INTODUCTORY LAB EXERCISES

The following exercises will serve to acquaint you with the basic tools to be used in the lab. It is suggested that you work through these and take notes as you go along, to help you prepare for future experiments. Answer all of the questions, and ask for help as needed!

1. **Resistors, DMM and Resistance Measurement**

    Figure out the color code labels for a 1 kΩ resistor with 5% tolerance (see expt. 1) and write them down. Then locate one in the supply box and verify that the code is as you expected. Record the color code value as $R \pm \delta R$ (Ω), and set the resistor aside.

    Locate a DMM and its instruction manual[1]. Also pick up 2 pairs of leads with banana plugs from the rack at the back of the lab and a pair of alligator clips from the supply cupboard.

    Measure and record the resistance of your resistor. The uncertainty in measurements with DMM's can be determined from the DMM manual, but for the purposes of this course, simply use 5 times the least significant (stable) digit, and in no case less than 0.2% for resistance, or 0.05% for voltage.

    Record your measured value of $R \pm \delta R$ (Ω) and compare it to the color code value. Do they agree within error?

    When measuring resistance with a DMM, why should you always isolate the resistor from a circuit?

2. **DMM Voltage and Current Measurements**

    Look up the internal resistance of your DMM when it is set to measure DC volts, and write this down. Figure out how to measure this using a pair of DMM's, and record the result. Do they agree?

    What is the resistance of the DMM when it is set to measure current? Look this up in the manual and compare it with your own measurement. Note that the result is scale dependent!

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[1] The instruction manual is online; note for future reference the page numbers of the manual where you find relevant information for the exercises below.

3. **Breadboard**
Locate a breadboard and set it up at your work
bench. This is a versatile device for circuit
construction and testing, and we will use one for all
of the experiments in this course. Study the layout
and convince yourself how the connections work,
then draw a sketch or annotate the photo
accordingly.
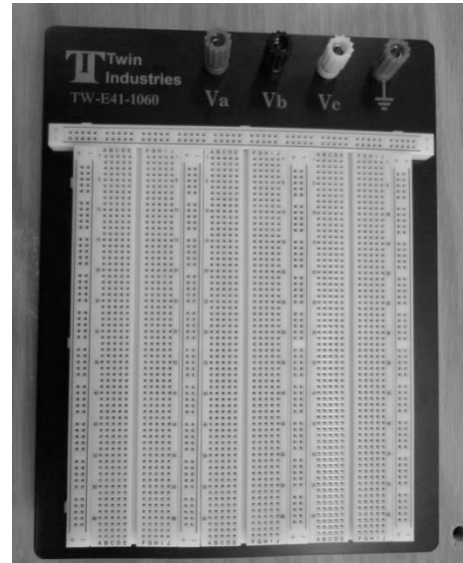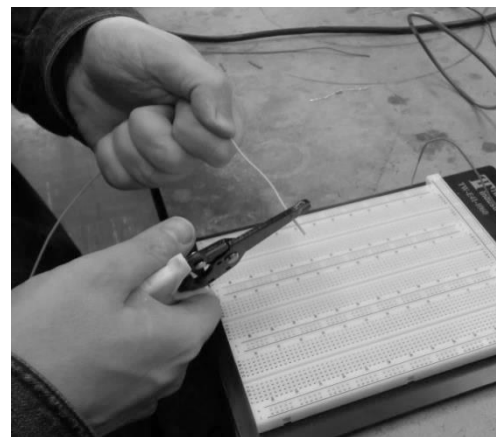
4. **DC Power Supply**
A DC power supply is like an adjustable battery.
Select one, and a power cord, and set it up at your
work bench. Notice that the supply has both a
voltage selector and a current limit selector. (Why
the latter? Think about the circuit breakers in your
house !)

When you start using a DC supply, before connecting it in a circuit, always turn it on and
turn both the voltage and current knobs to zero, using the digital scales for verification.
This ensures that when you do install it and turn it on, you won't unintentionally burn
out any circuit elements with a low power rating.

Sketch a diagram for a simple circuit that will allow you to apply 2 V across your resistor
using the breadboard, and to measure this voltage with a DMM. Include a second DMM
to measure the current. How much current do you expect in your circuit?

To connect the circuit, you will need to prepare
some short strips of wire using a stripping tool,
as shown in the photo.

Build the circuit, turn it on, adjust the power
supply voltage to 2 V and the current limit to an
appropriate value, and use the DMM's to
measure V and I in the circuit. Check that the
current is what you expect. A layout showing just
the DC supply and the leads for the voltage
measurement is shown in the lower photo.

**5.** **Function Generator and BNC connectors**
A function generator is a device that can output a time varying waveform with
adjustable amplitude and frequency. These will be used in our AC experiments. Locate
one, a power cord, and a coaxial cable with banana plug leads in order to connect it to
your breadboard instead of the DC power supply.

The coaxial connector on the front of the function generator applies the time varying signal between the center pin and ground, which is established at the outer conductor.

This type of connector is called a BNC connector. The cable consists of a central wire and an outer shield made of wire braid, separated by an insulating layer. Why is this a good design for ac signal transmission?

(Hint: think about the electric field inside the cable, and apply Gauss' Law!)
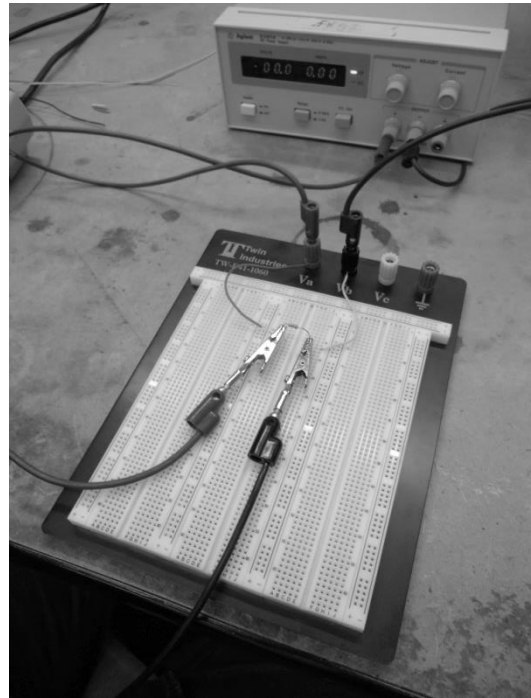
6.   **Oscilloscope**

An oscilloscope can display up to two time-varying voltage inputs, relative to ground, as a function of time. Collect a digital 'scope, another power cable, and a scope probe from the cable rack. Also locate an instruction manual and have a look through it.

Note that the outer casing of the coaxial connector on the scope input panel is connected to ground, and this corresponds to the small alligator clip on the end of the probe cable.

Note that ground cannot be established in two places simultaneously in your circuit if it is to behave as expected !

Look carefully, and you will see that the probe casing incorporates a "x1 / x10" attenuator switch. This will affect the amplitude reading on the oscilloscope screen. Always check that the setting is "x1" so that you can read the oscilloscope scale directly!

Turn on the function generator and set it to apply a sinusoidal signal at about 1 kHz across your resistor. Connect the scope probe across the resistor to the channel 1 scope input to display the voltage waveform on the screen. If you can't see anything, push the "autoset" button on the scope panel. Also check that you have the grounds correctly hooked up.

Once you have achieved a display on channel 1 of the scope, you can use the vertical scale to help you set the amplitude of the function generator to 1 V.

Play around with the scope controls until you are comfortable with how they work. Note that the main controls of interest are as follows:

Channel 1 (or 2):
- coupling (AC, DC or ground – try all these and compare)
- vertical offset
- vertical gain

Time base: horizontal gain (time per division)

Trigger: this function defines a common time reference for the two input channels – a very important feature if you want to determine the relative timing of two signals.   Play with the trigger controls until you are comfortable with how they work.   Try them all !

The Trigger Menu button allows you to select which signal is used as a reference. For this exploration, you want to set the source to channel 1. The time reference is then set by the trigger level (adjustable knob – this sets the voltage level) and choice of slope (rising or falling). Compare the "normal" and "auto" trigger settings – what is the difference between them? Explore how to find the trigger time and trigger level indicators on the screen.

Now think about the sinusoidal function V(t) that is output from the function generator a bit more carefully. What defines t = 0 for practical purposes ?

What trigger conditions (slope, level) should be set if $V(t) = V_o \cos\omega t$ in order to produce a display relative to the trigger time that appears as: a) $V_o \sin\omega t$ b) $-V_o \sin\omega t$ c) $V_o \cos\omega t$ d) $-V_o \cos\omega t$?
(To help sort this out, it is useful to sketch a graph of $V_o \cos\omega t$ for reference.)

Try capturing a scope trace with the computer; save the file, and print it. Note the exact procedure used so that you can do it again with ease!

7.   **Plotting Data**

Figure out how to plot a set of data points using the Origin software, and add a theory curve. A sample data set and theory equation is given in problem 2.6.4 of the lab manual. See the reference notes at the back of the lab manual for how to do this. Save your data file, and print a copy.