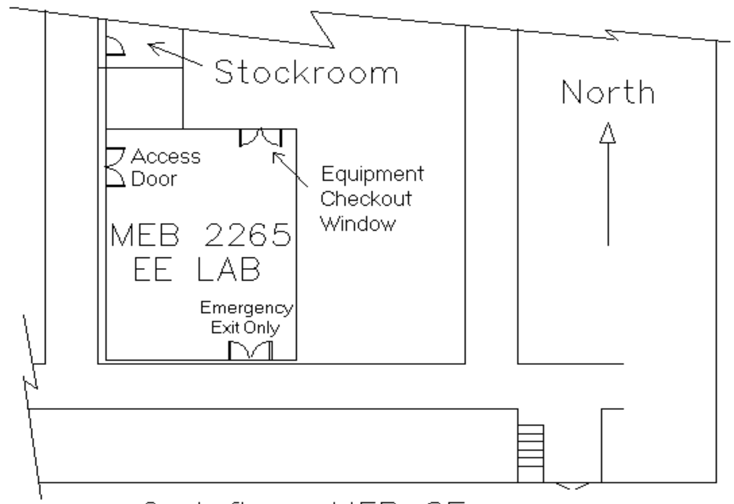
University of Utah
Electrical & Computer Engineering Department
ECE 2210/2200 Lab 1

Introduction

A. Stolp, 1/8/00
Rev. A.S., 1/7/14

Objectives

1 Teach the student to keep an engineering notebook.
2 Talk about lab practices, check-off, and grading.
3 Introduce the lab bench equipment.
4 Teach wiring techniques.
5 Show how voltmeters, ammeters, and ohmmeters are used.
6 Teach good data reporting and graphing.



2nd floor MEB SE corner

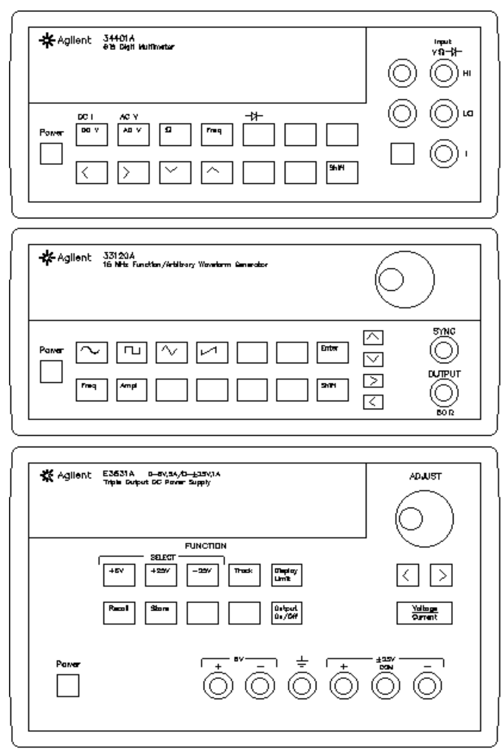
Parts to be supplied by the student:

- Lab notebook for this and all future labs
- 100 Ω, 270 Ω, 560 Ω, two 1 kΩ, two 2.0 kΩ, and 2.2 kΩ resistors
- breadboard and wires

The electrical parts may be bought from stockroom. You can buy parts using your "U-Card" but not with cash.

Check out from stockroom:

- Servo
- DMM (Digital Multi-meter)



General

Choose a workbench space with an Agilent or HP 34401A multimeter and an Agilent or HP E3631A DC power supply, perhaps grouped in a cluster like the one shown at right. (You may use different equipment but then you'll have to modify the specific instructions found in this lab and may need another multi-meter.)

Lab Notebook

As engineers many of you will be paid to do research, development, and invention. The companies that employ you may be interested in obtaining patents on these developments. In patents, timing is important—you've got to be first, and you've got be able to prove it. A well-kept engineering notebook can be used in court as part of your proof. The number-one purpose of a true engineering notebook is to keep an accurate, chronological record of your work, and ***you*** may need to keep one someday for your high-paying job. Many non-R&D jobs also require a similar notebook for record keeping or billing purposes. In this class you'll need to keep one to get a grade. We're going to pretend that it's job training. If your future boss asks you to keep an engineering notebook and all you can do is ask, "huh, what's that?" Both you and the "U" will look bad.

Keeping a true engineering lab notebook, acceptable in court, is fairly involved. You need to write everything in ink, all pages must be numbered, dated, and signed by others, etc. etc.. By these standards we'll be quite lax in this class. But we will pay particular attention to the following things:

- Work in your lab notebook at lab time—no scribble sheets for data so that you can "write it down neatly later." Before you leave the lab you will need to get your instructor to (check-off) initial your book. Some or all of your notebook may be graded at this time.
- Write clearly and make sure your work stands on its own, without reference to the handout.
- Follow the guidelines on the "Lab Notebook" handout for procedures, data, and conclusions.
- Use lots of drawings, tables, and graphs, and label them well. Often these are both easier to create and better than written text.

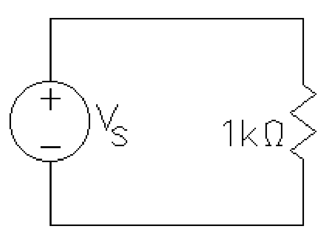
My main objectives are that you to work in your notebook, and that you make that work useful for later reference.

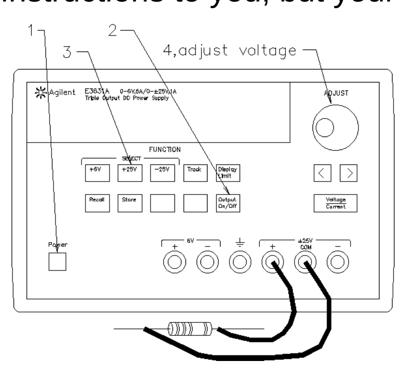
Check-off:
When you are finished with your lab, you should call your lab TA over to check you off. At this time, you should be able to demonstrate a working circuit, answer questions about what you did, and show your finished notebook. You'll get part or all of your lab grade right on the spot. Check-off becomes a problem if you ever miss your normal lab time, so try not to. If you have to miss a lab, make arrangements with your TA to make it up. Most TAs will accept the check-off from another TA or from me.

Experiment

TA Demonstration

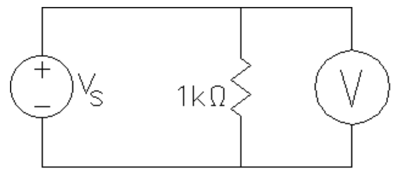
Your lab instructor will do this part of today's lab as demonstration and write example notebook entries on the whiteboard. If you follow along with your TA and write the same things in your notebook that your TA writes on the board, you won't have to re-do this part later. The following paragraphs are written as though they are instructions to you, but your TA will show you how to do them.

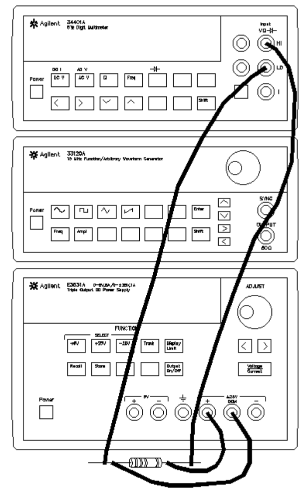




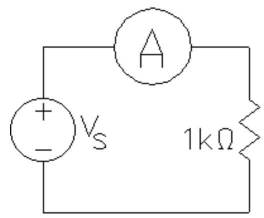
Construct the circuit shown at right. For V_s, use the +25V and COM outputs of an Agilent or HP E3631A DC power supply. Turn it on, wait for it to show "OUTPUT OFF", hit the "Output On/Off" button and the "+25V" button. Use the knob to turn up the voltage to a few volts. The voltmeter in the power supply will show the output voltage but the notice that the ammeter isn't sensitive enough to accurately show the current. Comment in your lab notebook.

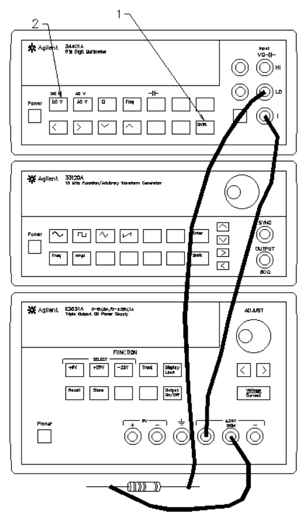
First, let's check Kirchoff's voltage law. We'll add a voltmeter to the circuit (shown as a circle with a V) and see if the voltage across the resistor is the same as the voltage at the power supply. Hook up a voltmeter and turn it on. Adjust the power supply to several different voltages. Is the voltage across the resistor the same as the power supply voltage? From now on you may rely on the internal voltmeter within the power supply.





Next, let's use the multimeter as an ammeter and make a new circuit. The ammeter is shown as a circle with an A. Notice that it is wired in the circuit so that the current must flow *through* it. Before rewiring your circuit, turn off the output of the power supply (hit the "Output On/Off" button). An ideal ammeter is a very low resistance and it is very easy to "short" the power supply while rewiring. Once you have the new circuit, hit "Shift" and "DC I" on the multimeter and turn the power supply output back on. Can you now read the voltage on the power supply and the current on the multimeter?

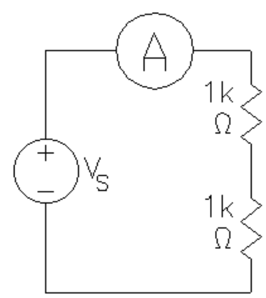




Whenever you make a circuit, make a drawing of your circuit in your lab notebook and indicate that you built it. On the first such drawing indicate what instruments you used by brand name and model.

Take a set of current and voltage measurements as you vary the power supply output between 0 V and 10 V. Make a table for your data and include space for several more columns of data that you'll take later. Make a current (I, mA) v.s. voltage (V, volts) graph for this 1 kΩ resistor. Be sure to label everything well and draw your graph accurately and to scale. Make it clear what circuit these measurements refer to. Comment on the shape of your graph and what that implies about the linearity of resistors.

Replace the 1 kΩ resistor with two 1 kΩ resistors in series. Use the breadboard (see figure on next page) to make this wiring job easier. Take another set of measurements and make another line on your graph. Comment in your lab notebook about and about effects of adding two in series. Find the slopes of all the lines on the graph and relate the slopes to the resistance values.



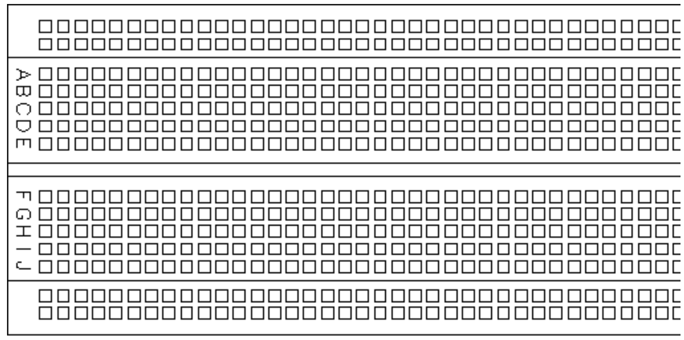
This ends the demonstration part of this lab. You should now have some idea how to use the lab equipment, how to wire circuits, and how to keep a lab notebook. For the remainder of this lab, you may work with ONE partner or on your own. No groups of more than two people.

Student Lab

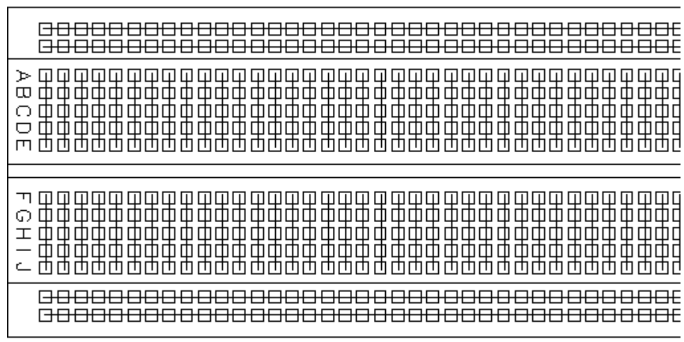
If you haven't already done so, begin your lab notebook entries with the title, date, and objective(s).

Experiment 1, Basic wiring and measurements

Construct the same circuit that your TA made with the single 1kΩ resistor. Use a multimeter as an ammeter. You may use the breadboard if you like, the breadboard wiring is shown at right. A 1 kΩ resistor has the following color band pattern: brn, blk, red, gold, blank (the bands should be scrunched towards the left, if not, turn the resistor over).

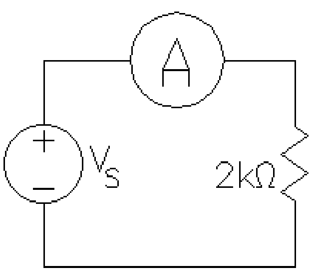


Breadboard



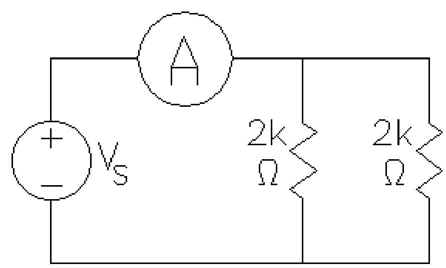
Breadboard with internal connections shown

Turn on the power supply and turn up the voltage. If you watched the TA demonstration and recorded the data taken then, you may simply check that your circuit is doing about the same thing and go on to the next paragraph. If you didn't watch the TA or record his/her data, go back to that section, make the circuit drawing, answer the questions, take the data, make the graph, and comment as described there for both the single and the series pair of resistors.



Replace the 1 kΩ resistor (R) with a 2 kΩ resistor. Take another column of data in your table and add another line on your graph.

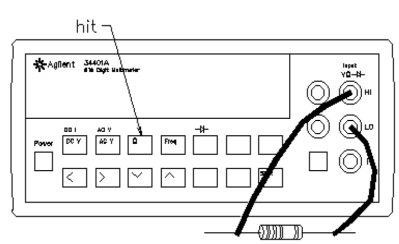
Repeat for the circuit at right, the parallel combination of two 2 kΩ resistors.



Comment on the shape of your graph lines. What does this imply about resistors? For each of your straight lines, calculate the ratio of voltage over current (V/I). This would be the inverse of the slope (1/slope = run/rise). Comment on the numbers that you get. How do they compare to the resistor values or equivalent resistor values of series and parallel combinations of resistors?

Experiment 2, Voltage v.s. resistance at a constant current

Make a table in your notebook like the one shown on the next page.



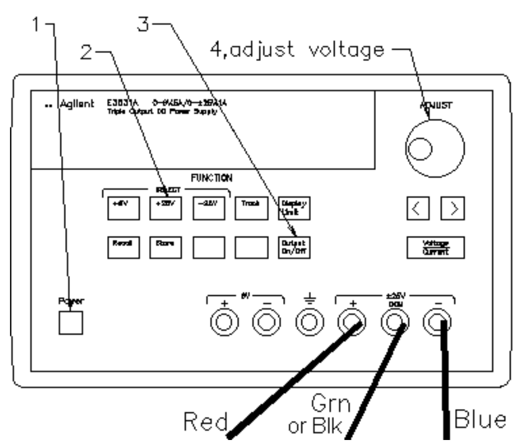
Find the six resistors shown in the table in the parts you bought. Switch the multi-meter to the "Ω" range and use it to measure the value of each resistor (simple touch the meter leads to the resistor leads). Preferably, don't touch the leads yourself while measuring or your body resistance will effect the reading (not really an issue at these resistor values).

Select one of the resistors from the table and make a circuit like the ones you've been making. Using both the knob and the arrow keys, adjust the power supply output until the ammeter reads 4 mA. Enter the measured voltage in your table. Repeat for all six resistors. (**Hint**: It's much easier to hook all the resistors in series, adjust the current to 4 mA only one time, and then measure the voltage across each resistor with the second DMM.)

Color code	Nominal Value (Ω)	Measured Value (Ω)	Volts needed to make 4 mA flow
brn, blk, brn, gold	100		
red, vio, brn, gold	270		
grn, blu, brn, gold	560		
brn, blk, red, gold	1000 (1k)		
red, blk, red, gold	2000 (2k)		
red, red, red, gold	2200 (2.2k)		

Graph your results, resistance on the x-axis and "volts to get 4 mA" on the y-axis. Comment or the shape of your graph and on what that implies about the relationship between voltage and resistance at a given current.

Experiment 3, Simple Servo Device
The servo is the device that you checked out which is built on a little wooden board. Examine it now and find the power switch and the power wires that are connected to that switch.



Power supply hookup
Turn on the Agilent power supply and activate the output by hitting the **Output On/Off** Button. Push the "+25V" button and then push and hold the **Track** button for a few seconds so that the - output will automatically "track" (be the same voltage value as) the + output. Adjust the + output to 6 V. Now the power supply will output ± 6 V. If you hit the **Store** button twice, you can store this setup as configuration #1. Next time you use this bench you can recall the ± 6 V configuration by simply hitting the **Recall** button twice (If no one else changed it in the meantime). Turn off the power switch on the servo. Now hook up the servo as shown. (Turn the outputs off again while connecting.) Watch out, the HP/Agilent's **+** connection and it's **–** connection are *both* red, **–** is on the right side of ground and **+** is on the left. Turn on the outputs of the power supply and turn on the servo.

Try to remember how to adjust power supply to ± 6V and how to hook up the servo. You will do this again and again in the labs to come. If you don't think that you will remember, keep a copy of this lab handout for the detailed instructions presented here. You may even want to tape these instructions into your lab notebook.

Play around with the input position shaft and watch the motor turn the output shaft to follow. (If the servo oscillates, turn down the gain.) In your lab notebook, write a short description of what the servo does. This is a very crude, slow, and weak servo, but it does illustrate how they work. Imagine what this, or a more powerful, servo could do if the output shaft was hooked to other mechanical devices, maybe a cutting device, or digging tool, or steering device, or... Write down at least 3 uses for servos. Do you think that you might work with servos in subsequent classes and later as an engineer? Mechanical engineering students should definitely answer "yes" here. Chemical Engineers, Material Scientists, and Environmental Engineers (a branch of Civil) are more likely to see process and temperature control systems, but they turn out to be quite similar. The servo is just a control system that controls a mechanical motion. For you Mining and Civil Engineers (Other than Environmental) that don't plan to go to grad school are less likely to deal directly with control systems. Although, I might point out that the Citicorp building has a large servo controlled mass at the top of the building that reduces its sway on windy days.

In the first two experiments of this lab you learned a little about resistors. At first thought a resistor may seem like a pretty worthless part, but resistors are used a lot in electronic circuits. About how many resistors are used in the servo circuit? Determine the value of at least one of the resistors from it's color code (try the most common value).

You will see this servo again many times in the lab. I will try use it to show you how the things you learn in class and in lab relate to something mechanical–something useful.

Conclude
Call your lab instructor over to check you off. Usually you do this before you tear down your final circuit. Be prepared to discuss your measurements, calculations, and conclusions and to show off your notebook.

Write a conclusion in your notebook. Make sure that you touch on each of the subjects in your objectives. Mention any problems that you encountered in this lab and how you overcame them.

This sort of check-off and conclusion will be required at the end of each lab, even if it's not specifically asked for in the lab handout. Before leaving, make sure everything is turned off and return everything that you checked out.