Soldering Laboratory Manual

Objective

This lab is intended to teach students the basics of soldering. Soldering is used to connect electronic components together or to a printed circuit board (PCB). Students will learn how to solder wires and through-hole components as well as test circuits for continuity and functionality.

Background

Soldering

Soldering is a technique used to form semi-permanent electrical connections between components by melting solder into the joint. The main principle of soldering is that the iron will heat up the components (wire, component or pad on a protoboard/PCB) and since they are hot the solder will flow between them and make a good connection. You want to avoid 'wiping' the solder on the components with the iron. Solder is a tin-(lead or copper-silver) alloy with a low melting temperature and good conductivity, it can be used with wires or PCB soldering but not welding where the work pieces are melted and the joint is structural. Soldering is one of many ways to make electrical connections.

Safety

Soldering irons are hot and can be very dangerous. Do not touch the pointed end when it's plugged in. Always use the stand when the iron is on to avoid melting things that you don't mean to. Fumes that are generated by melting the solder mainly consist of the flux that is in the solder and is hazardous. Always work in a well-ventilated area or use a fume extractor and wash your hands afterwards.

Maintenance

It is important to know how to take care of your iron because it can get damaged pretty easily. First, your iron should be hot but at the lowest temperature possible while still able to melt the solder, the recommended temperature for lead-free solder is around 315°C or 600°F. If it is too hot it will burn the tip and make it harder to solder later. Second, the iron should only be on when necessary, so do not leave it on while it is not in use. If you are working on something and use the iron intermittently, tin the tip of the iron (add a bit of solder) while it is in the stand to keep it from oxidizing. Third, keep the tip clean by wiping it on brass wool or a damp sponge, make sure to do this before putting it away. Finally, never use force while soldering, let the heat do its job.

The number one thing to remember when soldering is patience. The biggest mistake that is commonly seen is not waiting for the iron to heat up fully and then setting the temperature way too high. Some soldering irons can take up to 5 minutes to fully warm up. If the iron is not working after 5 minutes, use the tip tinner to help revive the tip.

Design for Manufacturing Considerations

Before doing any soldering make sure that the wires you are using are appropriate for the situation. If you require a lot of current use larger diameter wire. While unlikely, the tiny wires for Arduino can burst into flames at high current loads. Also consider different types of protoboard (or other components) which will best suit your application.

Once you have your iron ready at the right temperature, triple check your connections before doing the actual soldering. While it is possible to unsolder things, it is quite challenging and requires a lot of practice.

Make sure your systems are in their container before soldering. For example, if you need to seat a sensor in a certain place with a small opening, feed the wires through the opening before soldering otherwise, you'll have to design around the wires.

Don't solder parts if you don't have to. It is very useful to use headers or other connectors to be able to disconnect a component or replace it if it breaks.

Apparatus and Equipment Overview

The following equipment and materials will be used:

- 1 x 10cm of hook-up wire
- 1 x Soldering iron
- Lead-free solder
- 1 x Breadboard
- 1 x 2.2 kΩ through-hole resistor
- 1 x 47 kΩ through-hole resistor
- 1 x 0 Ω surface mount jumper
- 1 x 1x4 male header
- 1 x 5mm LED
- 1 x 2N3904 transistor
- 1 x Photoresistor
- 1 x Night light printed circuit board (PCB)
- 1 x Arduino Uno and USB cable
- 2 x Male-female dupont cable
- 1 x Wire cutters
- 1 x soldering mat
- 1 x Multimeter
- 1 x Fume extractor
- 1 x Helping hands
- 1 x Wire strippers
- 1 x Tweezers Optional:

- 1 x Solder wick ● 1 x De-soldering tool

Pre-Lab Preparation

Before arriving in the lab, students should review the lab manual and familiarize themselves with the lab setup and procedures. Also please watch the following videos to review the basics of soldering.

- How to solder. https://www.youtube.com/watch?v=Qps9woUGkvI
- How to de-solder connections: https://www.youtube.com/watch?v=Z38WsZFmq8E

Review Questions

Why is it important to have a well-ventilated area when soldering?

To avoid Fume exposure from the Burning Metal as well as to Dissipitate heat from the system. Doing so will provide more Fire Safety and lead to an overall better experience.

Why is it important to use lead-free Solder (i.e. what happens when you use lead)?

Lead Poising is a major risk to not only our health but the environmental surroundings as well.

How can you tell which is the negative terminal when looking at a diode or LED?

The shape inside the LED bulb where the negative end is usually far bigger, and also has a shorter leg compared to the positive end

Why is it important to build a circuit on a breadboard before soldering everything onto a protoboard?

In order to Ensure that your prototype works as intended and poses no problems to the main prototype

What is the difference between through hole components (THT) and surface mount components (SMD)?

THT components are larger and easier to handle but are less suited for compact designs, while SMD components are smaller and ideal for high-density applications but may require more specialized handling during assembly and repair. Each type has its own advantages and is chosen based on the specific requirements of the application.

Part A – Soldering basics

1. **Grab** a piece of wire of about 10 cm and cut it in half, **strip** 1 cm off each end and **twist** them around each other so it is in line with the wire.

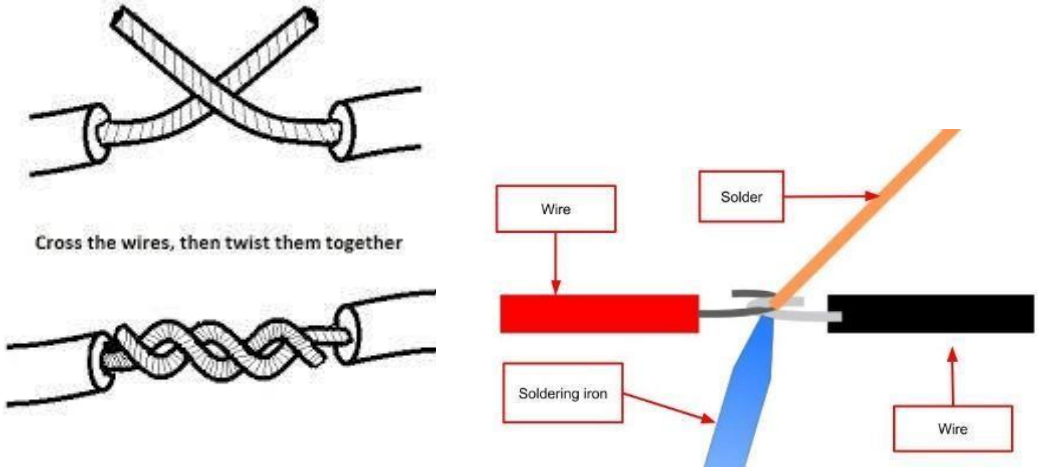


Figure 1 : Soldering 2 wires together

2. Make sure the wires are **secure** so that they can't move around as you solder (you should not need to use your hands to hold the wires steady).
3. **Hold** them with the helping hands.
4. **Clean** the tip of the iron on a damp sponge or paper towel and then use it **to heat** the two wires for 1-2 seconds and then **flow** solder on the connection. Once you see the solder flow evenly throughout the connection, **remove** the solder and soldering iron and do not disturb the joint as the solder cools.
    a. The solder finish should be shiny and you should be able to see the wire covered but still outlined in the shiny solder covering (not a big ball of solder). A "cold solder joint" occurs when the electrical contacts never get hot enough to allow the solder to melt properly, which results in a poor, or even intermittent, electrical connection. Conversely, over-heating a joint can cause component damage (melted insulation on the wires).

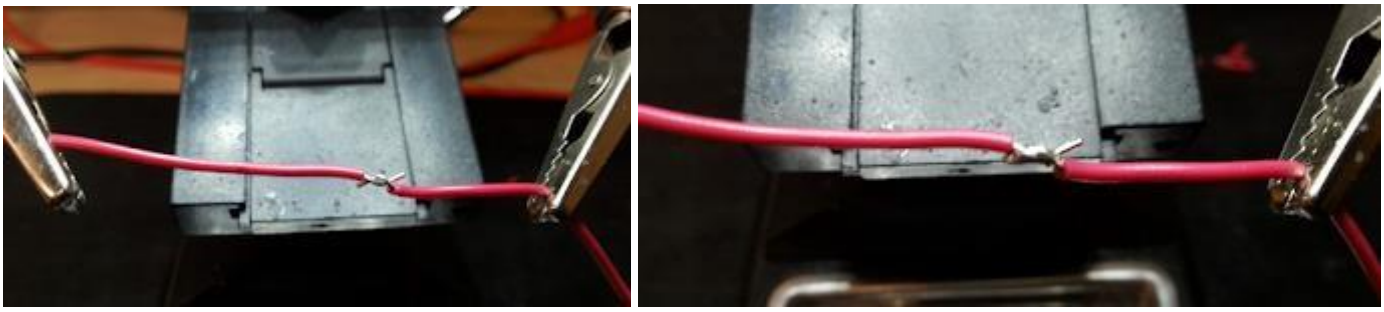


Figure 2 : Wires soldered together

5. **Strip** 1 cm off the other end of the wires and **bend** them to fit in wires in the PCB in JP1 and JP2 holes. **Solder** them in place. **Snip** the excess wire. **Use** the following picture as a

guide for what the solder joint should look like. Note that solder is not brought to the electrical joint using the iron but is added separately.

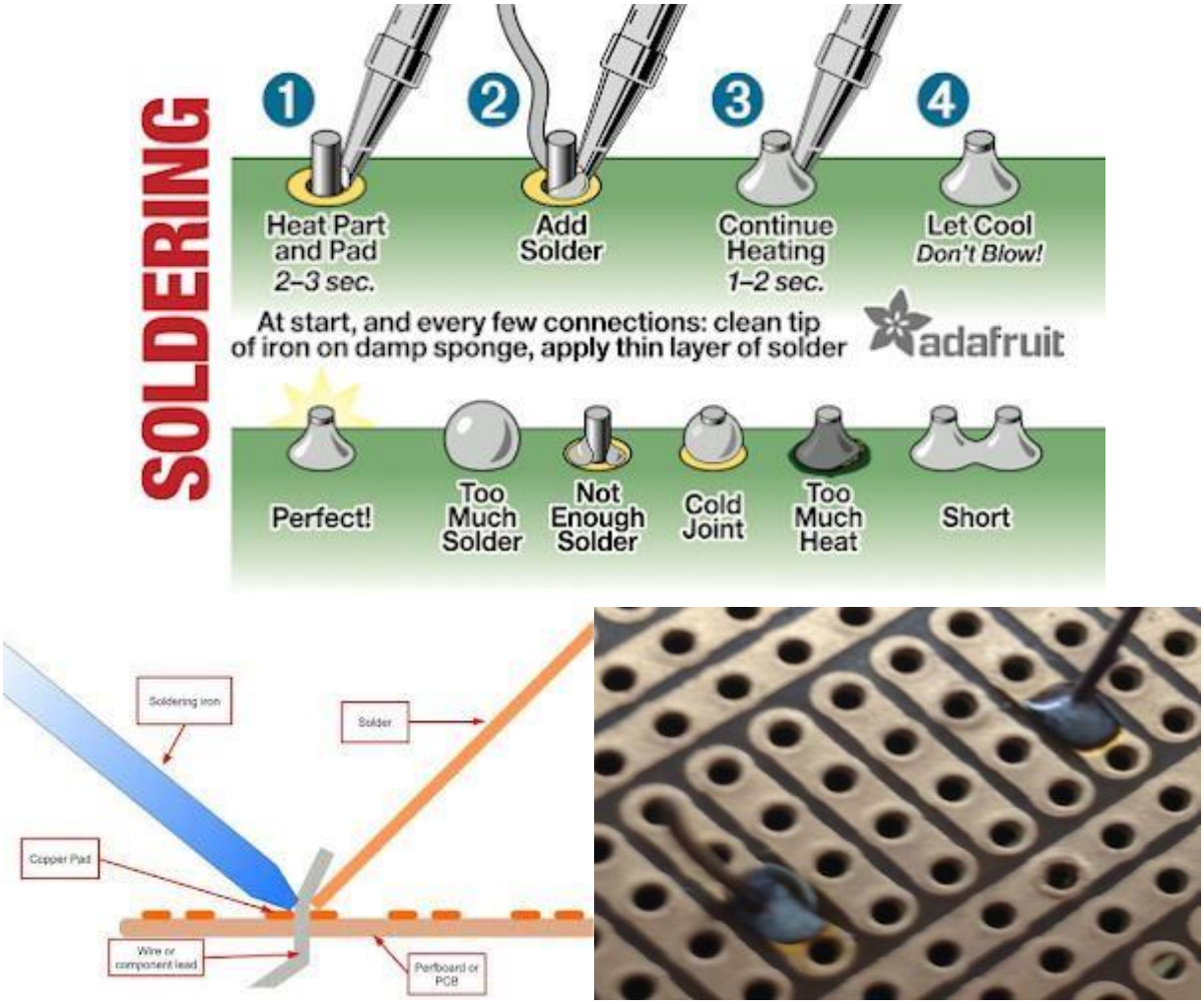


Figure 3 : Soldering a through hole component

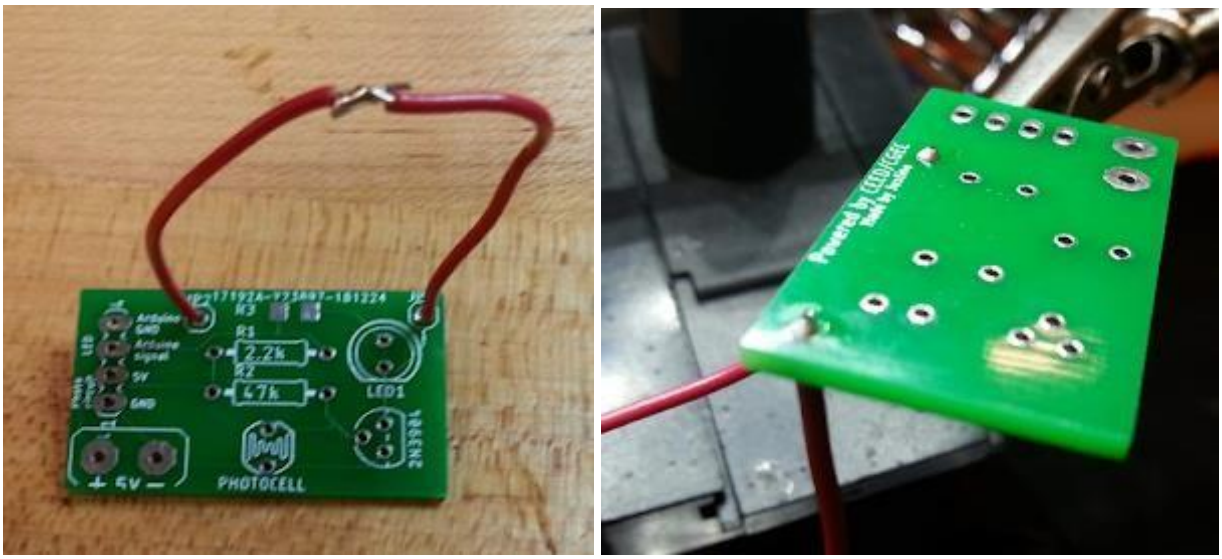


Figure 4 : Wires soldered in the PCB

Part B – Night light circuit

Continue assembling the night light circuit by following the rest of the following steps.

1. Making sure to **note** the orientation of the LED, **line up** the flat side of the base of the LED (negative) with the flat side on the PCB. **Solder** both leads so that the LED lays flat on the board. **Snip** the excess wire.
    a. The orientation of LEDs can also be identified with the legs, the shorter leg is negative.

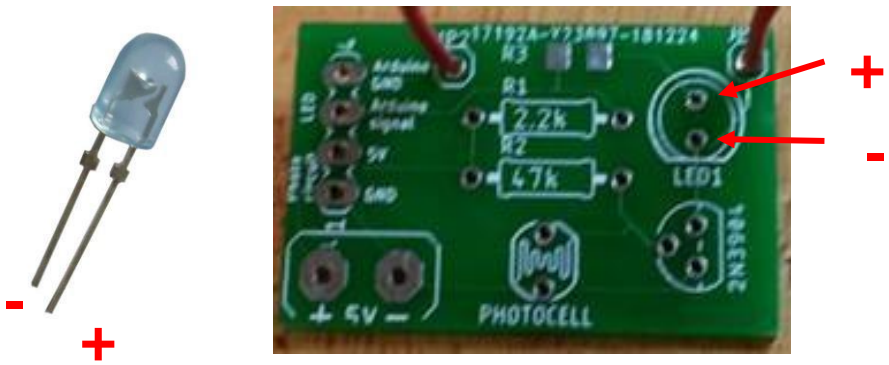
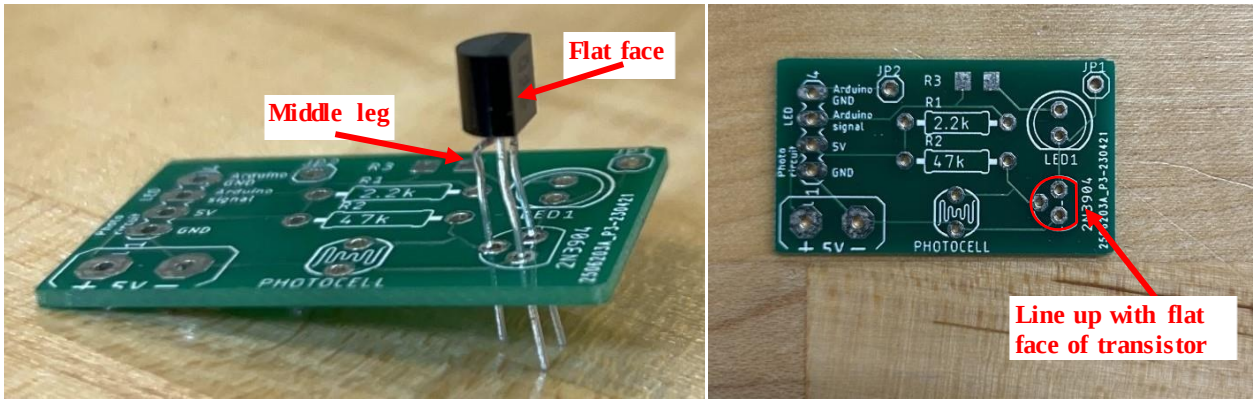


Figure 5 : LED soldered in the PCB

2. Slightly **bend** the middle leg of the transistor away from the flat side so it will fit in the PCB and **push** the component down until it is about 5mm from the board. **Solder** it in place and **snip** the wire.



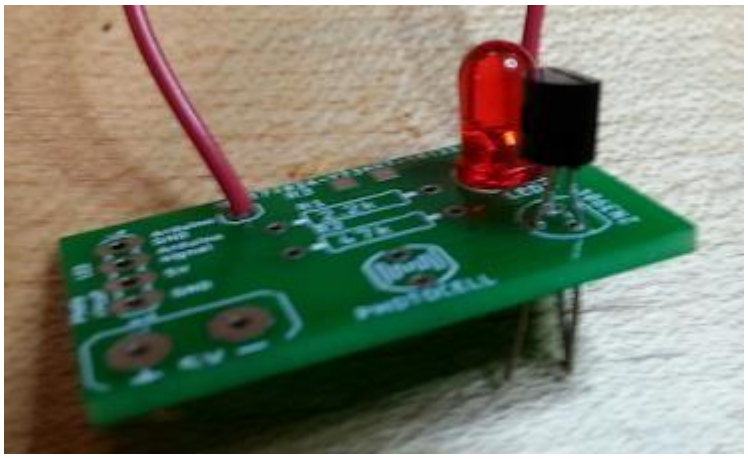


Figure 6 : Transistor soldered in the PCB

3. **Place** both through-hole resistors in the board, **make sure** to use the right values in the right spots but orientation doesn't matter. **Solder** both and **snip** the wires.

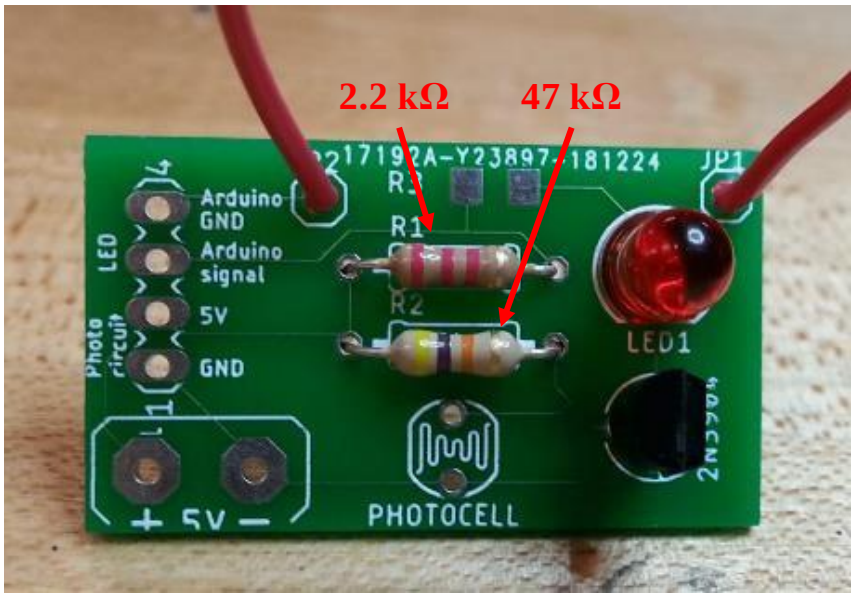


Figure 7 : Resistors soldered in the PCB

4. **Place** the photoresistor on the board (orientation doesn't matter). To make sure it doesn't fall out of place when you flip the board, **bend** the leads outwards. **Solder and snip** the wire.

Figure 8 : Photoresistor soldered in the PCB

5. Next, **solder** the header in place. The best way to do this is to **use** a breadboard as a guide to show that the header is perpendicular to the board. **Solder** each of the pins making sure the board stays perpendicular.

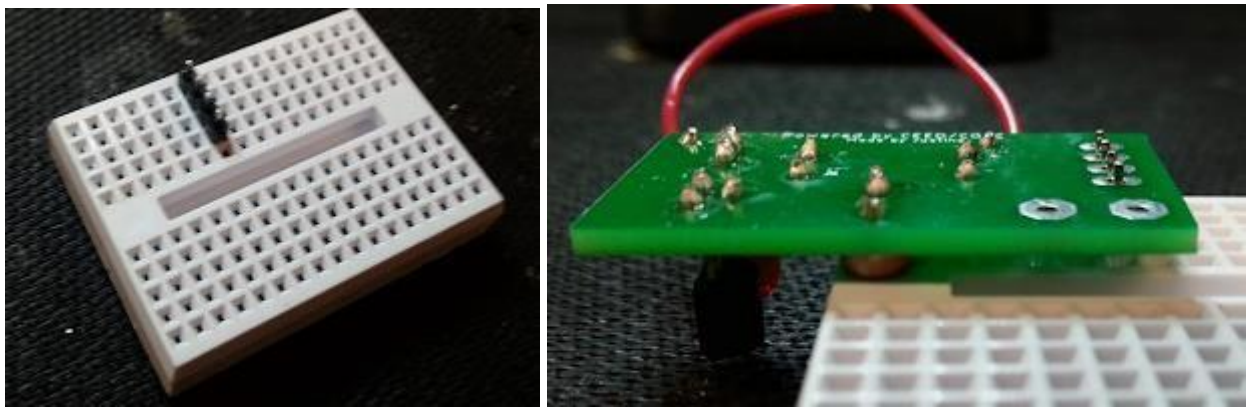


Figure 9 : Header soldered in the PCB

6. Finally **solder** the surface mount jumper (0 Ω chip resistor). You will need to remove the jumper from the white packaging to be able to use it.

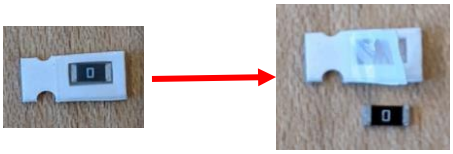


Figure 10 : Surface mount resistor

7. **Start** by tinning one of the pads (adding a small amount of solder). **Hold** the jumper in place with pliers or tweezers and **heat** the solder that is already on the pad to stick to the component. **Solder** the other side of the jumper and add some more solder to the first side if necessary.
    a. If you don't succeed with a surface mount you can solder a small wire in place instead (like a wire or resistor leg that was clipped off earlier). In real production factories, chip resistors like this are sometimes glued on with a tiny dot underneath that doesn't touch the electrical contacts before soldering.

Figure 11 : Surface mount resistor soldered on PCB

8. **Test** your soldering work with a multimeter by testing for continuity between joints. The multimeter will beep if you have a complete circuit. If the multimeter does not have a continuity measurement mode (the picture with the sound) on it, then measure the actual

resistance, which will be around 0.01 Ω or less for a good electrical connection. Note that changing resistance value or glitching resistance value might indicate an intermittent electrical connection or could be a probing problem (there is not a good electrical contact with the multimeter probe).

a. Make sure to **turn off** the multimeter when you are done with it.

Figure 12 : Continuity measurement on a multimeter

9. To test the night light circuit, **take** 2 male-female cables and **connect** PCB 5V to Arduino 5V and PCB GND to Arduino GND. Varying levels of light will now make the LED turn on or off.

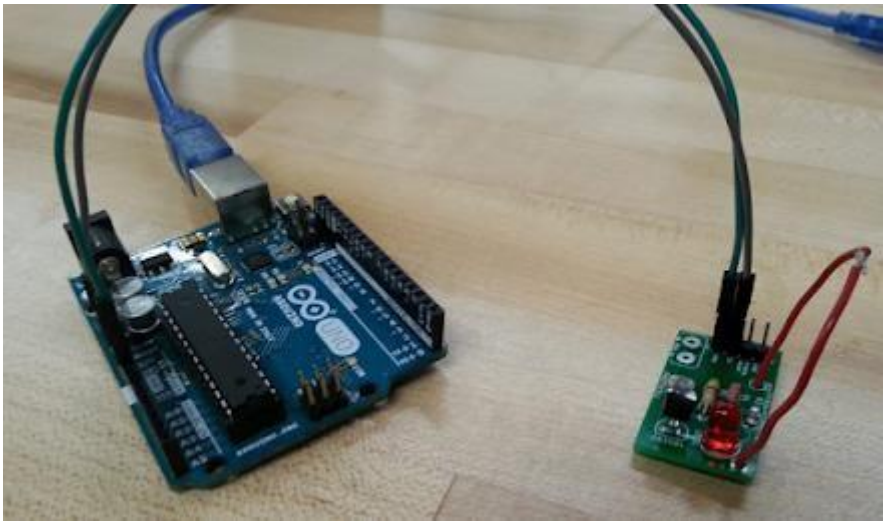


Figure 13 : Testing the PCB

10. You can also use the other 2 pins on the PCB to turn on/off the LED for testing purposes with the Arduino. Or you can solder a 5V power source to the PCB to be independent of the Arduino.

Additional Resources

- Here are a few tips and tricks about soldering to remember, http://www.instructables.com/id/Soldering-tips-and-tricks/ and here is a more in depth tutorial on soldering https://learn.sparkfun.com/tutorials/how-to-solder-through-holesoldering.
- For some project suggestions visit http://www.makeuseof.com/tag/learn-solder-simpletips-projects/.

Appendix

Here are a few steps if you need to desolder anything.

1. De-solder using pump: To activate the desoldering tool, **push** the end of the tool in until it clicks. To remove the solder, **push** the top button on the tool. **Place** the desoldering tool close to your joint so you can **move** it quickly when the joint becomes molten. **Heat** the solder joint until it becomes molten then place the desoldering tool directly over the molten joint and **press** the button to suck up the solder.
2. De-solder wire using solder wick. **Place** a fresh piece of wick on the joint and **press** the iron on top of the wick to melt the joint and **make sure** it gets absorbed by the wick.