18-100: Intro to Electrical and Computer Engineering

LAB00: Getting Started

Writeup Due: Friday, January 21st, 2020 at 5 PM

Name: Eunice Lee

Andrew ID: eunicel

How to submit labs:

Download from this file from *Canvas* and edit it with whatever PDF editor you're most comfortable with. Some recommendations from other students and courses that use Gradescope include:

pdfescape.com	A web-based PDF editor that works on most, if not all, devices.
Preview	Pre-installed default MacOS PDF Editor.
iAnnotate	A cross-platform editor for mobile devices (iOS/Android).

If you have difficulties inserting your image into the PDF, simply append them as an extra page to the END of your lab packet and mark the given box. ***Do NOT insert between pages.***

If you'd prefer not to edit a PDF, you can print the document, write your answers in neatly and scan it as a PDF. *(Note: We do not recommend this as unreadable lab reports will not be graded!)*. Once you've completed the lab, upload and submit it to *Gradescope*.

Note that while you may work with other students on completing the lab, this writeup is to be completed alone. Do not exchange or copy measurements, plots, code, calculations, or answer in the lab writeup.

Your lab grade will consist of two components:

1. Answers to all lab questions in your lab handout. The questions consist of measurements taken during the lab activities, calculations on those measurements and questions on the lab material.
2. A demonstration of your working lab circuits and conceptual understanding of the material. These demos are scheduled on an individual basis with your group TA.

Question:	1	2	3	Total
Points:	4	4	12	20
Score:				

Introduction

Welcome to 18-100 labs! These assignments are meant to be the hands-on component to material covered in lecture. The labs are also a great opportunity to get familiar with some of the equipment you will use in future lab course and through your entire career as an electrical and/or computer engineer!

Each lab will come with a handout (a.k.a. what you're reading right now!) that contains the exercises that you are to complete each week. You will be asked to generate data from each experiment and draw conclusions from it. **Make sure to thoroughly read the handout before attempting the lab!**

Following the completion of the lab, you will submit a writeup to `Gradescope` (instructions are on the cover of every lab) and then complete a demonstration to a TA. These demonstrations consist of explaining your completed circuit and then answering a few high-level conceptual questions on the lab material. These questions are *not* meant to trick you and, if you completed the lab, you should not have to "study" for them. The circuits you will be asked to demo will be clearly marked in the lab packet with a message that looks similar to this:

> ⚠ **Do NOT take your circuit apart yet! You will need it for lab checkoff!**

These labs, writeups, and demonstrations are meant to be completed on your own. We want you to collaborate and discuss the labs with other students however, come time to submit/demo, **all work must be your own! Students found building other students' circuits, copying data, or plagiarizing answers to writeup questions will be found in violation of the course's policy on academic integrity (see the Syllabus for more information).**

With that said, we wish you the best on your future laboratory endeavors in 18-100! If you get stuck on any of the parts of the lab or don't feel you can finish the lab before the due date, reach out to your group TA; they're here to help!

1. Continuity Tester

Troubleshooting is one of the most important skills that you will develop over the course of 18-100 labs. You will want to develop a systematic approach to use your tools to find errors in your circuits and fix them. In most cases, the TAs will guide you and not touch your circuit board. If your circuit doesn't work the first question TAs will ask you is "what have you tried to do to fix the problem?" They are not being cold; on the contrary, your TAs want to empower you to solve your own problems and build self-confidence.

Your first step on this journey is understanding the most important tool in your toolbox: **the digital multimeter (DMM)**. The purpose of this exercise is for you to understand some of the common troubleshooting tasks you can do with your DMM. The first tool is one you will use to diagnose open circuits: the **continuity tester**, which is marked by a sound wave symbol on your meter (Figure 1).

Figure 1: Selecting the continuity tester on the digital multimeter

Plug the test leads into your multimeter. The black lead goes into COM and the red lead goes into the port on the right (V · Ω · mA). When there is **electrical continuity** between the leads (i.e. a conductive path between them), the meter will beep.

Hold the two leads together. You'll hear a beep if your tester is working. We encourage you to test the continuity of several things in your room or lab kit. Good conductors will beep, everything else won't.

Your kit comes with 6x 25' spools of 22AWG wire to build your circuits. The wire is designed to easily make electrical connections on a breadboard, but you can't just use it right off the spool. You'll have to strip the insulation off of each end of the wire to reveal the copper conductor inside. You can use your kit's yellow-handled **wire-strippers** (Figure 2) to do this.

Figure 2: Using the wire strippers

Use them to cut off a short piece of wire, then strip some insulation from each end of the wire. Then use your continuity tester to verify that the wire is indeed a conductor. If you can't hear the beep, make sure you stripped off enough insulation and are making good contact between the DMM probes and the copper.

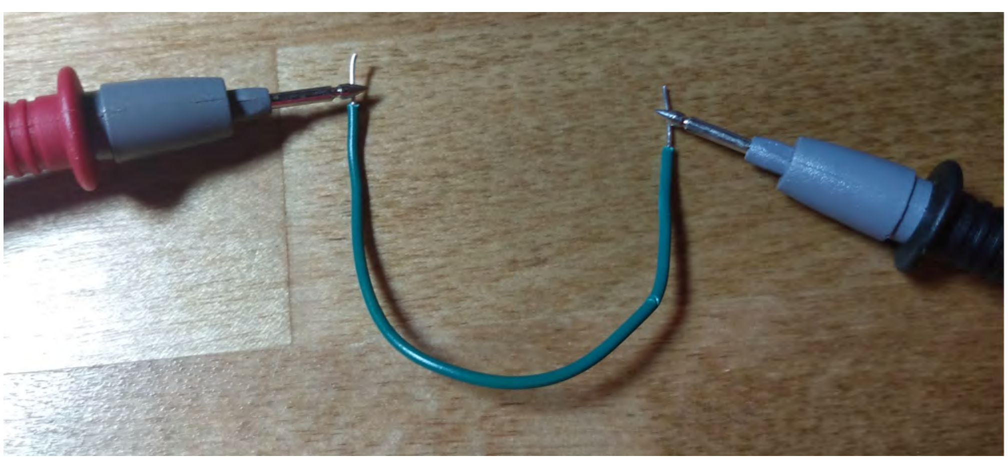

Figure 3: Testing the continuity of the wire with a digital multimeter.

The **breadboards** that come with your kit will be the base for all the circuits you build in 18-100. It allows you to quickly make electrical connections between components. The holes in the breadboard are electrically connected in groups of five. No connections cross the center groove. There are **power buses**, marked by a strip of red or blue, where all holes are connected. These are convenient for voltage supply connections, which usually need multiple connections throughout the circuit.

Don't take our word for it - use your continuity tester and your own breadboard to determine which of these points on the breadboard pictured in Figure 4 are electrically connected, and fill in the table next to it. Please note that there are two blue wires connecting some of the rows together.

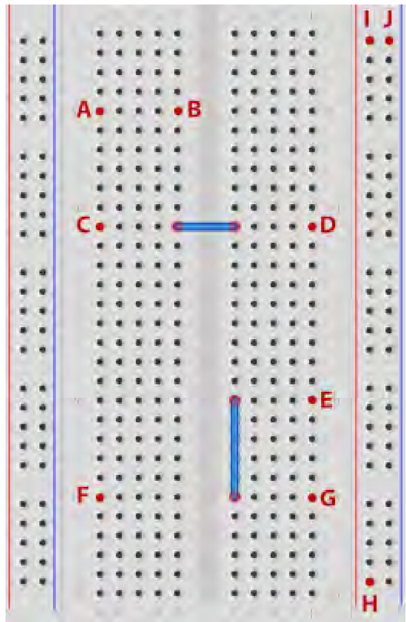

Figure 4: Determine the continuity between certain points.

4 pts

1.1 Which of the following pairs of points are connected? Which are not connected? Mark accordingly using the checkboxes.

Pair	**Connected**	**Not Connected**
A,B	☒	☐
A,C	☐	☒
C,D	☒	☐
E,F	☐	☒
F,G	☐	☒
E,G	☒	☐
H,I	☒	☐
I,J	☐	☒

2. Ohmmeter

Now that you've learned how a breadboard works, let's move on to another useful tool: the **ohmmeter**. This measures the electrical resistance present between the two probes. Simply use the dial on your multimeter to one of the 5 settings with an Ω symbol.

How do you know which setting to select? The different resistances give ranges for the the *maximum* resistance that the meter can measure. If the resistance that you're measuring goes over the maximum setting, you simply need to adjust your range to a higher setting. Smaller ranges give your measurements more precision. It's best practice to round up to a resistance a bit higher than what you expect. You can then lower the range to get a more precise measurement if possible.

Let's practice on some resistors.

Standard resistors use a color-coding system to denote their resistance. The first three bands mark the value, and the last golden band means a manufacturing tolerance of 5%. Sometimes, it can be hard to tell some colors apart, so it can be useful to verify the resistance with your Ohmmeter.

Pick out a 1kΩ resistor ( ), a 10kΩ resistor ( ) and a 100 kΩ Resistor ( ). Measure each one with your Ohmmeter and fill out the following table.

3 pts

2.1 Write down the actual resistance of each of the following resistors that you measured, using the highest precision you can for each resistor. Also give the range setting you used on the meter (e.g. 200Ω, 2kΩ, and so on).

Resistor	**Measured Value (Ω)**	**Range Setting (Ω)**
1kΩ	.983	2k
10kΩ	10.04	20k
100kΩ	98.1	200k

1 pts

2.2 Now switch to your continuity tester and measure the continuity of one of the resistors. Why doesn't it beep?

Since the continuity tester measures a strong conductive path, the tester does not beep when measuring the continuity of one of the resistors. Since resistors go against the flow of current, it is not a strong conductive path. Therefore, the tester does not beep.

3. Voltmeter

We've saved the best for last: the **voltmeter**. It measures the **potential** or **voltage** present between the two probes.

Because voltage is a relative measurement across two points, one of the probes (COM, black lead) is interpreted as the reference, so the reading is the difference between the red probe (V) and the black probe (COM). As with the ohmmeter, there are several range settings marking the maximum voltage. In 18-100, your voltage measurements will usually be direct current (V⎓) as opposed to alternating current (V∼).

You have several 9-volt batteries in your lab kit. A fresh battery's voltage should be close to 9V. As it is used up, the battery voltage will drop as low as 6V before it is no longer usable. Test the voltage of a battery by selecting the voltmeter and connecting one probe to each of the battery's terminals. Connect the red probe to the positive terminal of the battery and the black probe to the negative terminal as demonstrated in Figure 5.

Figure 5: Measuring battery voltage

2 pts **3.1** What voltage did you measure?

V = 9.71 V

2 pts **3.2** Switch the red and black probes. What happens to the voltage you measure and why?

The voltage is the same value as measured in 3.1 but negative, so -9.71 V. This is because voltage is a relative measurement. The difference in potential is 9.71 but the sign changes based on where the black lead, or the reference, is. When the black lead is on the negative side of the battery, the voltage is positive because there is an increase in voltage. But when the black lead is on the positive side of the battery, the voltage is negative because there is a decrease in voltage (relative to the reference).

8 pts **3.3 Check-off:** Be prepared to demonstrate some of these tasks to your TAs at your first small group meeting!