 6)  $340 \pm 10\%$  □ \_\_\_\_\_
- 7)  $850 \pm 5\%$  □ \_\_\_\_\_
- 8)  $1000 \pm 20\%$  □ \_\_\_\_\_
- 9)  $1200 \pm 5\%$  □ \_\_\_\_\_
- 10)  $2100 \pm 10\%$  Ω \_\_\_\_\_

Given Three (3) different resistors, read the values of the resistors and then verify with the DMM, and then check precision.

Resistor #1 \_\_\_\_\_  
 Resistor #2 \_\_\_\_\_  
 Resistor #3 \_\_\_\_\_

The Digital Multi-meter is a very useful instrument for measurements on DC and AC circuits. However for alternating voltages or currents, which change polarity (sign) and magnitude in a regular periodic (cyclic) pattern an oscilloscope allows a more detailed analysis.

## Introduction to Oscilloscope:

An oscilloscope is a versatile measurement tool that can display “real-time” plots of voltage versus time or voltage versus voltage (**in ‘X-Y’ mode**). The vertical and horizontal axes of an oscilloscope can be rescaled independently while data is being displayed. Unlike a graph that has a beginning and an end, an oscilloscope’s plot of voltage (known as a “trace”) is refreshed or redrawn continuously as long as data is being measured. One other difference is that an oscilloscope displays voltages, not calculated values (e.g., velocity). An oscilloscope can be setup so that a plot of voltage will begin when a specific starting condition (or “triggering” condition) occurs.

The oscilloscope allows the analysis of time-varying voltages over a wide dynamic range (frequency). Your TA will explain the principle of operation. The signal trace is observed on a CRT (**Cathode Ray Tube**) screen. The trace is produced by a beam of electrons swept across the phosphor screen by two sets of electrostatic deflection plates. The trace is swept across the horizontal axis by the “Time Base” plates. This sweep is regular and allows the divisions on the horizontal axis to be proportional to time. The trace is swept in the vertical direction by the voltage input to the oscilloscope. The combination of these two sweeps allows observation and analysis of time varying voltages. Since we are not using a “real oscilloscope”, but adapting the computer to act as an oscilloscope the function is not quite the same. The computer is acting more like a DMM, measuring voltage, but with time resolution, (e.g. 5000 samples per second).

The Wave function Generator produces voltage waveforms that are regular in time. It can be used to analyze a circuit’s response to a well defined input signal. The “response” of the circuit is the output signal, which can be observed on an oscilloscope. Comparison of the input and output signal as a function of the input frequency and amplitude, for example, can be an important diagnostic feature of a circuits’ performance.

## Frequency and Period measurements:

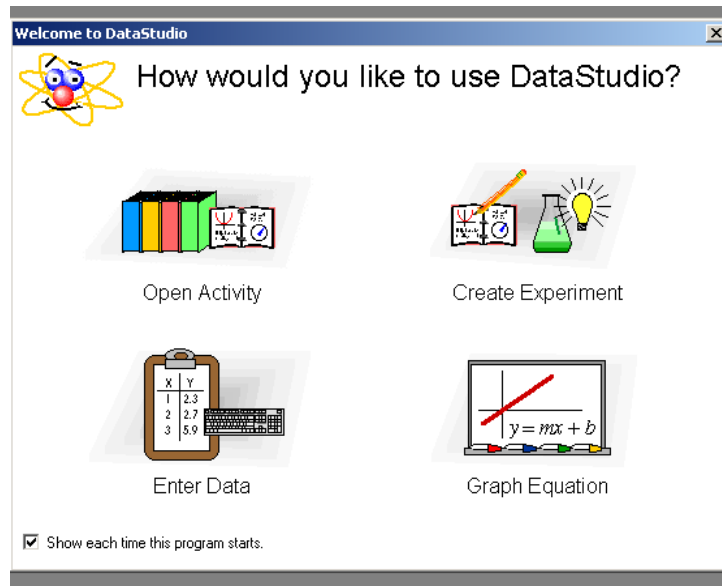
The frequency of the wave output is the number of complete waves per second; units are in (**cycles/second or Hz**). The **PERIOD** of the wave is the time taken for one complete cycle of a wave, (i.e., from one wave crest to an adjacent wave crest).

The **frequency (f)** is equal to the inverse of the period (**T**),  $f = 1 / T$ .

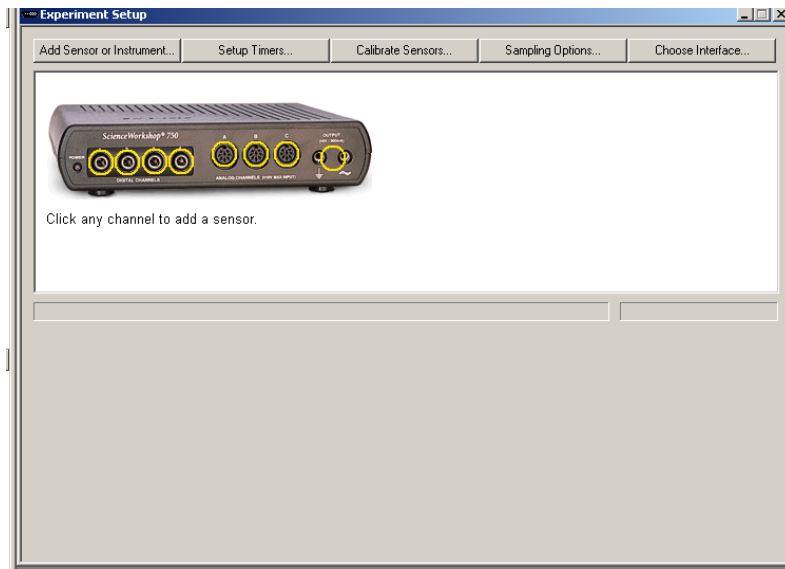
## Oscilloscope Procedure:

**Note:** If the Science Workshop Signal Interface was not turned on, the computer will ask you to try again or continue w/o interface. If this happens check to make sure the interface is turned on and all connections (Cables) are correct.

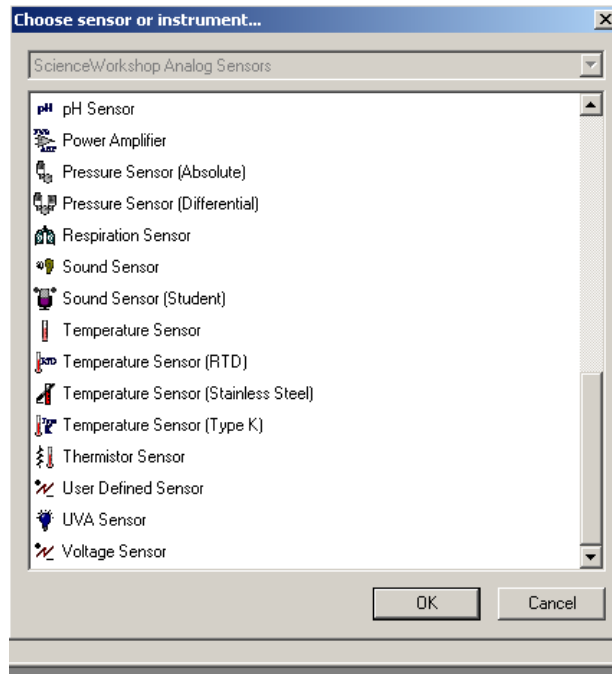
- 1) Turn on the computer, monitor, Science workshop interface and Pasco CI-6522 Power Amplifier II
- 2) Connect the voltage sensor (6500) to the signal interface II Analog channel **A**. Then connect the Red lead to the Red terminal (Signal Output +) on the power amplifier II. Now connect the black lead to the black terminal ( Signal output -) on the power amplifier II.
- 3) Connect the gray lead from the back of the amplifier II to the Signal Interface II Analog Channel **B**.
- 4) Now click the Data Studio icon on the desktop. A window will pop up in the data studio software like the below one.



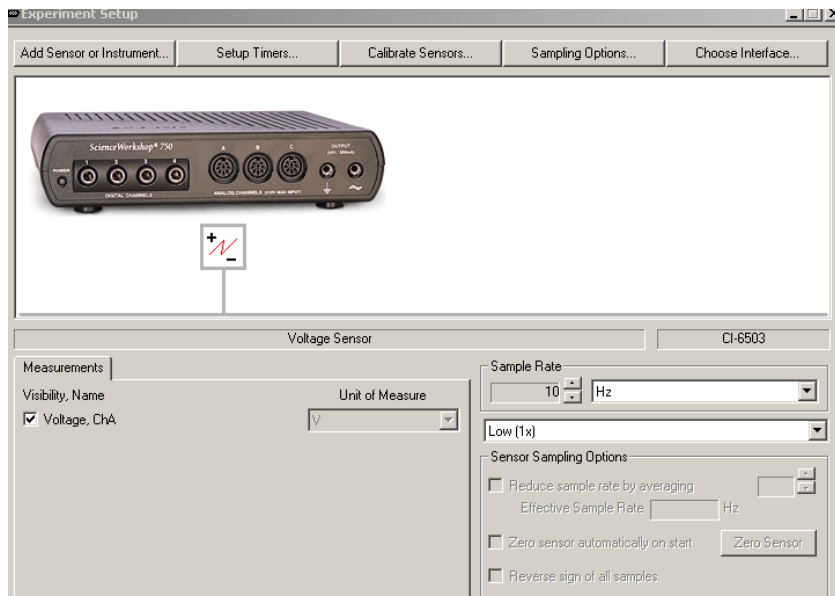
5) Click on the create experiment icon. A window like the one below will open.



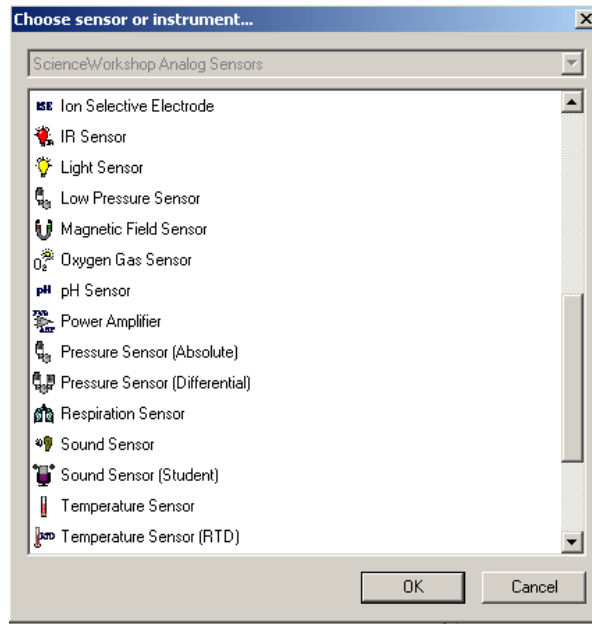
6) Click on the yellow circle with Alphabet A over it. The following window will pop up.



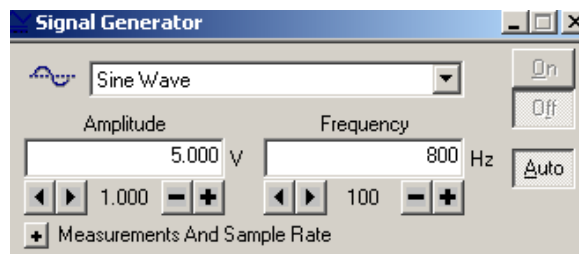
- 7) Scroll the window until you reach the bottom of the window. Then click on the Voltage sensor and click OK. The following window will open up.



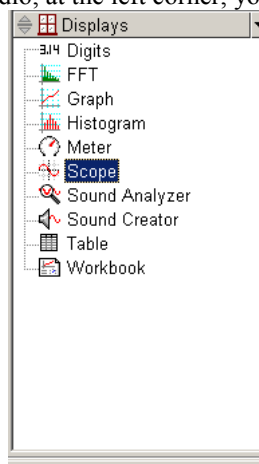
- 8) Then click on the circular connector below the alphabet **B**. The following window will open up.



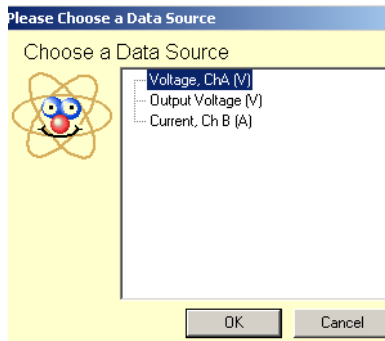
- 9) Scroll the window until you reach the Power Amplifier icon and click on it. Then click OK. The following window will open up.



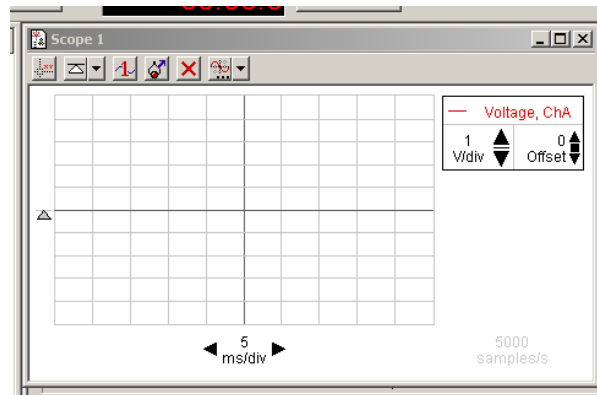
- 10) On the top field select the Sine Wave. In the amplitude field put 5 V. Then put 800 Hz in the frequency field. Make sure that auto icon is clicked on.
- 11) On the main window of the data studio, at the left corner, you'll see the following window.



- 12) Double click on the Scope icon. The following window will pop up.

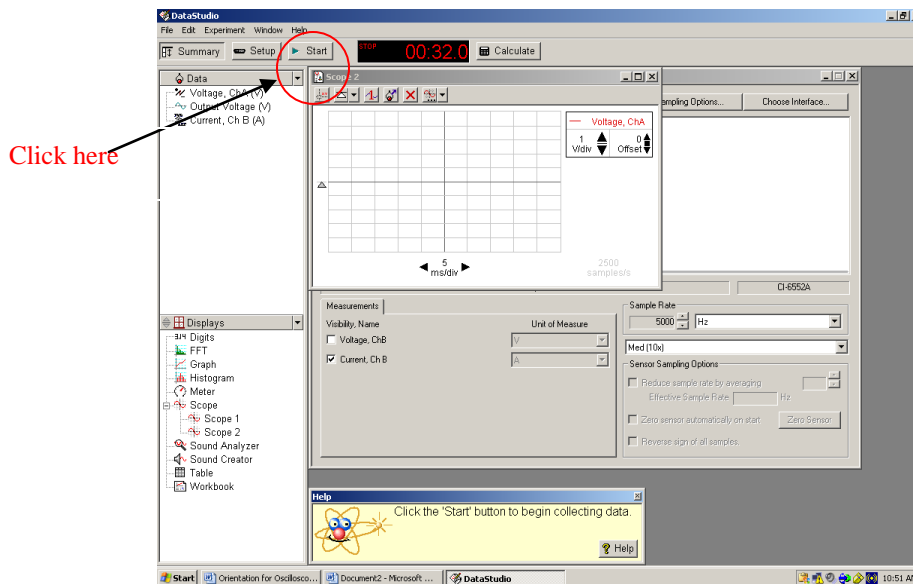


13) Select Voltage, Output Voltage [V] and click OK. The following window will open up.

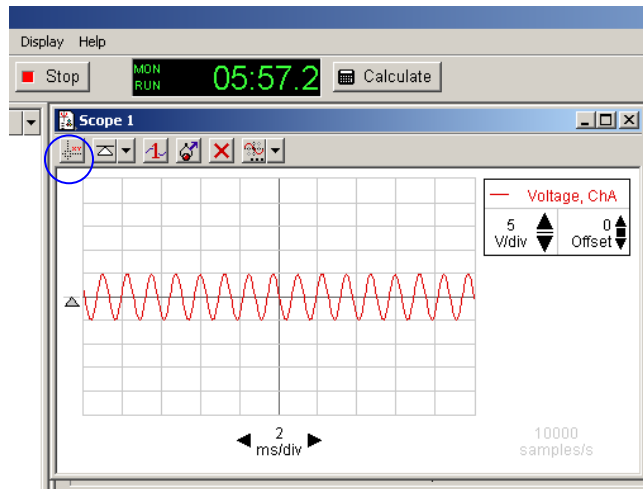


14) On the scope window set your voltage per division button to (A the only active-cell) **5.000v/div.**, (this is the small wave form button next to v/div.), and you time per division to **2.00 ms/div.**, (located at the bottom of the scope window, next to the trig button). The samples/sec should be 5000.

15) Then click the start button on the top of the main window as shown below.



- 16) The sine wave will show up on the scope as shown below. The graph you'll be seeing is the Voltage vs Time graph, with voltage on the vertical axes and time on the horizontal axes. You can change the settings for voltage and time on the scope by clicking on the arrows adjacent to the V/div and ms/div.



- 17) Then click the stop button on the main window. For taking measurements, press XY button on the Scope window, as shown above.
- 18) The following measurement tool will appear on the scope. You can use this to measure voltage and time. You need to place the marker on the point you want to take the measurement.
- 19) Now click on the voltage per division's button and change to **2v/div.**, (top button), and observe the change in the trace.

**Question #1: What happened to the trace and why?**

- 20) Use the x-y axis button (located below the trig button on the scope window) to give a time display and a cross axis. Set the horizontal axis at some fixed wave point then move the vertical axis from a point on one wave to an adjacent point on the next wave point. Take the difference of these two times and find the frequency. Make at least two measurements.

$$f = 1/T$$

- 21) Notice how the voltage reading changes as you move the horizontal axis up and down. Click the x-y axis button again to turn it off or just click the left mouse button.
- 22) Change time/div. scale from **2.00 ms/div. to 1.00 ms/div.** (Right bottom) then to **0.50 ms/div.** Observe the change in the trace. Calculate the frequency. **Did it change?**
- 23) Click on stop **Experiment.**
- 24) Go to the Signal Generator window and change the Amplitude/Voltage to about **2.00 volts** and the frequency to **1200.00 Hz.**

- 25) Go back to the Scope window and set voltage per divisions to **1.000v/div.** and time scale to **0.20 ms/div.** Make at least two measurements using the x-y axis button (as in described in step 20) at This setting of 1200Hz. Calculate the frequency.

**Oscilloscope table**

<b>Sample (no.)</b>	<b>Initial time <math>T_1</math></b>	<b>Final Time <math>T_2</math></b>	<b><math>T = T_2 - T_1</math></b>	<b>Frequency (f) = <math>1/T</math></b>