

## ORIENTATION

Many of the components presented in the mechanics lab (Physics 151L) orientation are still pertinent for the Physics 152L laboratories. You may wish to consult the orientation section Physics 151L (pg. 8) for a review of the following topics:

These include the discussion of:

- 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 152L 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 and 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

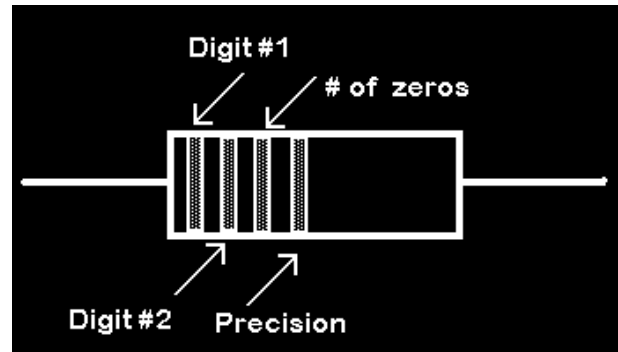
To read, start at the end where the colors start. Then the first two bands give the first two digits while the third gives the number of zeros following these digits. The fourth band gives the precision.

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

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). The principle of operation will be explained by your TA. The signal trace is observed on 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 wave forms 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 circuit's 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:**

- 1) Turn on computer, Monitor, Pasco CI-6560 Signal Interface II, and Pasco CI-6552 Power Amplifier II.
- 2) Wait for computer to boot-up to the C-prompt (C:\>).
- 3) Type in "**win**" and then press the enter key.
- 4) Wait for windows to load.
- 5) The Science Workshop window should now be open. If the Science Workshop icon is blue press the enter key or double click on the icon with the left mouse button..

**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.

- 6) Connect 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.
- 7) Connect the gray lead from the back of the Power Amplifier II to the Signal Interface II Analog channel **B**.

- 8) Click and drag the Analog Plug on the Science Workshop Screen to Analog channel **A**. ( The arrow should change to a hand as you drag the plug to channel **A**). Then drop it on top of channel **A** icon.
- 9) The computer should show a screen that asks you to choose an analog sensor. Click on voltage sensor (should turn **Blue**), then click on **OK**.
- 10) Click and drag the Analog Plug again on the Science Workshop Screen to **Analog Channel B**. Again the arrow should change to a hand as you drag the plug to channel **B** and drop it.
- 11) The computer again shows you a screen that asks you to choose an Analog Sensor. Click on the **Power Amplifier**, (should turn Blue), then click on **OK**.
- 12) Now a Signal generator window should be open.
- 13) Click on the Title Bar and drag the window down to the lower left corner of the screen. (If you don't know how to do this ask your instructor for help).
- 14) On the Signal Generator Window you will see a DC-button, AC-Wave form buttons, on/off/auto buttons, Amplitude arrows, and Frequency arrows.
- 15) Set the AC-Wave form button to sine wave, first button.
- 16) set the on/off/auto buttons to **auto**. (Click on auto button)
- 17) Set the Amplitude/Voltage arrows to **5.00 volts**. (Click on down arrow)
- 18) Set the Frequency to **800 Hz**. (Click on down arrow)
- 19) Select window **UNTITLED.SWS** and click any where in the window, once, to make active.
- 20) Click and drag the scope icon to analog channel **A**, and drop it.
- 21) A window titled **Scope** should now appear.
- 22) 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 your time per division to **2.00 ms/div.**,( located at the bottom of the scope window, next to the trig button). The samp/sec should be 5000.
- 23) On the title bar click on **Experiment**. This gives a drop down menu. Now click on **Monitor (ALT + M)**. Now you should see a trace across the scope screen, at +/- **5.00 volts**.
- 24) Now click on the voltage per divisions button and change to **2v/div.**, (top button), and observe the change in the trace.

#### **What happened to the trace and why?**

- 25) 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.

$$f = 1/T$$

- 26) 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.
- 27) 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?**
- 28) Stop, (**ALT + .**). Click on **Experiment**, then on **stop**.
- 29) Go to the Signal Generator window and change the Amplitude/Voltage to about **2.00 volts** and the frequency to **1200.00 Hz**.
- 30) Go back to the Scope window and set voltage per divisions to **1.000v/div.** and time scale to **0.20 ms/div.**

**Calculate the frequency, using the x-y axis button again.**

### Triggering

When the trigger control (**TRIG**) is On (default setting), the voltage traces will not begin until the triggering condition is matched. For example, you may want voltage traces to begin when the value of the voltage reaches a minimum amount, but not before. The default trigger condition allows all traces to begin when the input for the first trace rises to 0.0 volts. This tends to stabilize the appearance of the signal. Double click on the Scope display area (or press **ALT + E** on the keyboard) to open the scope setup dialog box. You can change the title of the scope display and/or alter the trigger condition. Click on the menu to change the trigger condition from “rises” to “falls” (or vice versa). Enter the level of voltage at which you want the trace to begin, then click OK. For example, if you want the traces to begin when the voltage of the first input increases to 1.00 v, enter 1.00 in the “volts” box and leave the choice in the menu on “rises”. Click on the smart cursor button and move the cursor into the scope display area. While the cursor is in the screen area, the horizontal position of the cursor will be displayed in the sweep speed settings area. The coordinate of the horizontal position will be given in milliseconds. The vertical position of the cursor will be displayed in the sensitivity area in volts. Notice that if each trace has a different sensitivity setting, the coordinates of the vertical position will be scaled up or down accordingly.

- 31) “To Close Science Workshop.” Click on **File** on the menu-bar and then click on **Quit. (Alt + Q)**
- 32) Exit Windows, (**ALT + F4**), or click on File and then on Exit.
- 33) Click on OK, or press the Enter Key.

### **Short Cut Keys:**

<b>Record</b>	<b>ALT + R</b>
<b>Monitor</b>	<b>ALT + M</b>
<b>Pause</b>	<b>ALT + ,</b>
<b>Stop</b>	<b>ALT + .</b>
<b>Quit</b>	<b>ALT + Q</b>