LABORATORY 1

PHYSICS 117, Fall 2017

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The lab write-ups are based on the laboratory manual by Hayes and Horowitz, but have been modernized and adjusted by the professor. If you find mistakes or unclear items, let the Prof. know so he can update these sheets.

Reading: S&M 2.1 to 2.19 (You know most of this, so esp. 2.19), 2.32

Beginning exercises:

a) Set your DC voltage to a nominal 5V. Use both the lab-bench voltmeter and a DVM, and compare to the power supply display. Compare the precisions. (Note: while the displayed voltages on these power supplies are pretty good, don't count on that in general.) Now use the oscilloscope to measure the voltage. (You can use either "force trigger" or use "auto" trigger. This is one of the very rare times when it makes sense to use auto trigger.)

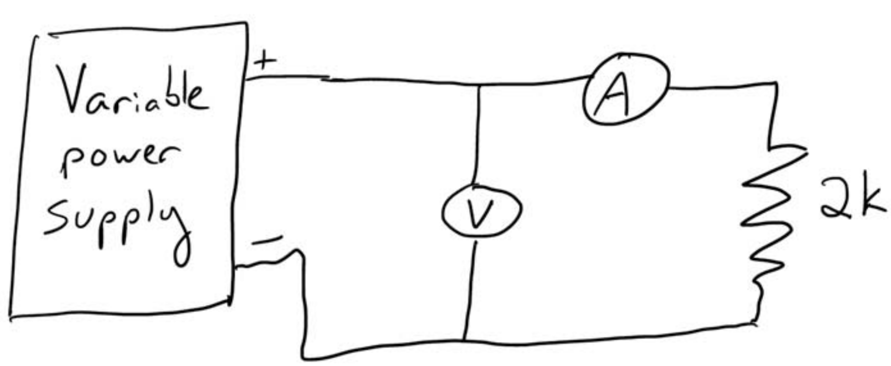
Never use the "Autoset" button on the scope. It is a bad habit that will come back to bite you. It could cost you hours of trouble at some point.

b) Explain to your TA, ATA or Prof why: (1) You cannot hook up the ammeter directly to the voltage source. (2) Explain why when the meter is set to Ohms, you cannot hook it up to anything that is powered. DO NOT CONTINUE UNTIL THEY SAY OKAY.

c) Get a breadboard from the back of the lab. Use your lab meter on Ohms mode to figure out the connectivity of your breadboard. Sketch the pieces of basic elements of the breadboard showing the connectivity of the "busbars" and other sections.

Ohm's Law

d) The figure below and the few that follow before part (k) will be about the only times we will draw a complete circuit in the course. As you encounter them, redraw using grounds following the convention of this course (and engineering).



Build the circuit above using your breadboard, not in the air. Amateurs suspend items such as resistors in the air using alligator clips. Instead bring in the power through the banana jacks and then bring the power to the breadboard using wires.

When using the figure above, use your lab-bench meter as the ammeter and the oscilloscope as the voltmeter. (Note that sometimes you will see the meters labeled as “VOM” instead of “DVM” or “DMM”. That is an antiquated term for “Volt-Ohm Meter”.) Verify Ohm’s law by measuring a few points.

In general, get used to making your circuit as follows:

1. match the figures geometrically so it is easier to debug when they get more complicated. (This will not always be possible.) In general circuit diagrams will flow from inputs to outputs by going left-to-right top-to-bottom like reading a page.
2. Put your grounds and powers on a busbar so they are easy to connect to.
3. Use sensible color coding. Typically red is for one voltage being supplied and black is for the grounds. If you use other voltages, you can use other colors.

Now measure Ohm’s law by measuring a few voltages and currents.

<u>Effects of instruments on your readings</u>

e) Use the DVM and procedures similar to the previous part to measure how non-ideal your lab-bench multi-meter is on the ammeter setting. Estimate its internal resistance on the ammeter setting. (Hint: you shouldn’t just measure its resistance with an ohmmeter. Why not? (In this case it turns out you can, and it pretty much works, so do that as a check.))

<u>More Exercises</u>

f) Use your ohm-meter to measure the resistance of a 10 MΩ (or larger) resistor. Do it once in your breadboard and again using your fingers to hold the meter probes against the leads. Why is there a difference? Can you use your fingers to measure a 10kΩ resistor?

g) We have mostly 1/4 W resistors on the shelf. (That means you cannot use them to safely dissipate more than 1/4 W). Using the 5V setting but not exceeding the 1 Amp output of the power supply, what resistor value should you choose to dissipate several watts in a resistor that is only rated for 1/4 W and what happens? Try it. (Throw away the resistor when you are done.) We have some 2A power supplies in the lab if you want to get all dramatic about it.

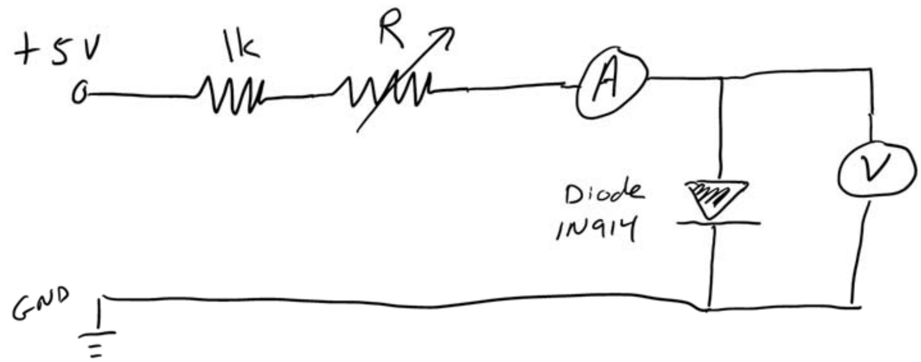
<u>Testing Ohm’s law on Lamp</u>

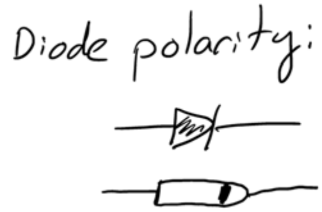
h) Now perform the Ohm’s Law test on one of the small lamps we have. Do not go far beyond the listed maximum ratings. You should take enough points to show the violation of Ohm’s Law. Does it go the direction you would anticipate? (We have hot air guns you can use to see what they do to the circuit.) How would you report the “resistance” of the lamp?

(If you break a lamp in a base, throw away the bulb but not its base.)

Testing Ohm's law with diode

i) Another circuit element that does not obey Ohm's Law is the "diode". (We will explain how a diode works later this quarter, for now it is just an example of something that does not obey Ohm's "Law".) Follow the circuit below or similar:





Measure the diode's I vs. V (called an "I-V curve" with voltages ranging from at least 350mV to 750mV. You may need to adjust the voltage on your power supply as well. You can ask Excel plot both lin-lin and log-lin for this section.

You can vary R more easily if you use a "variable resistor" also known as a "potentiometer" (why?), which you can find in the lab drawers. Use the ohmmeter between 2 of the 3 leads to learn how it works. If you pick one up and want to know its maximum value to put back in a drawer, how would you determine that without having to turn the knob?

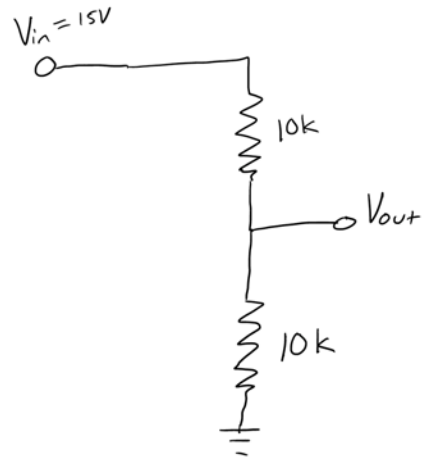
Typically diodes are used with a current rage from 10-100mA in our course. Is there a convenient "rule of thumb" you can say about voltage drops across diodes then?

j) When you are done, you can put the full 5V across the diode just to see what happens. DO NOT PUT BROKEN COMPONENTS BACK IN WITH THE GOOD DIODES. WE HAVE A TRAY FOR "BROKEN DIODES" FOR A FUTURE LAB. You can use the Fluke meter's diode setting (checking both polarities) to see if the diode still works. Look up the diode's "data sheet" and explain how what you did is consistent with the specs.

Note: in this lab room we also have "Zener Diodes". These look similar and are almost impossible to separate if you mix them in with the other diodes. "Just Say No!" to mixing up different types of diodes.

Voltage Divider and Thevenin Mode

k) Build the circuit below, now using our standard convention:



Apply V_{in}=15V. Measure the open-circuit output voltage (V_{OC}). Then attach a 10k "load" resistor between the output and ground and see what happens.

Remove the load and measure the short-circuit current (I_{SS}) from V_{out} to ground. (Why is it safe to "short circuit" V_{out} to ground in this case?) Using your measured I_{SS} and V_{OC}, draw the Thevenin equivalent circuit.

Now build the Thevenin equivalent circuit you drew. Verify that V_{OC} and I_{SS} stay the same. Now attach the 10k load resistor to your Thevenin equivalent circuit and see if the voltage droop at the point marked V_{out} stays the same as in the first circuit.

Function generator

l) Connect your function generator to the speaker and drive it with a sine wave you can hear. Use the "sweep" feature to make the Star Trek (TOS, of course) "Red Alert". Manuals (with an index) are on the shelf.

1-5 (Oscilloscope)

m) Get familiar with the scope and function generator. You gen generate various frequency sine waves (eg 1000 Hz or 1kHz, or old-school 1 kilocycles/sec) and other shapes which you should be able to see on the scope. There are a lot of knobs and such, but don't worry you will get used to them.

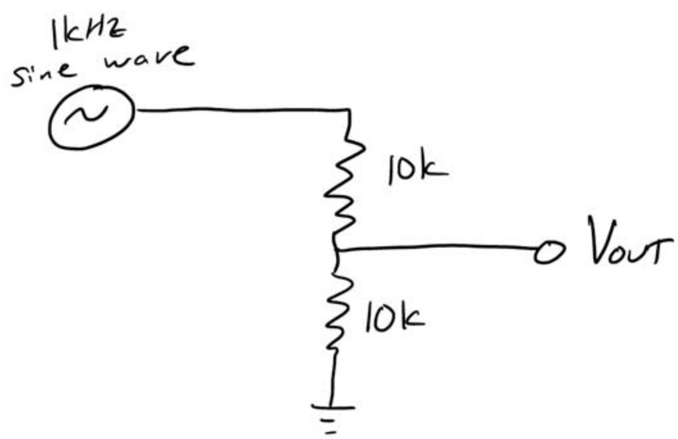
(For a very stupid reason your TA, ATA, or professor will explain, the display on the function generator for V-PP ("Voltage peak-to-peak") is off by a factor of two. They can show you how to fix it.)

Try the following with your function generator and scope:

---See what the volts/div knob does. Make sure you can read off the peak-to-peak voltage by eye from your scope without having to use any fancy scope features.

--Now use a fancy scope feature under the "measure" menu to measure the peak-to-peak voltage
--Similarly adjust the time/div knob. You should be able to read off the period by eye and calculate a frequency in your head reasonably well.
---Repeat using the "measure" feature to measure the frequency
---Use "normal" trigger and get a feeling for what the "level" adjustment does does. Change the slope of your trigger and see what happens and explain why. You should always try to use Normal trigger. Why did you have to use Auto trigger in part a of this lab?
---With the function generator on square waves look at a rising edge and use the "measure" tools to measure the risetime. You might think the risetime looks instantaneous. It is not. Adjust the scope so you can see that fact. Repeat for falltime. How are risetime and falltime precisely defined? Is that the same as the "time constants" you learned in Physics 1B and 1C?
--Use another channel to look at the SYNC output of your function generator while it is making a sine wave. Which is a better signal to trigger the scope with and why?
--Put an offset into your sine wave so that it moves up and down on the scope. If you change the scope to AC coupling that blocks the DC component. Try it and show that it works. What happens if you try to look at a slow signal 50 Hz square wave but are on AC coupling instead of DC coupling?

<u>AC voltage divider</u>
n) Take the voltage divider you built earlier and apply a 1kHz sine wave instead.



Does the analysis of its output voltage change now that you have a voltage that changes in time? (If you have a long answer, you either know too much or too little.) What happens to V_{out} as you change the frequency of the sine wave?