**PTH Soldering Instructor Helper**

**First things first, don’t forget to introduce yourself and your teaching team followed by the students. Then launch into the information below.**

**Soldering** is a process in which two or more [metal](http://en.wikipedia.org/wiki/Metal) items are joined together by melting and flowing a filler metal ([solder](http://en.wikipedia.org/wiki/Solder)) into the joint. The filler metal has a lower [melting point](http://en.wikipedia.org/wiki/Melting_point) than the pieces being joined together.

**Tools and terms to be explained (hold up each item as you go):**

**Soldering Iron:** Irons come in many different forms. The most basic soldering irons are commonly referred to as “fire starters.” They are a simple iron with no heat adjustment. You are most likely using an adjustable temperature solder iron. These soldering irons should be set above 350 Celsius for standard solder. There may be an LED and a buzzer that beep and flash when your iron is not up to temperature. This may happen for a couple of reasons. If the object you are soldering can “sink”, or absorb, more heat than your iron can supply the iron will get cold. If you continuously have this problem you may have a bad connection somewhere in your soldering iron. Try pushing the tip of the soldering iron in (Careful! It is very, very hot!) by pressing down with the tip of the iron on a surface that will not burn. If your iron is still beeping after this, try unscrewing and screwing the cord connection to the soldering iron base.

While soldering you will generally hold your soldering iron like a pencil in your dominant hand.

**Solder:** Solder is a fusable metal used to join two pieces of metal together.

**Tweezers:** These tweezers are the ones you're familiar with from the medical profession (forceps). A curved-tip model keeps you clear of other components on a circuit board.

**Clippers:** These are a set of wire cutters that have the jaws offset from the handles at about 45 degrees. When through-hole soldering, very often you'll be left with long pins on the components. These long pins are trimmed to avoid possible short circuits. This is a great application for the diagonal nips, as they allow trimming very close to the board. Careful when clipping though, the wires like to fly off to who knows where.

**Pliers:** A set of needle-nose pliers is a pretty mandatory addition to a basic tool set. For bending wire, straightening pins, and tugging on stubborn parts, they can't be beat.

**Sponge:** Sponges are used to clean oxidization and excess solder off of soldering irons. Sponges are most often one of two materials: regular sponge or brass wool. These sponges may come with a holder for the sponge that also acts as a rest for the soldering iron. To clean your soldering iron melt solder onto the iron’s tip and then swipe the tip of the iron on the sponge in line with your soldering iron shaft.

**Flow or reflow:** The state of solder when it has been heated to the point of melting. When solder is “flowing” it is liquid and very hot. Liquid solder, while hot, usually will not burn below the first layer of skin due to it’s tendency to quickly solidify.

**Flux:** This liquid helps to improve the flow of solder, cleans the joint you are preparing to solder, and will greatly aid in loosening up a stubborn part that needs to be removed. Flux is conductive so make sure you wipe it off your board once you are done.

**Solder Wick:** The braided copper wick is made to soak up solder. It is great for loosening parts that need to be removed. It also can be very handy when working with surface-mount components. In a surface-mount joint that might bridge two pins, causing a short, the wick is just the thing to absorb the excess solder.

**Tip tinner:** Tip tinner is used to remove especially stubborn oxidization. Press your iron into the tip tinner while it is on.

**Heat pad:** Use this to handle object that are too hot for your bare hands. This tool is especially handy when switching out iron tips.

**Pin:** Also known as a “lead”, these are the pieces of wire that come off of your components and provide a pathway for electricity to travel into or out of your components. Careful when bending these, if you bend them too many times they may snap.

**Via:** These are the little holes in the PCB that you will be placing the pins of your components in and soldering them to. The vias have copper walls and small copper circles around the top and bottom of the holes. This is so the solder has something to stick to.

**PCB: (**Printed Circuit Board): This is the board you are soldering your components to. It is comprised mainly of layers of fiberglass and thin copper foil. The PCB contains the vias you will be soldering to.

**Multimeter:** Measuring power is done with a multimeter. In the SparkFun toolkit is a digital multimeter with an LCD readout that is very basic and easy to use. We can measure voltage, current, resistance and continuity by making contact with the probes and points within a circuit. How you measure each of these values differs.

For a multimeter tutorial go to this link: http://www.sparkfun.com/tutorials/202

**Oxidization:** Crud that forms on the end of the soldering iron. Oxidization impedes heat transfer, making it very difficult to solder. Oxidization is your enemy and you should be cleaning your soldering iron as often as possible.

**Safety goggles:** You only have two eyeballs and you might need both of them. Depth perception is pretty cool. Please wear your safety goggles. (Even instructors should be wearing safety goggles, lead by example.)

**Burn cream:** Use this for anyone who burns a hand. We find the best way to deal with burns is to make sure you don’t pressure the student to either continue or quit. Leave the decision entirely up to them. Usually students will persevere. When they do make sure that they are proud of their decision to push through. Our instructors will usually say something like this: “Wow. You burnt yourself but you kept going and now you have a working Simon game. Way to stick with it. You must be really proud of yourself!”

**Ask for questions here before continuing.**

**How to Make the Ideal Soldering Joint:**

There is a 3-step method that can be used to create an ideal soldering joint and it is as follows:

1. Hold the side of the tip of the soldering iron in contact with both the pin and the via and count for one second.
2. Feed solder into the heated pieces of metal. Ideally you would do this from the opposite side of the joint as the soldering iron, but if you need to you can briefly touch the solder to the iron to get it flowing (although among some this is considered “cheating”). As long as you get an ideal solder joint it doesn’t really matter how you got it though.
3. First take the solder away from the solder joint and then remove the soldering iron. This is so that you don’t wind up with solder stuck to the solder joint. If you do wind up with your solder stuck to the soldering joint, don’t worry, you can just melt it off with your iron.

**What an Ideal Solder Joint should look like:**

A Hershey Kiss, a volcano, a silver anthill, or an upside down ice cream cone dipped in tin. The circumference of the solder should not be any larger than the via and solder should be just barely visible from the other side of the via. The solder should also completely surround the pin and cover the entire via. You should not see any gaps between the via and the pin.

**Ask for questions here before continuing.**

**Working with solder continued:**

**What is oxidization?** The process of oxidizing; the addition of oxygen to a compound with a loss of electrons; always occurs accompanied by reduction.

**Cleaning your soldering iron:** The best way to avoid oxidization on your soldering iron is to clean it as much as possible. Pros will clean their soldering iron before every solder joint. To clean your soldering iron melt some solder onto the tip and swipe it towards you through the sponge.

**What is solder and how does it work:**

The solder you are working with is lead free solder which consists of 99.3% Tin and 0.7% Copper. The solder already has flux in it that makes it a little easier to work with. If working with lead free solder is too difficult for you we suggest you use leaded solder. Whenever soldering make sure you are working in a well-ventilated area.

**What is flux and how does it work?**

Flux is a liquid that causes solder to flow easier by corroding an oxidization or dirt that impedes heat flow.

Fluxes for soft solder are currently available in three basic formulations:

1. Water-soluble fluxes (no [VOCs](http://en.wikipedia.org/wiki/Volatile_organic_compound) required for removal) are fluxes that are designed to be removed with water after soldering. Water-soluble flux is what SparkFun uses.
2. No-clean fluxes that are mild enough to not "require" removal due to the non-conductive and non-corrosive residue. Performance of the flux needs to be carefully evaluated; a very mild 'no-clean' flux might be perfectly acceptable for production equipment, but not give adequate performance for a poorly controlled hand-soldering operation. They are so-called "no-clean" because the residue left after the solder operation is non-conductive and won't cause electrical shorts; nevertheless these fluxes leave a white-color residue, which is plainly visible. Since the presence of foreign matter, detritus, even lint, on circuit boards is a *defect* for all three classes of electronic circuit boards (ranging from cheap consumer electronics to high-reliability, mission critical applications), these sorts of fluxes must still be cleaned as with all hand solder work, typically brushing with 99% isopropyl alcohol as the solvent and lint-free non-synthetic (eg cotton) wipes.
3. Traditional [rosin](http://en.wikipedia.org/wiki/Rosin) fluxes are available in non-activated (R), mildly activated (RMA) and activated (RA) formulations. RA and RMA fluxes contain rosin combined with an activating agent, typically an acid, which increases the wettability of metals to which it is applied by removing existing oxides. The residue resulting from the use of RA flux is [corrosive](http://en.wikipedia.org/wiki/Corrosive) and must be cleaned off the piece being soldered. RMA flux is formulated to result in a residue that is not significantly corrosive, with cleaning being preferred but optional.

**Heat transfer:**

Heat transfer is the most important aspect of soldering. The solder is drawn towards heat. Because of this it is very important to heat up the pin and the via before you start adding solder to the solder joint. If you don’t heat up the pin and via the solder will just stick to the iron because it will be the only hot part out of the pieces you are trying to solder. Because heat transfer is so important you need to make sure that you are touching the soldering iron to the pieces of metal properly. Heat transfer is a function of contact area, so touching the tip of the soldering iron to the pin and via does not work very well. You will need to use the side of the tip of the soldering iron and touch as much of it as possible to the pieces you are attempting to heat up. Be careful when holding the iron on your pin, via or PCB longer than 3–5 seconds. The PCB is designed to withstand heat, but too much heat will melt the plastic.

**What not to do:**

**Cold joints:**

A cold joint is a solder joint that has not properly connected to one or more of your connections. Often you will be able to see a gap around the pin in the via. Other times it won’t be as obvious and will look like a good solder joint, but with a tiny crack between the mound of solder and the PCB or via. Just throw some flux on the solder, reflow and add a little more solder. Make sure you don’t just heat up the solder though! Remember to make contact with both the pieces you are soldering together.

**Jumpers:**

Jumpers occur when a student uses too much solder on a solder joint causing the solder to spill out of the via touching another electrical connection. This is very bad because it gives the electricity an alternate path to travel, negating the connection you are creating. Don’t worry though! You can just use some flux and solder wick or a solder sucker to take care of these pesky little (or not so little) blobs of solder.

**Polarity:**

Polarity is one of the most important things to explain to newbies when they are putting together a PCB for the first time. In SparkFun kits the polarized components are all high lighted in yellow. Explain to the students that polarized components are like puzzle pieces; they only work if you put them in the correct way. Despite your best attempts you will have at least a couple people put something in backwards. Be patient and knowledgeable with a rework station. Think of it as a teaching opportunity. You can have the student help you by pulling on the offending piece while you hold the PCB and hit it with hot air. If the same student has a polarization issue again you can switch places so the student gains experience with a hot air rework station.

**Explain to the class that solder suckers, wicking and hot air rework will be explained on a case-by-case basis because let’s face it, that was a lot of information! Ask for questions one last time.**

**Finally, go over the 1, 2, 3 method outlined above and cleaning the soldering iron one last time before setting the future electronic geniuses loose on their irons, PCBs and components.**

**Turn on your fans! Put on your safety goggles! Go!**

Because all the information above is a lot to process we suggest addressing de-soldering as needed on a one on one basis. This way a mishap can be turned into a learning experience and students are able to focus on the do’s and don’ts outlined above.

**De-soldering process:**

The process of taking components off of PCBs comes in many forms. Without using a hot air rework station there are three main ways to take solder off of components and PCBS, they are outlined below.

**Solder wick:**

First apply plenty of flux to the solder you wish to remove. Place a length of unused solder wick on top of the solder you wish to remove. Press the side of the tip of the iron onto the wick, sandwiching the wick between the solder and iron. Be careful when handling the wick because it will heat up once you apply the iron. Since the solder is attracted to heat, once the solder flows it will suck away from the PCB or component into the spaces in the solder wick. Don’t be afraid to roll the iron on the wick in order to get as much of the solder as you can. Remove the iron and wick at the same time; otherwise you will wind up with solder wick stuck to your PCB. If this happens, don’t worry, just reapply the iron and remove them together after the solder has reflowed. If you didn’t get all the solder off either use more wick, try one of the two methods below, or move to a hot air rework station. Clean off the flux once you are done.

**Solder sucker:**

First apply plenty of flux to the solder you wish to remove. Hold the iron in your dominant hand and a cocked solder sucker in your other hand. Press iron to the solder you are removing. You may have to actually put the tip of the iron inside the via, or apply the side of the tip to one side or the other of the solder you are trying to remove. Once the solder has flowed place the nozzle of the solder sucker as close as possible to the solder and press the release mechanism. You may have to experiment with placement of the solder sucker and soldering iron a couple times, but this should suck solder away from the via into the solder sucker. Clean flux off after you are done. Some people swear by solder suckers. We don’t use them very much at SparkFun.

**The bump method:**

Ahh, the good old fashioned bump method. As with the other methods, apply flux to the solder joint you are de-soldering. Hold the PCB in your dominant hand, near the edge of the table and a few inches above it. With you other hand place the soldering iron on, or even better, in the via. Wait until the solder flows. Keep you iron where it is and, quickly jerk the PCB down, away from the iron and bump it firmly against the table. If you did it properly you should cause the solder to fall out of the via, leaving you with a nice clean via to work with. Ideally you will “bump” the PCB against the table as close to the via as possible. Clean off the flux after you are done.

**Here’s the short version:**

1. **Intro**
2. **Describe their tools and materials**
3. **Talk about how easy the kit is if you RTFM (POLARITY!)**
4. **How to solder in 4 steps**
5. **How/When to use flux**
6. **How to use wick**
7. **Other iron-only rework methods**
8. **If they make a mistake we will show them how we fix it the first time, have them help fix it the second**
9. **SAFETY GOGGLES!!!!**
10. **Go over how to solder in 4 steps one last time**