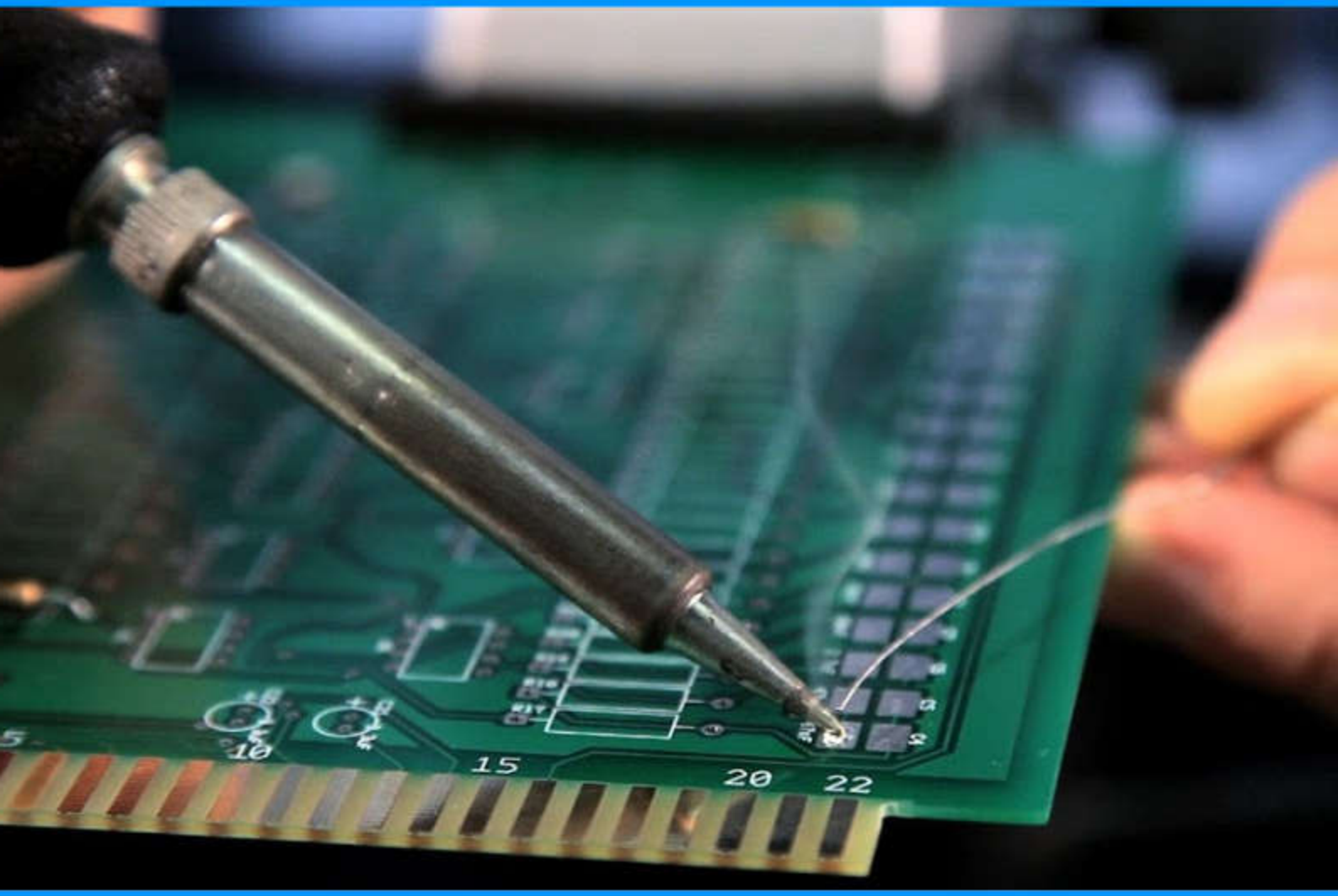
Soldering



Step by Step

For beginners

By Alexander Chukhryaev

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Introduction

This eBook will help you to master is the ability to solder electronics as this is the one of the most fundamental skills a maker should be able to do.

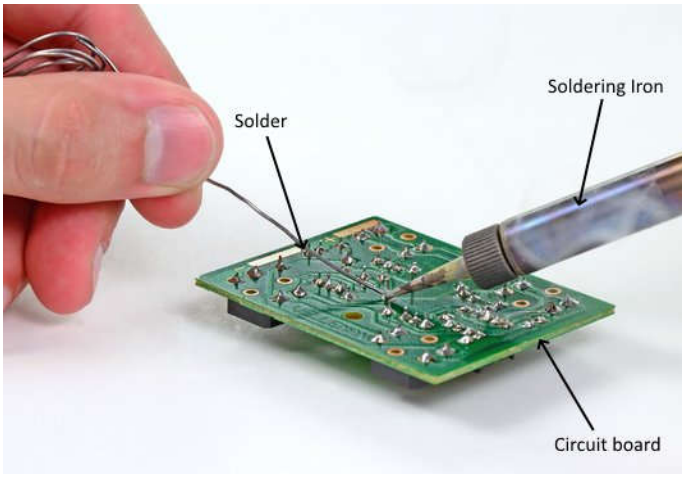

Image credit : Acoptex

Whether you are building a robot or working with Arduino or Raspberry Pi, knowing how to solder will come in handy. The best thing about soldering is that it is really fun to learn and easy to master.

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What Is Soldering?

Soldering is a process in which two or more items are joined together by melting and putting a filler metal (solder) into the joint, the filler metal having a lower melting point than the adjoining metal.

Unlike welding, soldering does not involve melting the work pieces. In brazing, the work piece metal also does not melt, but the filler metal is one that melts at a higher temperature than in soldering. In the past, nearly all solders contained lead, but environmental and health concerns have increasingly dictated use of lead-free alloys for electronics and plumbing purposes.

Soldering was historically used to make jewelry items, cooking ware and tools, as well as other uses such as in assembling stained glass. Soldering is used in plumbing, electronics, and metalwork from flashing to jewellery and musical instruments.

Electronic soldering permanently connects electrical wiring and electronic components to printed circuit boards by utilizing a metallic alloy substance called solder. This special alloy is melted by using a soldering iron, a wave bath, or a specialized oven, as it joins conductors to PCBs, terminals, and wires.

Solder is like a metallic "glue" that holds the parts together and forms a connection that allows electrical current to flow. You can use a solder less breadboard to make test circuits, but if you want your circuit to last for more than a few days, you will want to solder the components together. If you were to take apart any electronic device that contains a circuit board, you will see the components are attached using soldering techniques.

Even though soldering can create a permanent connection, it can also be reversed using a desoldering tool as it will be described later.

Soldering Tools

Let's have a look on what do you need to get started. The good thing about learning how to solder is the fact that you don't need a lot of tools. Below we will outline the basic tools and materials you will need for most of your soldering projects.

Soldering Iron

Image credit : Aliexpress

A soldering iron is a hand tool that plugs into a standard 110V/220V AC outlet and heats up in order to melt solder around electrical connections.
It is recommended to use a 25- to 40-watt (W) soldering iron for electronic circuits. Higher wattage soldering irons are not necessarily hotter; they are just able to heat larger components. A 40-W soldering iron makes joints faster than a 25-W soldering iron does.

There are essentially four different soldering irons types available in the market - soldering pencils, soldering guns, soldering stations, repair/rework stations.
Every soldering iron is used for different industry depending the type of project. If you are going to be doing a lot of soldering, soldering station is great to have. As it has the ability to precisely adjust the temperature of the soldering iron which is great for a range of projects.

Soldering Iron Stand

Image credit : Aliexpress

A soldering iron stand is very basic but very useful and handy to have.

This stand helps prevent the hot iron tip from coming in contact with flammable materials or causing accidental injury to your hand.

A soldering iron stand has arrangement for sponge and/or brass sponge for cleaning the tip and solder.

Most soldering stations come with a soldering iron stand built in and include a sponge or brass sponge for cleaning the tip.

There is a variety of stands available.

It is important to always keep the hot soldering iron in its stand when not in use.

Soldering Iron Tips

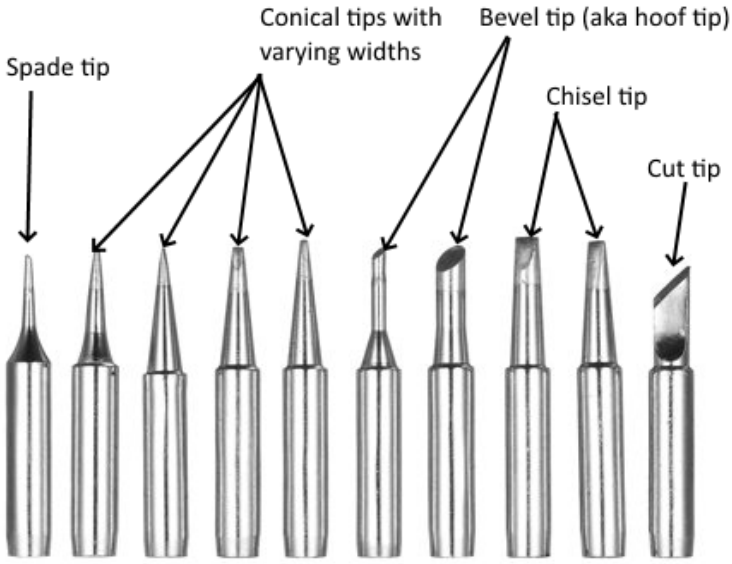


Image credit : Walmart

At the end of most soldering irons is an interchangeable part known as a soldering iron tip. A soldering iron tip is the part of the soldering iron that heats up and allows solder to flow around the two components being joined. Although solder will stick to the tip when applied, a common misconception is that the soldering iron tip transfers the solder. A soldering iron tip actually transfers heat, raising the temperature of the metal components to the melting point of the solder, and the solder melts accordingly. Most soldering irons give you the option to change your soldering iron tip, should you need to replace an old soldering iron tip or if you need to switch to a different style of soldering iron tip.

There are many different types of soldering iron tip and they have different of shapes and sizes. Each soldering iron tip is used for a specific purpose and offers a distinct advantage over another. There are endless varieties of specialized tips designed for specific jobs - even if they aren't soldering related. For example, this spade tip is used to scrape UV glue off of LCD glass. The most common tips you will use in electronics projects are the **conical tip** and the **chisel tip**. **Conical Tip** is used in precision electronics soldering because of its pointed end, it can deliver heat to smaller areas without affecting its surroundings. **Chisel Tip** is well-suited to soldering wires or other larger components because of its broad flat tip.

Brass or Conventional Soldering Sponge

Image credit: Aliexpress

Using a soldering sponge will help to keep the soldering iron tip clean by removing the oxidation that forms.

Soldering iron tips with oxidation will tend to turn black and not accept solder as it did when it was new. Especially with lead-free solder, there are impurities in the solder that tend to build up on the tip of your iron, which causes this oxidization.

You can use a conventional wet soldering sponge but this tends to shorten the lifespan of the soldering iron tip. By wiping your tip on a cool, wet sponge, the tip tends to expand and contract from the change in temperature. This expansion and contraction will wear out your tip and can sometime cause a hole to develop in the side of the tip. Once a tip has a hole, it is no good for soldering. A wet soldering sponge will drop the temperature of the tip temporarily when wiped too.

A better alternative is to use a brass soldering sponge. Brass sponges pull the excess solder from your tip while allowing the tip to maintain its current heat level.

Solder

Solder is a metal alloy material that is melted to create a permanent bond between electrical parts. Inside the solder core is a material known as flux which helps improve electrical contact and its mechanical strength.

Image credit: Aliexpress

Solder wire can be as a spool and in a tube. It comes in both lead and lead-free variations with diameters of 0.75 mm and 1 mm being the most common. Traditionally, solder was composed of mostly lead (Pb), tin (Sn), and a few other trace metals. This solder is known as **leaded solder** (60% tin, 40% lead) rosin core). As it has come to be known, lead is harmful to humans and can lead to lead poisoning when exposed to large amounts. Unfortunately, lead is also a very useful metal, and it was chosen as the go-to metal for soldering because of its low melting point and ability to create great solder joints. **Lead-free** solder is very similar to its leaded counterpart, except, as the name states, it contains no lead. Instead it is made up of mostly tin and other trace metals, such as silver and copper. This solder is usually marked with the RoHS symbol to let potential buyers know it conforms to the standard.

For electronics soldering, the most commonly used type is **lead-free** rosin core solder. This type of solder is usually made up of a Tin/Copper alloy. If you do use lead solder, make sure you have proper ventilation and that you wash your hands after use.

When buying solder, make sure NOT to use acid core solder as this will damage your circuits and components. Acid core solder is sold at home improvement stores and is mainly used for plumbing and metal working.

The thicker diameter solder (1 mm) is good for soldering larger joints more quickly but it can make soldering smaller joints difficult. For this reason, it is always a good idea to have both sizes on hand for your different projects.

Third Hand

Image credit: Aliexpress

The third hand is a solderer's best helper. It comes with a heavy base, two alligator clips, a soldering iron holder, and a good magnifying glass. This alligator clips will assist you by holding the items you are trying to solder while you use the soldering iron and solder.

A very helpful tool to have in your workshop.

Adjustable PCB holder

Image credit: Aliexpress

It is designed to clamp a circuit board, ideal for PCB soldering and desoldering rework. Bottom is equipped with rubber gasket, stable and no shaking.
Adjustable PCB holder can be adjusted according to the circuit board size, maximum width is 200mm, and four different thicknesses. It can rotate 360 degrees and easy to be fixed on a desired position, improving work efficient.

Soldering Accessories

Image credit: Sparkfun

Solder Wick is the eraser to soldering's pencil. When dealing with issues such as jumpers or the removal of parts (desoldering), solder wick comes in very handy. Solder wick (aka desoldering braid) is comprised of thin copper wire braided together. Solder is soaked (wicked) up by the copper allowing you to "erase" extra globs of solder.

Image credit: Sparkfun

Tip Tinner is a chemical paste used to clean the tip of your soldering iron. It is composed of a mild acid that helps remove baked on residue (like when you accidentally melt your tip on a component) and helps prevent oxidation (the nasty black stuff) that accumulates on your soldering tip when not in use.

Solder Vacuum (Solder Sucker) is a great tool for removing solder left behind in through-holes when desoldering components.

Water Soluble Flux Pen. Flux is a chemical agent that aids in the flowing of lead-free solder. Flux pens allow you to dab stubborn components with liquid flux to create better looking solder joints. It is recommended to clean and remove any remaining water soluble flux residue on the board.

Image credit: Sparkfun

No Clean Flux Pen. Flux is another chemical agent that aids in the flowing of lead-free solder. Flux pens allow you to dab stubborn components with liquid flux to create better looking solder joints. Cleaning and flux removal is not required. For those interested in removing the flux residue, isopropyl alcohol (IPA) is required.

Insulated Silicone Soldering Mat. Protect your desktop and keep it clean with a silicone soldering mat.

Needle Nose Pliers. Mini pliers are a must have for any hobbyist or electrical engineer. Crucial for inserting devices into breadboards and bending pins.

Diaconal Cutters. Cutters allow you to trim the legs of components you solder to the PCB. They can also be used to grip, grap, and pry connectors or other various cables.

Flush Cutters. Giving you a way to cut leads very cleanly and close to the solder joint. Diagonal cutters are good, but if you really need to get up close and personal, flush cutters are the way to go.

Image credit: Sparkfun

Hobby Knife - We use these extensively when working with PCBs. These small knives work well for cutting traces, scraping ground pours, and guiding hair-like wires into their proper place

Anti-magnetic Tweezers - Straight or Curved. They have a very fine tip which allows you to pick up very small parts with precision. This is a great tool to have if you're working with surface mount components or anything with very small parts. The ESD-safe coating will also help prevent electro-static damage to sensitive electronic components.

Wire Strippers. These are your basic, run-of-the-mill wire strippers with a comfortable grip making them an affordable option if you need to remove the protective sleeve from a desired wire.

Electronic Snippers. Sometimes you need something with a little more bite. These electronic snippers are great for cutting wires and component leads. They have a cushioned handle which makes them much more comfortable to use. These snippers can be used are wire cutters if the need be, and are great if you are looking for something a little better than hobby grade.

Soldering Safety

Now that you know what tools and materials are required, it's time to briefly discuss ways of staying safe while soldering.

1. A soldering iron can heat to around 400°C, which can burn you or start a fire, so use it carefully. We always recommend you use a soldering iron stand to help prevent accidental burns or damage. Keep flammable liquids and materials (such as alcohol, solvent etc.) away from the work area.
2. Unplug the soldering iron when it is not in use.
3. Keep the power cord away from spots where it can be tripped over.
4. Take great care to avoid touching the soldering iron on a power line. If a power cord is touched by a hot iron, there is a serious risk of burns and electric shock.
5. Always return the soldering iron to its stand when it is not in use.
6. Make sure you are soldering in a well ventilated area. When solder is heated, there are fumes released that are harmful to your eyes and lungs. It's recommended to use a fume extractor which is a fan with a charcoal filter that absorbs the harmful solder smoke.
7. The smoke that will form as you melt solder is mostly from the flux and can be quite irritating. Avoid breathing it by keeping your head to the side of, not above, your work.
8. Solder contains lead, which is a poisonous metal. Wash your hands with soap and water after soldering. Use protective gloves.
9. It's always a good idea to wear protective eye wear in case of accidental splashes of hot solder.
10. Hold wires to be heated with tweezers, pliers or clamps to avoid receiving burns on your fingers from objects that are heated.
11. Wear ESD (Electro-Static Discharge) protection if you are going to solder electro-static sensitive components such as CMOS components. For most of DIY projects it will be good enough to wear ESD wrist straps.

Image credit: Aliexpress and Ramfax

Changing The Soldering Iron Tip

Changing the soldering iron tip is a simple process that consists of either unscrewing the wand or simply pushing in and pulling out the tip.

The efficiency of the heat transferred from the soldering iron tip to the joint is dependent on the size of the soldering iron tip that you are using.

Usually, you want to have a soldering iron tip that is about the same width as the soldering pad you are soldering to.

Image credit: Sparkfun

Tinning The Soldering Iron Tip

You should always tin your soldering iron tip before starting to solder and after. Tinning is the process of coating the surface of your soldering iron tip in solder (which contains tin) to prevent oxidisation and to aid the solder in sticking to your tip and flowing to where it should. Tinning will also help to protect the tip and reduce wear.

Step by Step instruction:

1. Make sure that the soldering iron tip is attached to the soldering iron and screwed tightly in place.

2. Turn on your soldering iron and let it heat up. If you have a soldering station with an adjustable temp control, set it to 400' C/ 752' F. Turn on power switch on soldering station and set the temperature of soldering station by turning knob on front panel. Most of good soldering stations take 1-2 minutes to reach the temperature set.

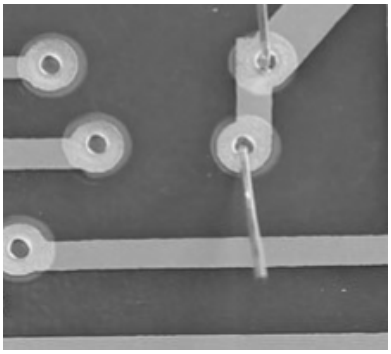
3. Wipe the soldering iron tip on a damp wet sponge or brass sponge to clean it. Wait a few seconds to let the tip heat up again before proceeding to next step.

4. Hold the soldering iron in one hand and solder in the other. Touch the solder to the tip of the soldering iron and make sure the solder flows evenly around the soldering iron tip.

5. Eventually, every soldering iron tip will wear out and will need replacing when it becomes rough or pitted.

How To Solder

Step by Step instruction:



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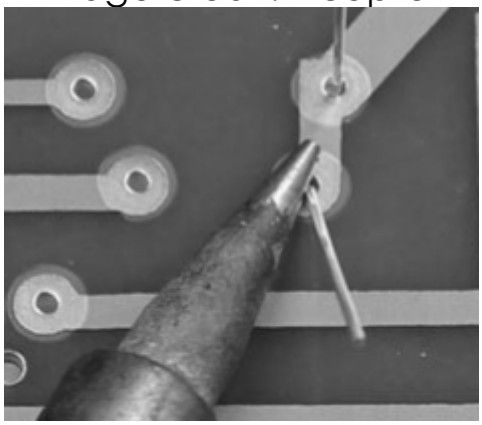


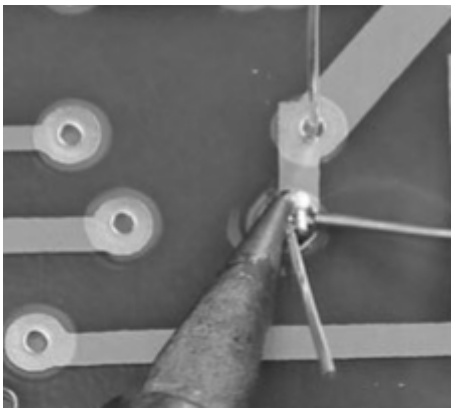
Image credit: Acoptex

0. Preparing surface. Solder needs a clean surface on which to adhere. Buff the copper foil of a PC board with steel wool before soldering. Remove any oil, paint, wax, etc. with a solvent, steel wool, or fine sandpaper.

1. Mount The Component. Begin by inserting the leads of the resistor into the holes of the circuit board. Flip the board over and bend the leads outward at a 45' angle. This will help the component make a better connection with the copper pad and prevent it from falling out while soldering.

2. Prepare To Solder. If you are right-handed, then hold the soldering iron in your right hand and the solder in your left. If you are left-handed, then do the opposite. You should spool off 30 centimetres or so of solder from your spool, straighten the end of it out, and hold the solder at least 5 centimetres from the end.

3. Heat The Joint. Turn your soldering iron on and if it has an adjustable heat control, set it to 400'C. At this point, touch the tip of the soldering iron to the copper pad and the resistor lead at the same time. You need to hold the soldering iron in place for 2-3 seconds in order to heat the pad and the lead.



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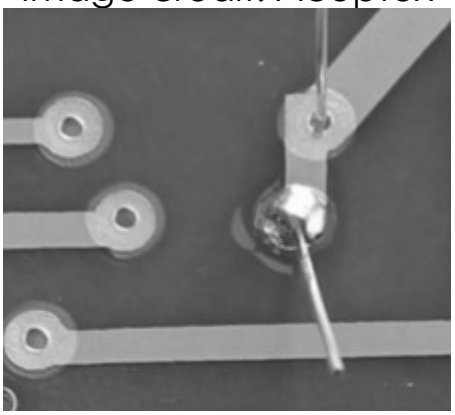

Image credit: Acoptex

4. Apply Solder To Joint. Continue holding the soldering iron on the copper pad and the lead and touch your solder to
the joint. Very important: Don't touch the solder directly to the tip of the soldering iron. You want the joint to be hot enough to melt the solder when it is touched. If the joint is too cold, it will form a bad connection.

5. Snip The Leads. Remove the soldering iron and let the solder cool down naturally. Don't blow on the solder as this will cause a bad joint. Once cool, you can snip the extra wire from leads.

A proper solder joint is smooth, shiny and looks like a volcano or cone shape. You want just enough solder to cover the entire joint but not too much so it becomes a ball or spills to a nearby lead or joint.

The main soldering problems are:

1. Blobby solder joints. It happen normally when you haven't applied enough heat to the solder joint, either while you're adding the solder or after you have removed the solder. It can also happen when your soldering iron just isn't hot enough, as can be the case with cheaper soldering irons. Blobby solder joints will often not make a proper electrical contact with the copper surround on the board, but can be fixed by holding your soldering iron against the blobby joint until the solder melts and flows down into the hole.

2. Adding too much solder. If your joint is blobby, or the solder isn't flowing right around the pins (both problems are caused by applying too little heat), then the temptation can be to add more solder. This won't fix the problem, and can result in solder bridges to nearby pins, meaning that you'll have to go through the stress of desoldering the joint/s. Again, the solution is to add more heat until

the solder flows properly. A little dab of flux with a flux pen can often help too.

3. Sometimes **messy solder joints** and **solder bridges** can be the result of using a soldering iron tip that is too big or too wide for the job in hand. Try using a finer tip, like a needle tip or a small chisel tip. You might find that it suits you better than the one that you've been using.

4. Too much heat will also cause you strife. Just as too little heat will cause problems like blobby or poorly soldered joints, too much heat will cause its own set of problems. The most common issue is pin headers with plastic surrounds melting, resulting in pins being crooked or slipping too far through the board. This can happen when your soldering iron is too hot (turn the temperature down if it's a controllable one), or if you hold the soldering iron on the joint for too long.

5. Ground pins, connected to the ground plane of the board, will always be much harder to solder than regular pins. This is because the ground plane of a PCB will act as a heatsink and suck up the heat from your soldering iron and hence from your solder and the pin you're trying to solder. This means that you might need to spend a little longer soldering these pins, i.e. pre-heat the pin for a little longer and hold your iron for a little longer after to let the solder flow into the joint. The same goes for larger components like USB or micro-USB jacks.

6. Solder will not flow. The parts to be joined may be dirty. Remove the solder and clean the parts.

How To Solder Wires

It's time to show you how to solder wires together. For this process, it's recommended to use third hand or other type of clamp device.

Step by Step instruction:

Image credit: Acoptex

1. Begin by removing the insulation from the ends of both wires you are soldering together with wire strippers. If the wire is stranded, twist the strands together with your fingers.

Image credit: Acoptex

2. Make sure your soldering iron is fully heated and touch the tip to the end of one of the wires. Hold it on the wire for 3-4 seconds.

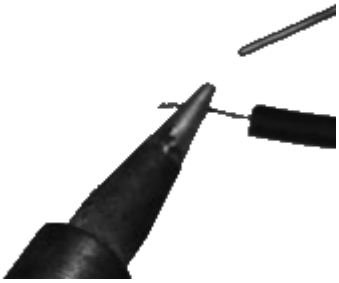

Image credit: Acoptex

3. Keep the iron in place and touch the solder to the wire until it's fully coated. Repeat this process on the other wire.

Image credit: Acoptex

4. Hold the two tinned wires on top of each other and touch the soldering iron to both wires. This process should melt the solder and coat both wires evenly.

Image credit: Acoptex

5. Remove the soldering iron and wait a few seconds to let the soldered connection cool and harden. Use heat shrink to cover the connection.

Desoldering

Desoldering is the removal of solder and components from a circuit board for troubleshooting, repair, replacement, and salvage.

We will show you how to use a solder wick (desoldering braid) and desoldering pump (solder sucker) in this section.

1. Solder wick. To desolder a joint, you will need solder wick which is also known as desoldering braid.

Image credit: Sparkfun

Step by Step instruction:

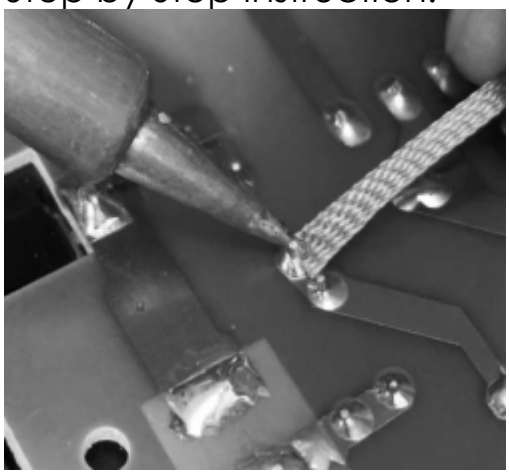

Image credit: Fast-PC

1. Place a piece of the desoldering braid on top of the joint/solder you want removed.

2. Heat your soldering iron and touch the soldering tip to the top of the solder wick. This will heat the solder below which will then be absorbed into the desoldering braid.

3. Remove the braid to see the solder has been extracted and removed. Be careful touching the braid when you are heating it because it will get hot.

2. Desoldering pump (solder sucker)

Image credit: Aliexpress

If you have a lot of solder, which you need to remove, use a device called a desoldering pump. A desoldering pump, which is also known as a solder sucker, is a manually-operated device which is used to remove solder from a printed circuit board. There are two types: the plunger style and bulb style. The plunger type has a cylinder with a spring-loaded piston which is pushed down and locks into place. When triggered by pressing a button, the piston springs up, creating suction that sucks the solder off the soldered connection. The bulb type creates suction by squeezing and releasing a rubber bulb.

Step by Step instruction:

Image credit: Jaycar

1.Press the plunger down at the end of the solder sucker.
2. Heat the joint with your soldering iron and place the tip of the solder sucker over the hot solder.
3. Squeeze and release a rubber bulb to suck up the liquid solder.

Image credit: Ecbidbuy

1.Press the plunger down at the end of the solder sucker.
2. Heat the joint with your soldering iron and place the tip of the solder sucker over the hot solder.
3. Press the release button to suck up the liquid solder.
4. In order to empty the solder sucker, press down on the plunger.

Repair And Cleaning

Repairing a **blobby solder joint** is a fairly easy fix. Simply touch the tip of your soldering iron against the blob, and hold it until the solder flows down into the joint.

A **solder bridge** between pins can often be fixed by simply holding your soldering iron against the middle of the bridge until the solder melts and drawing it through to break the bridge. If the bridge is too large, and this method doesn't fix it, then you'll need to desolder (and resolder) it with a solder sucker or some desoldering braid.

A **poor joint** that isn't making proper electrical contact can be fixed by first applying more heat with your soldering iron, and then adding a little more solder if necessary.

A **wonky pin** caused by too much heat can (sometimes) be fixed by holding the offending pin with a pair of needle-nose pliers and then applying some heat to the solder joint (you might need just enough heat to soften the plastic around the pin again). Gripping the pin with the pliers, move it back into the correct position, remove the soldering iron while still holding the pin, and let the solder and plastic harden again.

Clipping legs and rounding off joints gives your solder joints a really professional look. Some components, like LEDs, resistors, etc, have

long legs that need to be clipped after soldering. You should clip them with a pair of flush-cutting snips, like the Engineer Tools ones that we sell, as close as possible to the board. Once clipped, you can briefly touch your soldering iron against the clipped joint to round it off and make it look really neat.

When working with lead-free solder, flux tends to get everywhere, be it from the flux in the solder or from external flux applied by the user. Flux can corrode the PCB and components over time, thus it's good to know how to clean your PCBs so they're free of any flux residue. **Removing flux residue** will also improve the visual appearance of your board. Because lead-free solder contains flux, once soldered, it can leave residue around the solder joints. This can be removed using isopropyl alcohol (IPA) and a clean, lint-free cloth. Give part to be cleaned a quick spray with the IPA, and then rub it with the cloth to clean off the residue. If you are soldering more than a few boards, it may be necessary to clean them in batches. For this, we recommend a crock pot filled with distilled water. The distilled water keeps other impurities and contaminants away from your circuit. It's not 100% necessary to clean your board, however, it will increase the life of your circuit tremendously.

Tips for Successful Soldering

Reliable operation of a circuit with soldered connections depends on good soldering practices. Here are some tips for successful soldering.

1. Plan before you start to solder. Identify all the parts that you will be using.

2. It is helpful to attach each part to a piece of paper and write what it is and its value (for example, resistor #1: 100 Ohm).

3. Some components, such as LED's, capacitors, diodes, transistors must be placed the correct way around in order to function.

4. The order for the installation of various components should be: integrated circuit (IC) holders (note the orientation, add IC later);

resistors, capacitors (less than 1 micro farad); large capacitors (1 micro farad or greater, note the orientation); diodes (note the orientation); LED's (note the orientation); transistors (note the orientation)

5. Solid wire connections between components on the board. Solid wire is fairly rigid, so it will stay in place once attached.

6. Stranded wire to parts that are connected by wire to the circuit. Stranded wire is more flexible than solid wire.
7. Integrated circuits. Connect them the correct way around. Many IC's are static sensitive. Leave IC's in their antistatic packaging until you need them, then ground your hands by touching a metal water pipe or window frame before touching the IC's. Carefully insert IC's in their holders. Make sure all the pins are lined up with the socket, then push down firmly with your thumb.

8. Don't overheat the connection, as this might damage the electrical component you are soldering. Transistors and some other components can be damaged by heat when soldering. A crocodile clip can be used as a heat sink to protect these components.

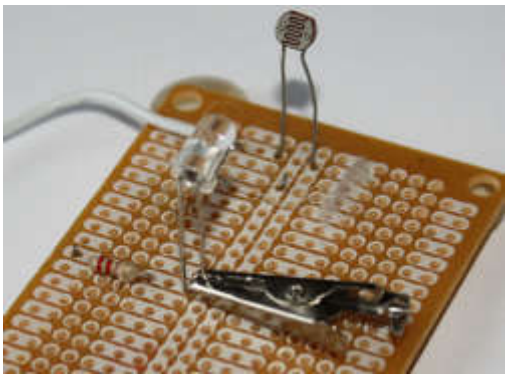

Image credit: sciencebuddies.org