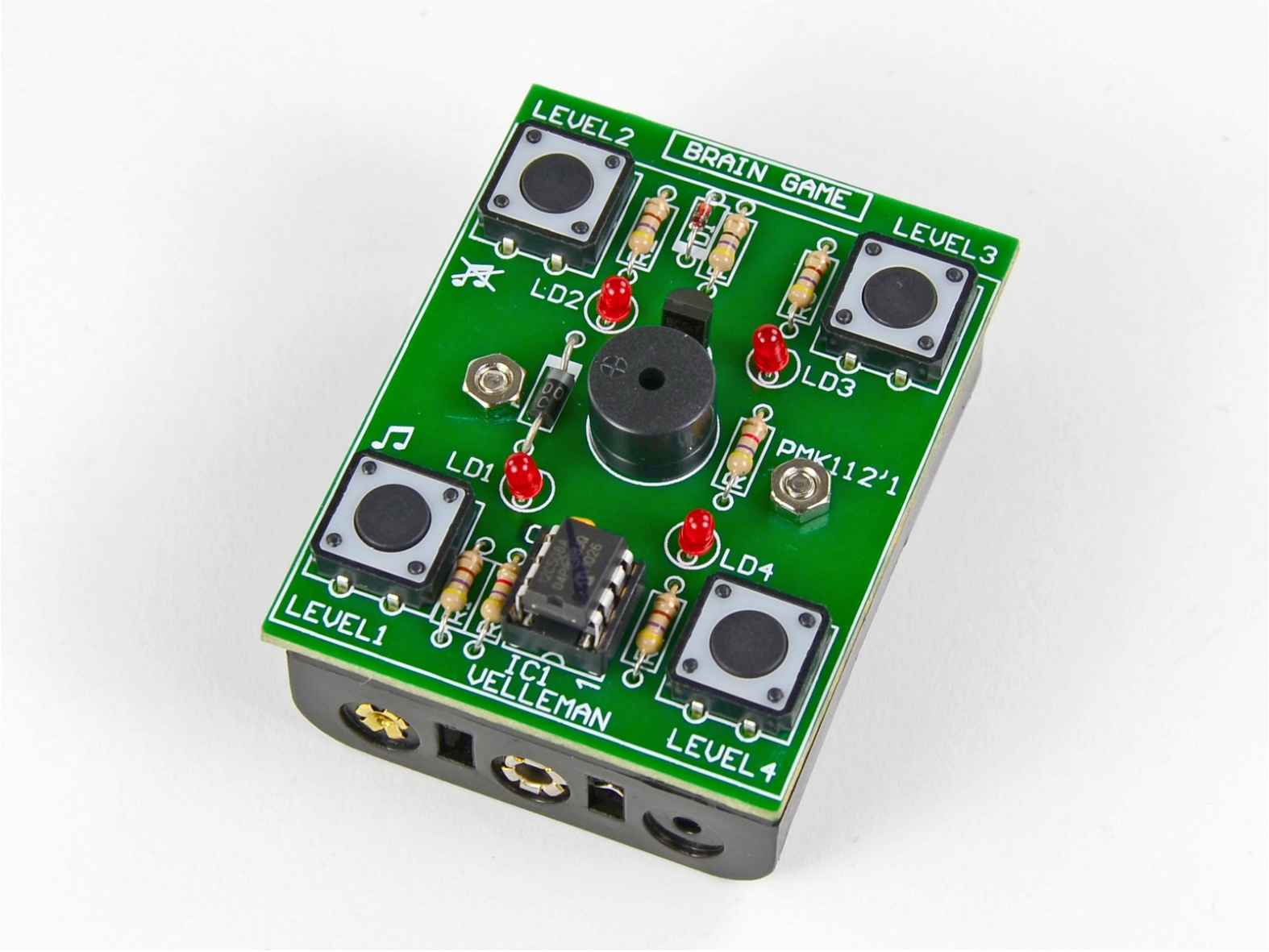
Electronics Skills Kit 101

This guide will help you through the steps while teaching you about soldering, resistor reading, and component polarity.

Written By: Jake Devincenzi



INTRODUCTION

So you just purchased our Level 1 Soldering Kit to practice your through-hole soldering. This guide will help you through the steps while teaching you about soldering, resistor reading, and component polarity. Soon, you'll be ready to replace the battery in your iPod Nano 3rd Generation.

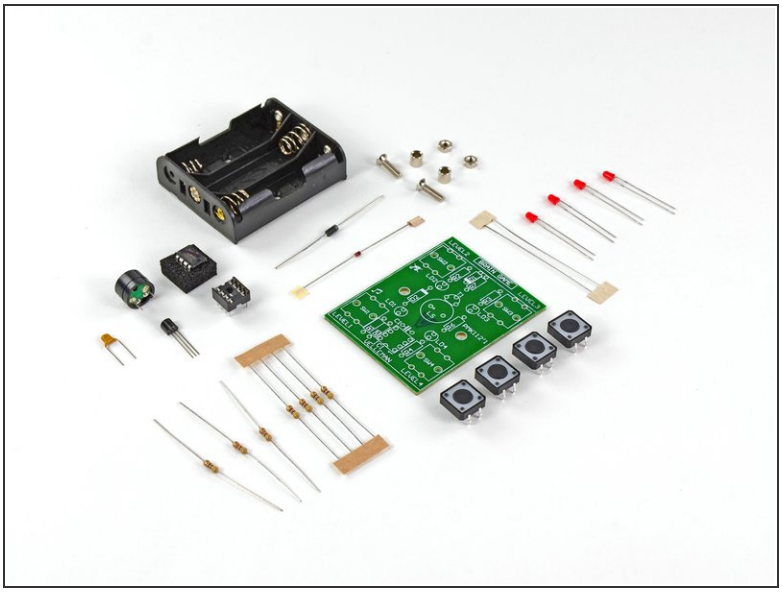
TOOLS:

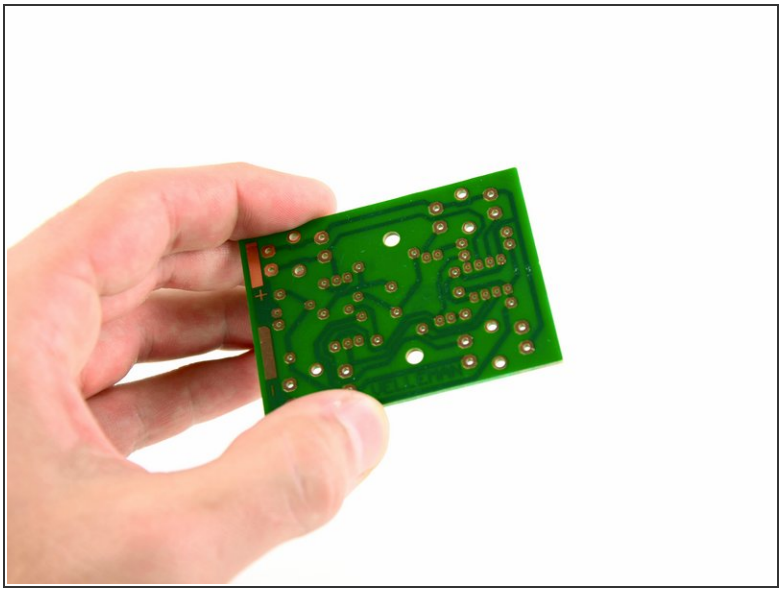
- Desoldering Braid (1)
- Metric Combination Nut Driver (1)
- Phillips #2 Screwdriver (1)
- Flush Cutter (1)
- Solder (1)
- Spudger (1)
- Soldering Iron (1)

PARTS:

- Electronics Skills Kit 101 (1)

Step 1 — Electronics Skills Kit 101





- Before diving into the assembly of your brain game, we should go over the procedure for through-hole soldering.
- Why is it called through-hole, you ask? You'll notice the circuit board has a bunch of holes in it, each with a copper trace on the underside of the board. The leads of each component are fed through these holes (hence through-hole) and soldered to the copper trace.

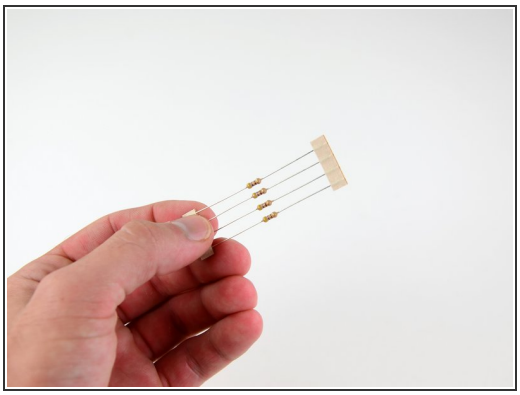
Through-hole soldering is generally regarded as the simplest form of soldering.

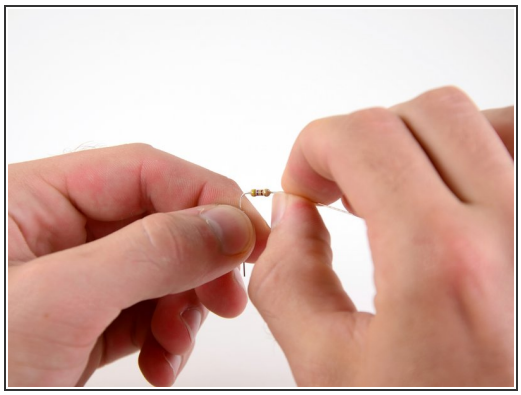
Step 2

- The most important tool for any soldering job? Your soldering iron, of course! For this procedure we'll be using the soldering station that we sell in our parts and tools store.
- For this project, you won't want your soldering iron to exceed 40 watts *at the tip*. For our station which *draws* 50 watts of power from the wall, it is safe to crank it up all the way to max.
- If this is the first time you're firing up your soldering iron, you may notice some smoke and a not-so-pleasant scent. Don't worry; this is just the coating on the tip burning off. Wait a couple minutes for the soldering iron to stop smoking.
- Before you start soldering, be sure to dampen your cleaning sponge. A dry sponge will just get burned.

⚠ It is always a good precaution to wear safety goggles while soldering. Hot pieces of solder occasionally shoot off and a scorching piece of metal to the eye will ruin even the greatest optimist's day.

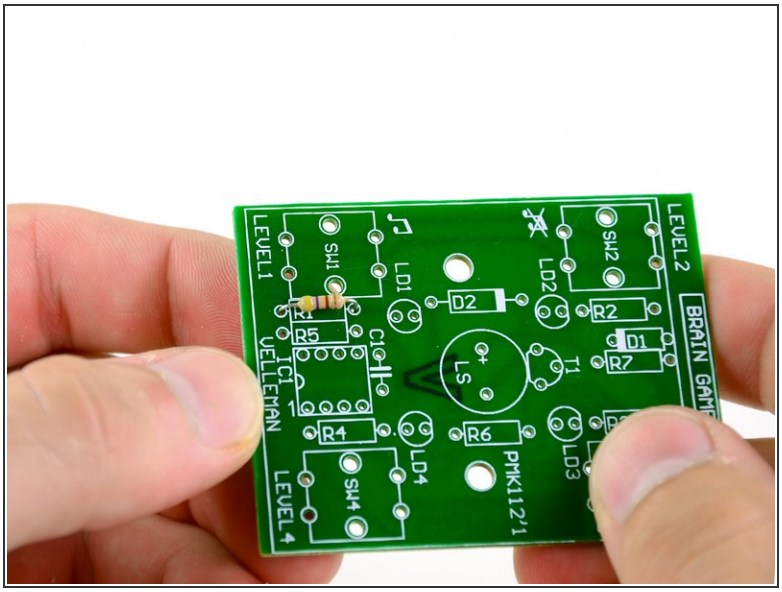
Step 3

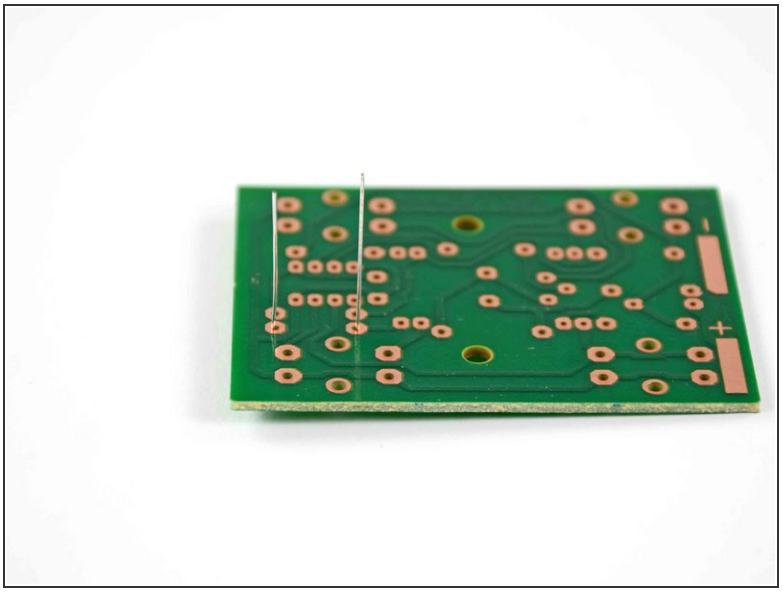




- We'll start with resistor R1 in your kit, which has yellow, purple, brown, and gold rings on it (more on what these colored rings mean later).
- Bend the leads of the resistor to 90 ^{o} angles about 1.5 mm away from the body of the resistor.

Step 4





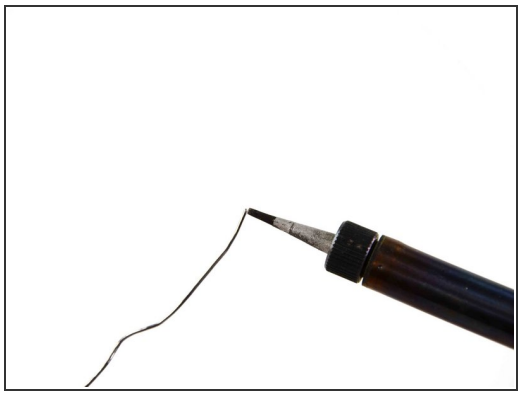
- Place the leads of the resistor through the holes on either side of the rectangle marked **R1** on the circuit board.

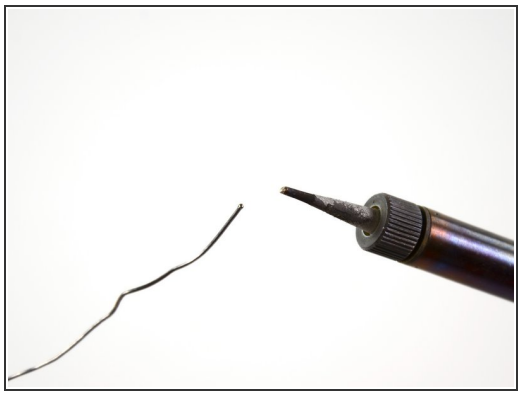
  Resistors do not have to be installed in a particular orientation. Either lead can go into either hole.

- Turn the board over so that the copper traces are facing up and the resistor leads are pointing straight up in the air, as seen in the second picture.

  You may also bend the leads outward to hold the resistor in place, but this is not necessary. As per NASA guidelines, any angle up to 30° down from vertical is acceptable.

Step 5

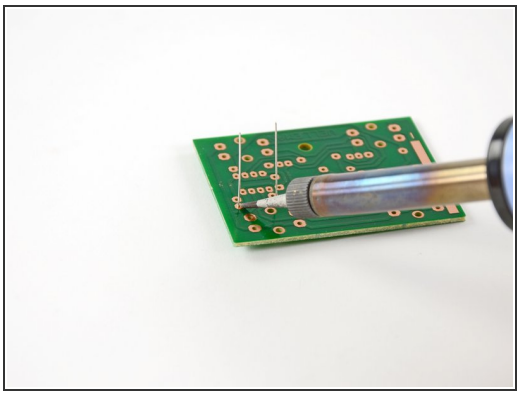
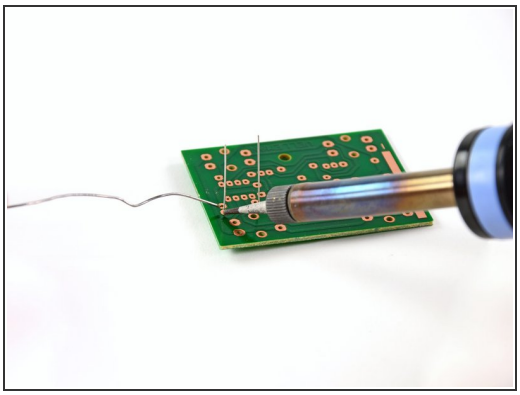
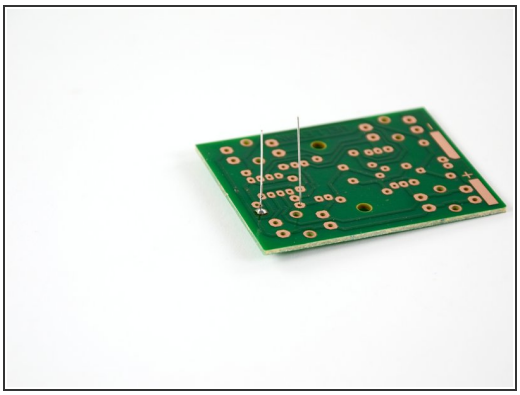




- You must be itching to throw down some molten metal by now; however, you still need to prepare the tip of your soldering iron.
- Now that your soldering iron's tip is hot, clean it by melting a small amount of solder directly on the tip and wiping it off on your damp sponge.
- Melt another small ball of solder onto the tip of the soldering iron, but do not wipe it off. This is called "tinning" the iron, and will improve heat conductivity, allowing you to solder more quickly and efficiently.

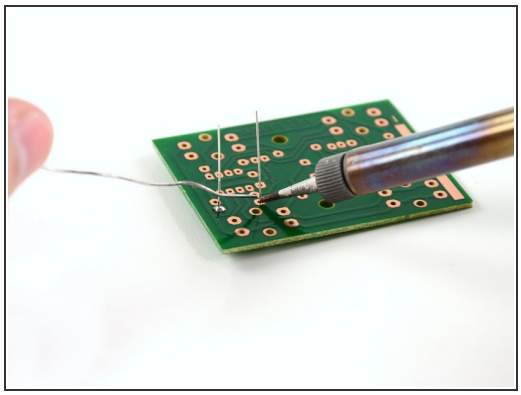
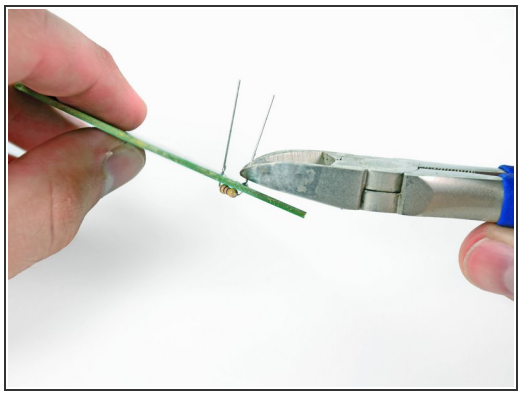
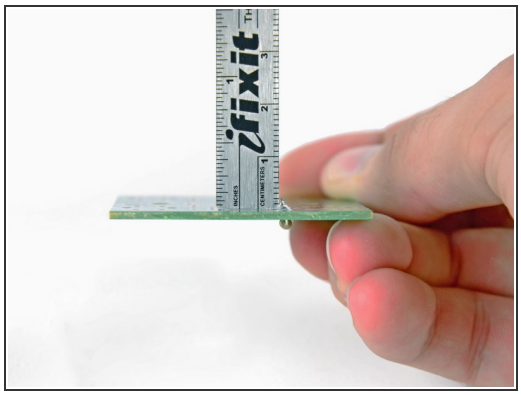
Regular cleaning and tinning of your soldering iron while working will lead to better solder joints and longer tip life.

Step 6

- Here we are: the moment of truth. It's time to get that solder flowing.
- Set the tip of the soldering iron on the two parts to be connected. In this case, that's the resistor lead and the copper trace on the circuit board.
- Touch your solder to the tip of your soldering iron to melt it onto the joint. Don't hold it there for more than a second or two.
- Quickly, but not frantically, pull both the soldering iron and the solder away from the joint.
- Your solder joint should be shiny and conical, and not expand beyond the copper trace.

Step 7

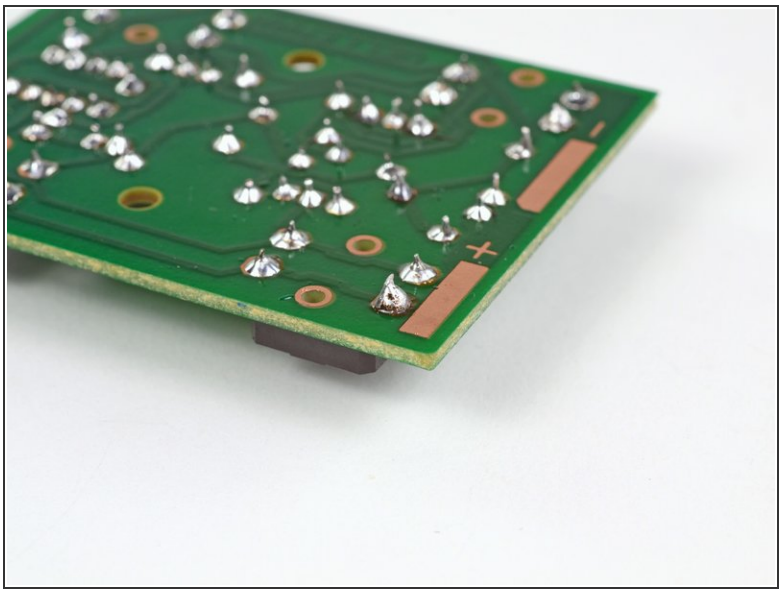




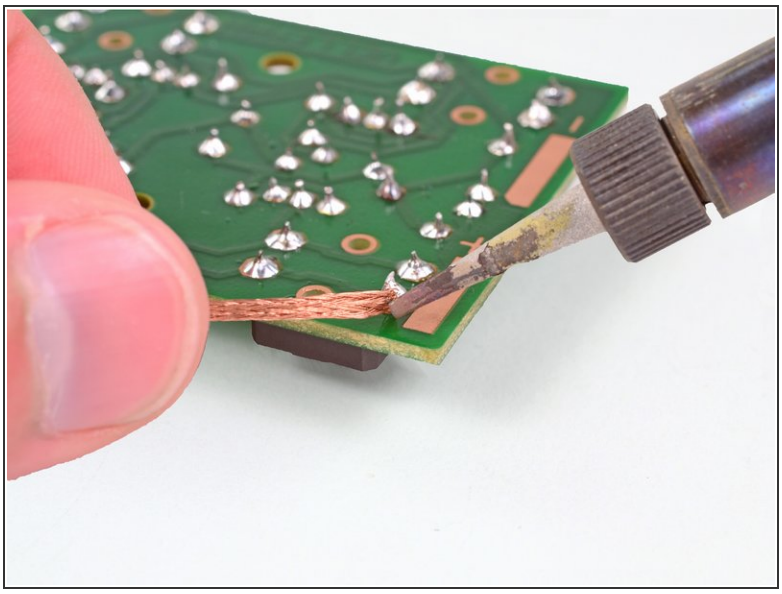
- Use the same method above to solder the second resistor lead to the circuit board.

  After soldering a joint, if you are going to put the soldering iron down, be sure to place it back in its stand to prevent burning yourself or anything around you.

- Cut the extra lengths of the resistor leads with a pair of wire cutters. NASA workmanship standards state that any length up to 2.29 mm is acceptable.

Step 8



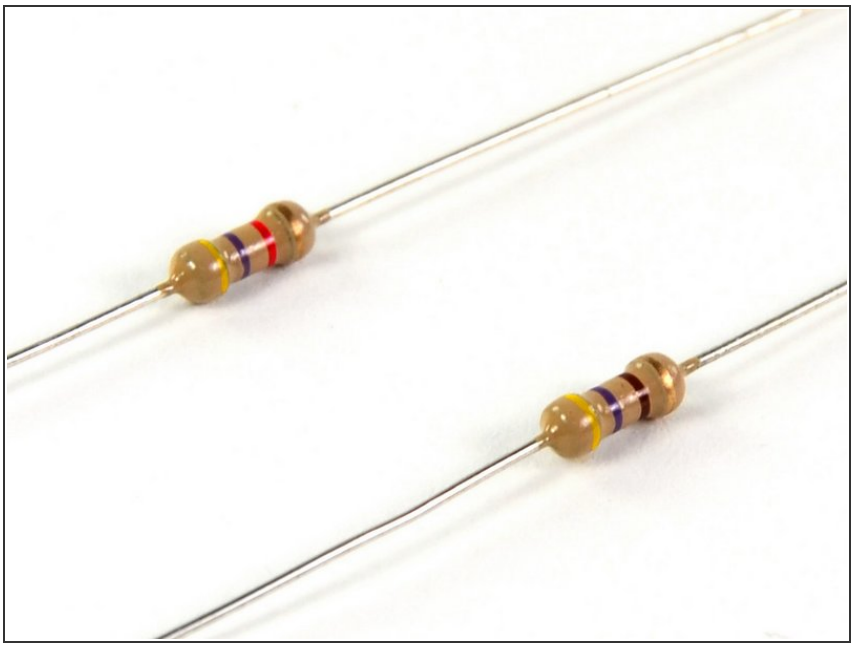


- We all make mistakes, especially when trying something new. Soldering is no exception, so here's what to do when one of your soldered joints comes out less than ideal.
- Lay a strand of desoldering braid over the solder in question. Press the tip of the soldering iron firmly onto the desoldering braid. This will heat up both the solder and the braid.

  Do not hold the braid close to the solder point while using it—it gets very hot and can burn you.

  Be careful not to lay the desoldering braid across the fiberglass circuit board. As the braid heats up, it could leave marks in the board.
- The solder should flow from the joint to the desoldering braid. After the solder flows into the braid, remove it and the soldering iron from the board. You should now have a clean contact to start over with. Use wire cutters to cut off the used end of the desoldering braid.

Step 9

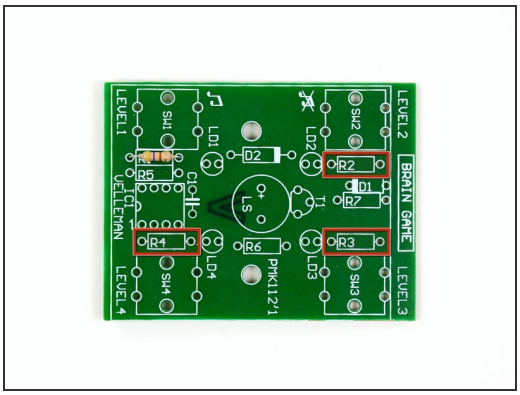


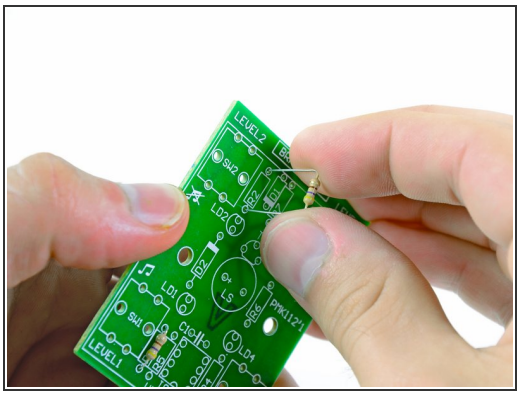
- So, what are resistors, and why do we care about them? Resistors are components used in circuitry to control the amount of current flow. The more resistance a resistor has (measured in Ohms, Ω), the less current it allows to flow.
- The colored bands on a resistor are the key to determining the resistance of that particular resistor. A resistor color code chart will come in handy here.
- If there are four bands on your resistor, the first band to locate is the red, gold, or silver band on one of the swollen ends; these are called tolerance bands. Since our resistors have gold bands, we know the actual resistance is within ±5% of the nominal value
- The next step is to determine the nominal value of your resistor. Starting at the opposite side of the tolerance band and moving from left to right, there are three colored bands. The first two color bands correspond to a number (0-9), and the third band is the multiplier band, which corresponds to a specific power of 10.

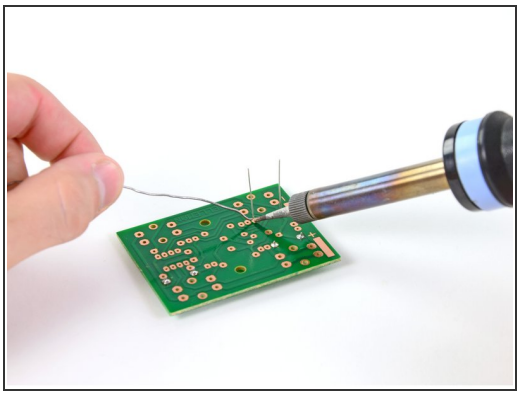
- Looking at the top resistor shown, we see yellow, violet, and red bands. Consulting a resistor color code chart shows us that those correspond to 4, 7, and 100, respectively, giving us a nominal resistance of 4,700 Ω.

ⓘ Can you determine the resistance of the bottom resistor?

Step 10

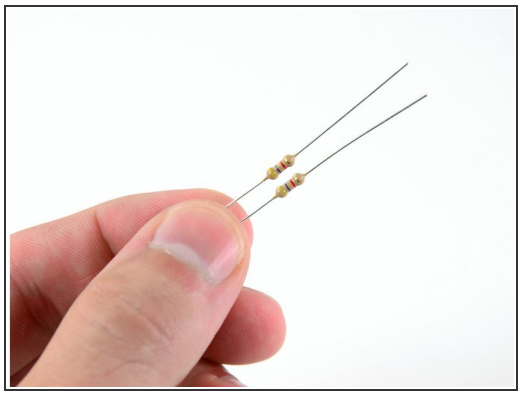
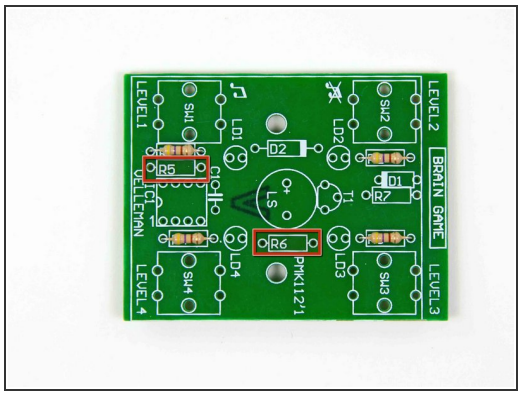


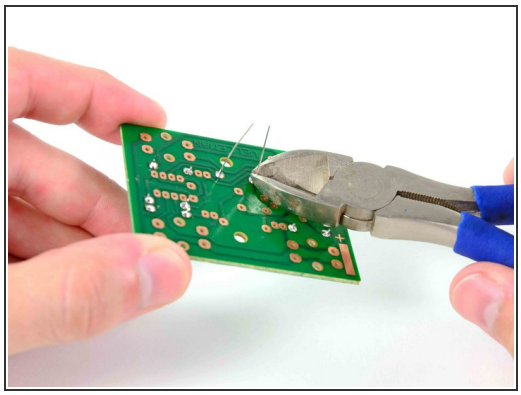




- Install the three remaining 470 Ω resistors (yellow/violet/brown) into the terminals marked **R2**, **R3**, and **R4**.

Step 11

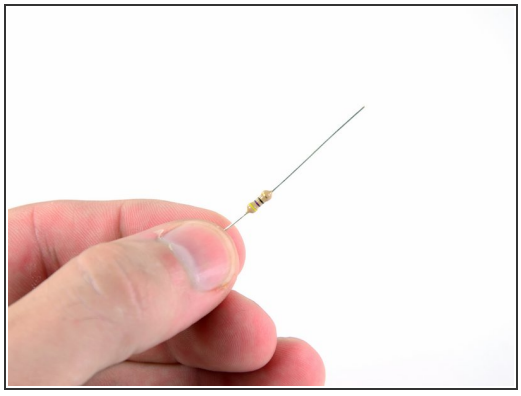
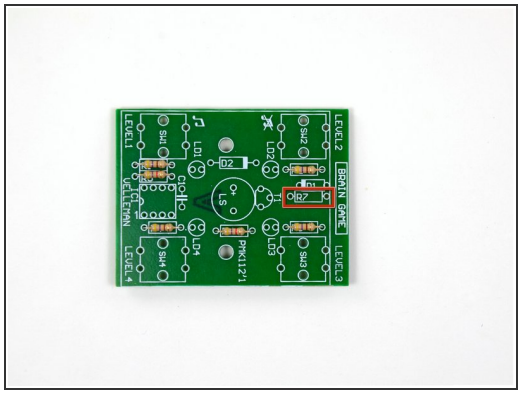


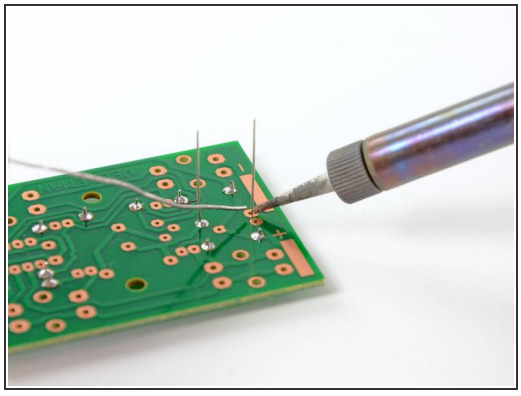
- Fish the two yellow/violet/red resistors out of your kit.

  Consulting our resistor color code chart tells us that these resistors have a 4,700 Ω resistance.

- Install these two resistors into the **R5** and **R6** terminals on the circuit board.

Step 12

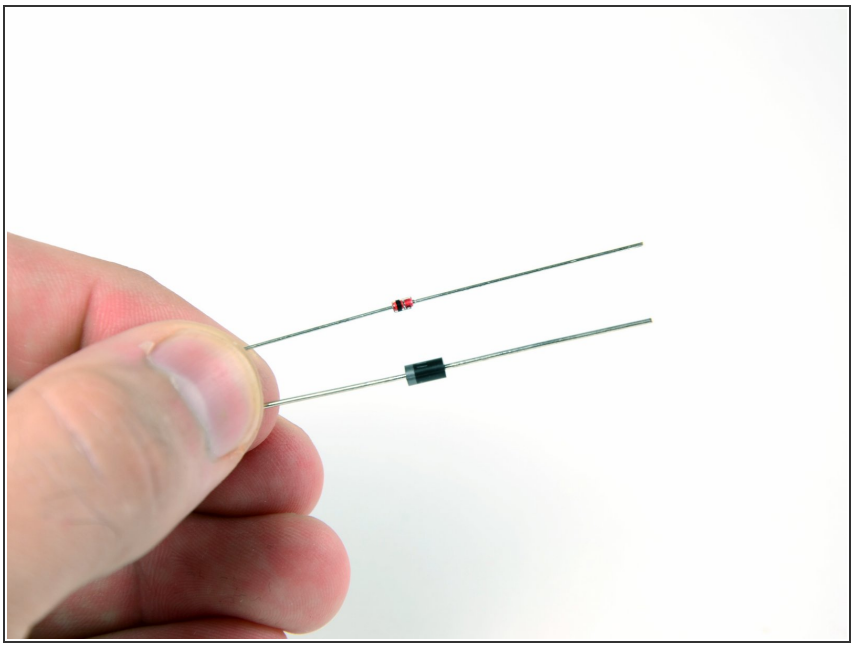


- Locate your single yellow/violet/black resistor.

  Try figuring out the nominal resistance value yourself before we tell you that it's 47 Ω.

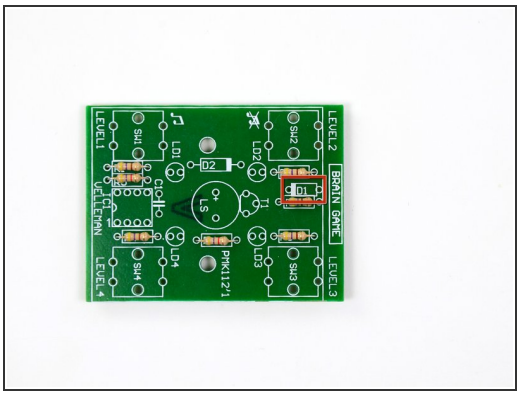
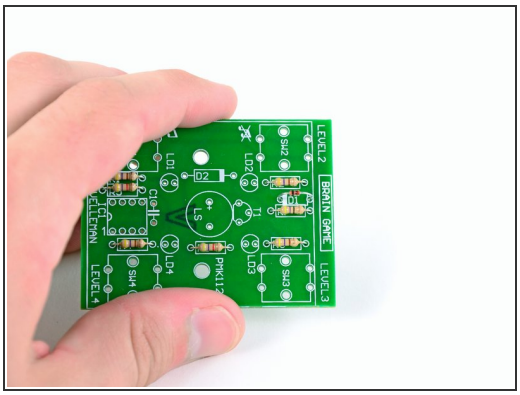
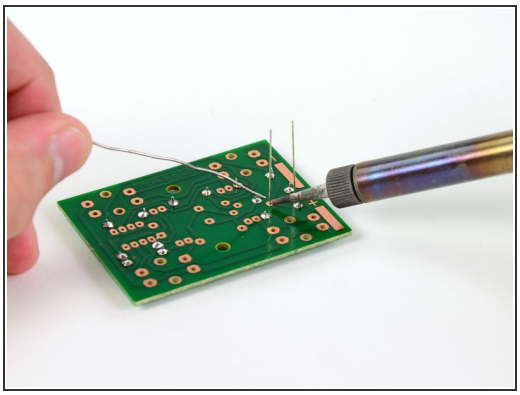
- Install this resistor into the terminal marked **R7** on the circuit board.

Step 13



- Dig around your kit a little more, and you'll find some new and exciting components with long leads attached to them.
- These are diodes—circuitry's "one way" signs. Their job is to make sure that current only travels in the forward direction, from anode to cathode, while blocking it from traveling in reverse. Current enters the anode (positive terminal) and leaves the cathode (negative terminal).
- Since they only allow current to travel in one direction, it is rather pertinent that you install diodes with the correct polarity. The stripe on a diode signifies which side is the cathode.

Step 14

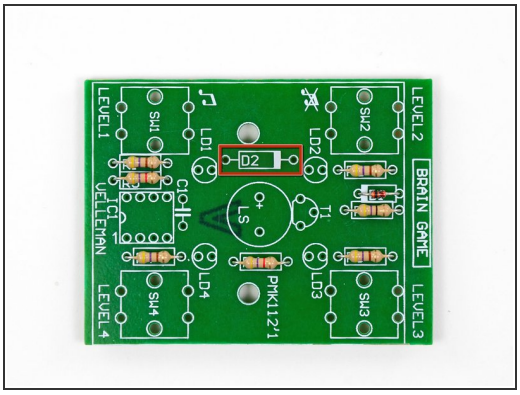
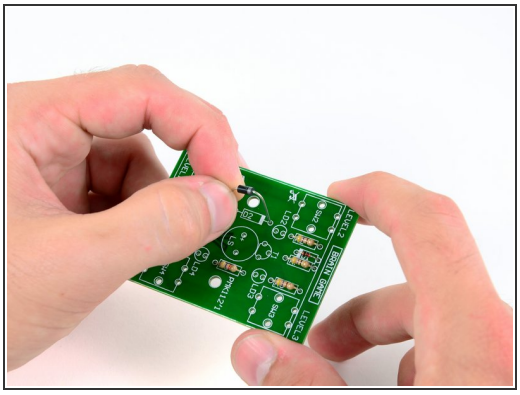
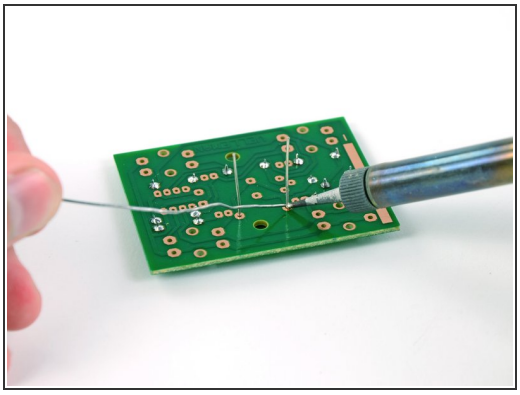




- Bend the leads of the small red diode and insert them into the terminal marked **D1**.

Make sure that the cathode (marked by a small black band) lines up with the white stripe to the left of where it says **D1** on the circuit board.

- Use the same method you used to solder the resistors to the board to install the diode.

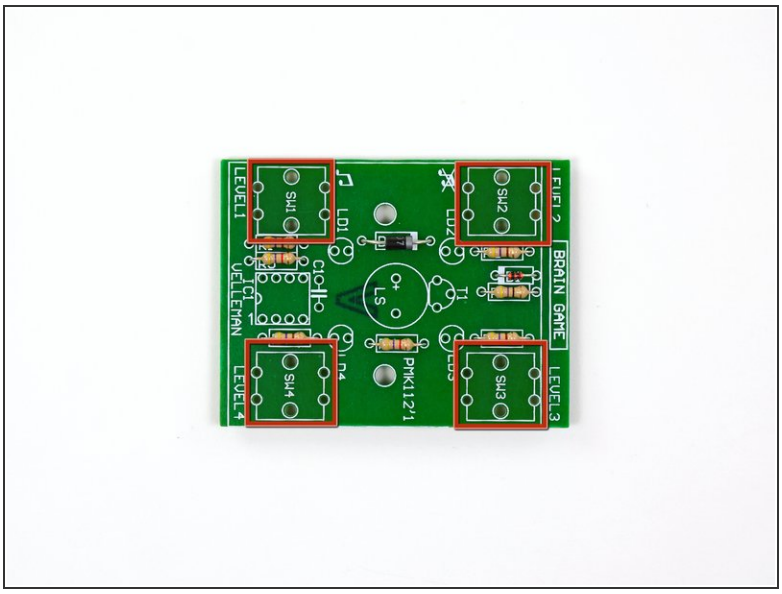
Step 15

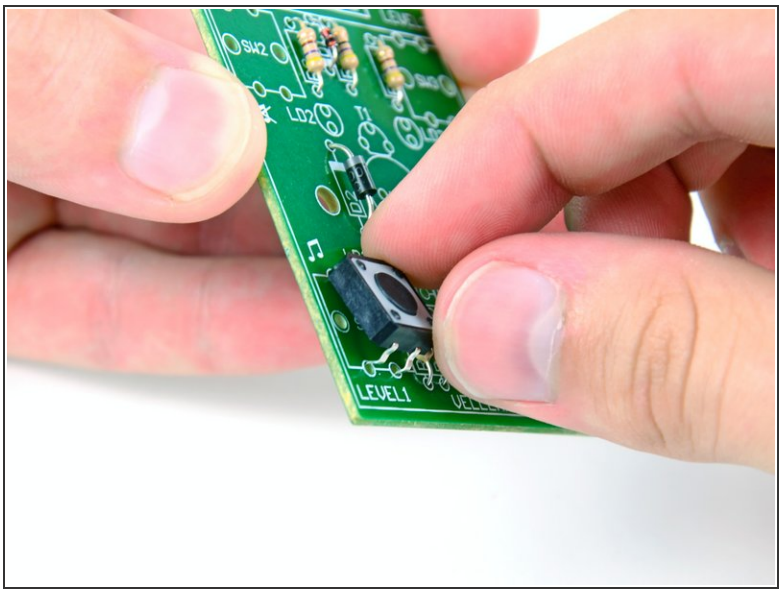




- Install the larger, black diode into the terminal marked **D2**.

Don't forget to line up the gray end of the diode with the side of the terminal marked for the cathode.

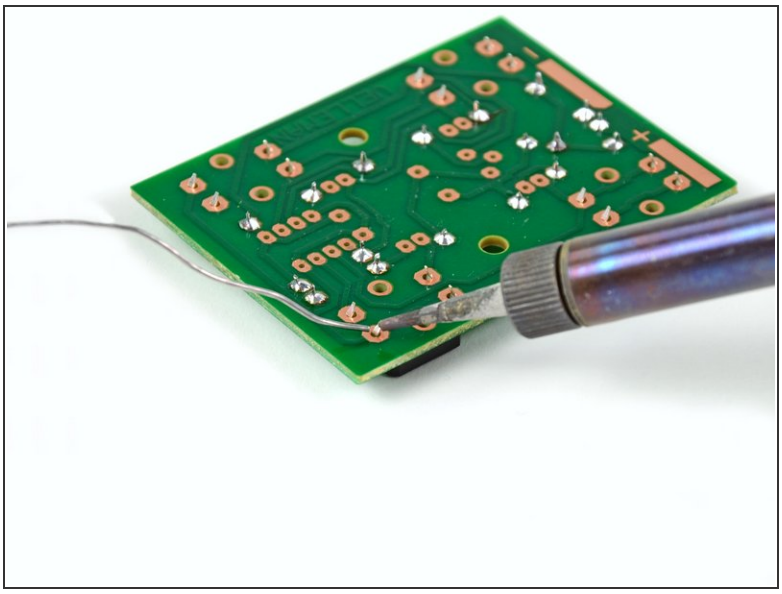
Step 16

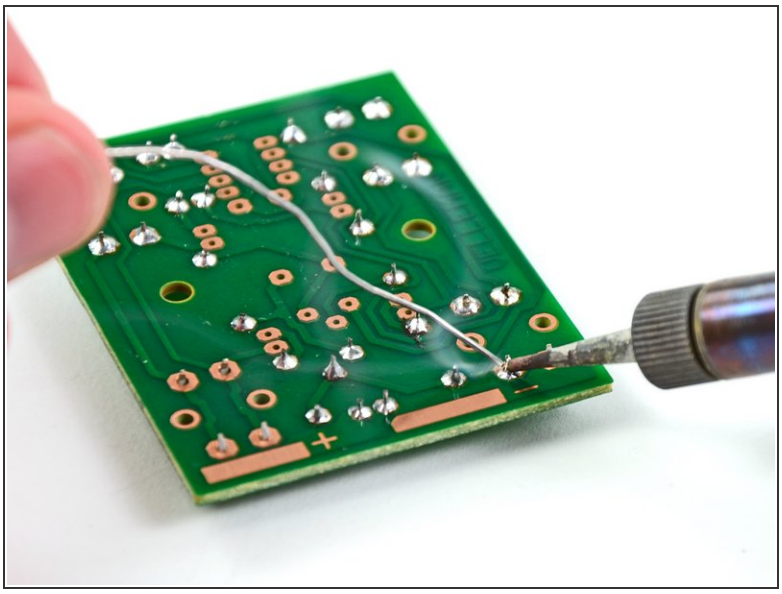




- No game is really a game until there are buttons involved, so let's put those on the board next.
- Insert the leads of the four buttons into the spots marked **SW1** through **SW4**.
- There is no particular orientation that the buttons must be installed in, as long as the leads are properly seated in their holes.

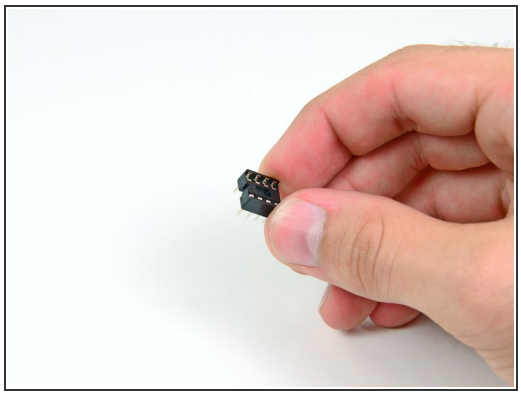
Step 17

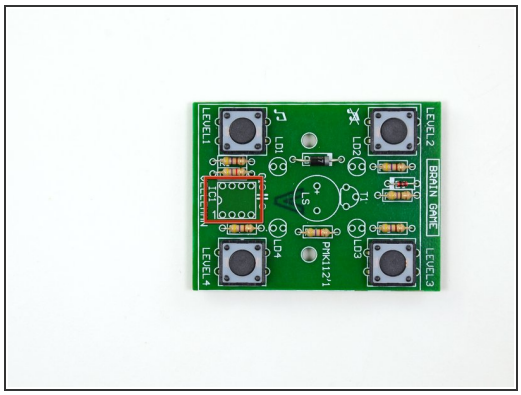


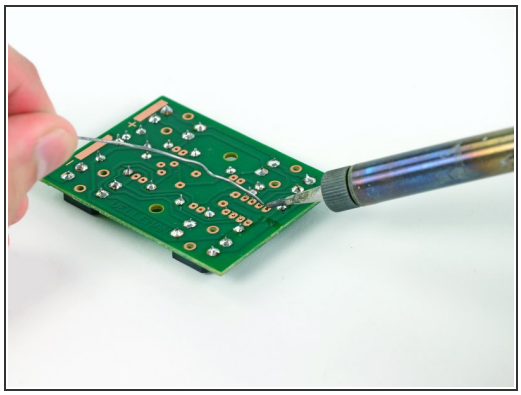


- Solder each of the leads for each button.
- The technique for soldering the buttons is the exact same as soldering the resistors and diodes, except that you do not need to cut any excess leads after soldering the joint.

Step 18

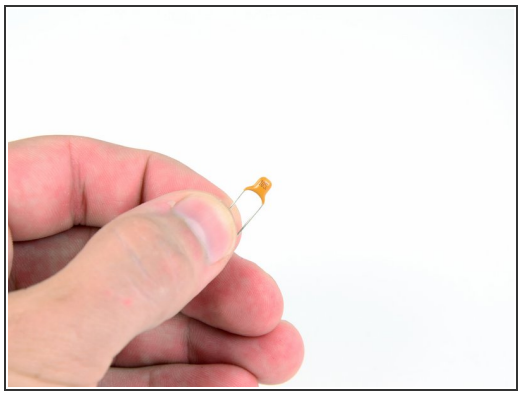


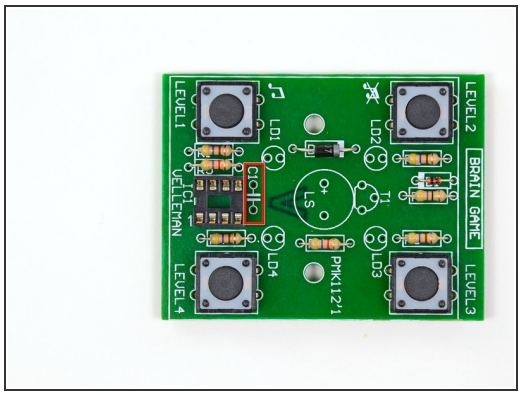


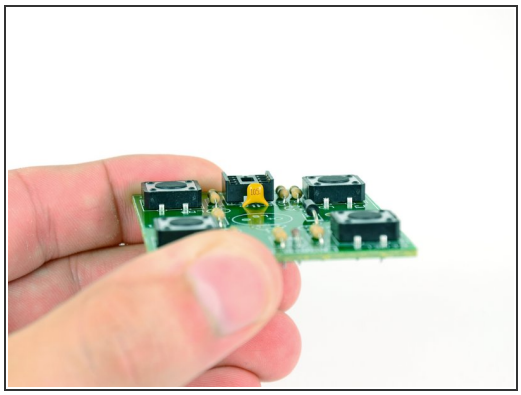


- Next you will install the IC socket, also known as a CPU socket. IC sockets use a mechanical connection to connect a processor to a printed circuit board. These sockets allows the processor to be easily replaced without the risk of damage associated with soldering processors directly to a circuit board.
- Stick the eight leads of the IC socket through the holes in the rectangle marked IC1. Make sure that the semi-circle on the top of the socket lines up with the semi-circle printed on the edge of the rectangle on the circuit board.
- Turn the board over and solder the eight leads of the IC socket to the board. Similar to soldering the buttons, there is no need to trim any excess off the leads.

Step 19



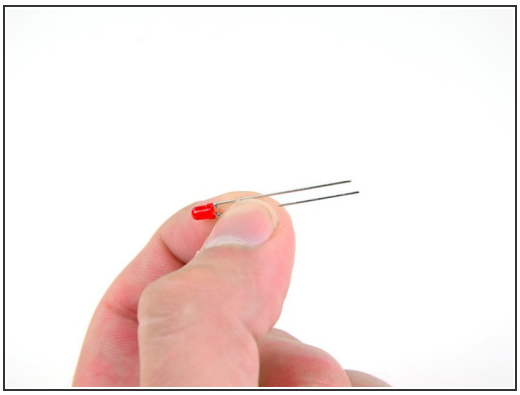


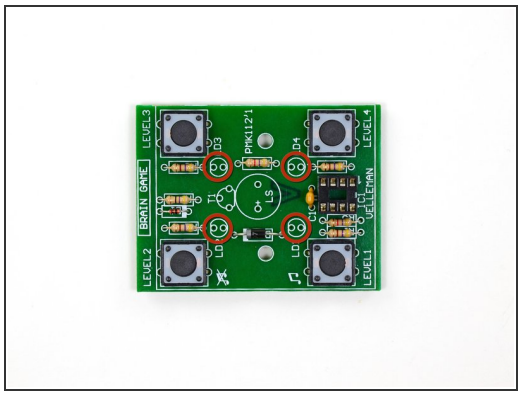


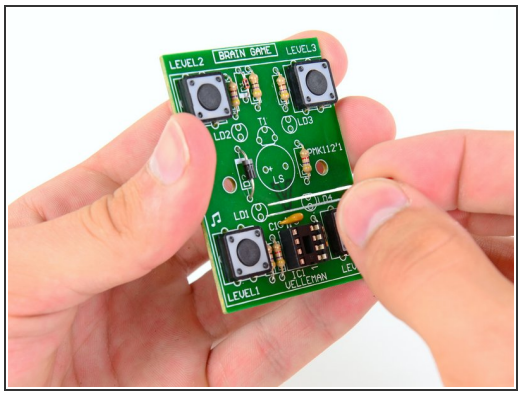
- The next component we will be installing is the yellow capacitor. Capacitors store electrical charge, and are helpful when a circuit needs a quick shot of energy to illuminate a light or make a beep.
- Capacitors are measured (in Farads) as the ratio of the electrical charge on each conductor to the potential difference between them. This capacitor is a 1 µF capacitor.
- Install the capacitor in the terminal next to the IC socket marked **C1**. Soldering the leads of a capacitor follows the same through-hole procedure used thus far.

Make sure that the printed markings on the capacitor face away from the IC socket so that you can still read it.

Step 20







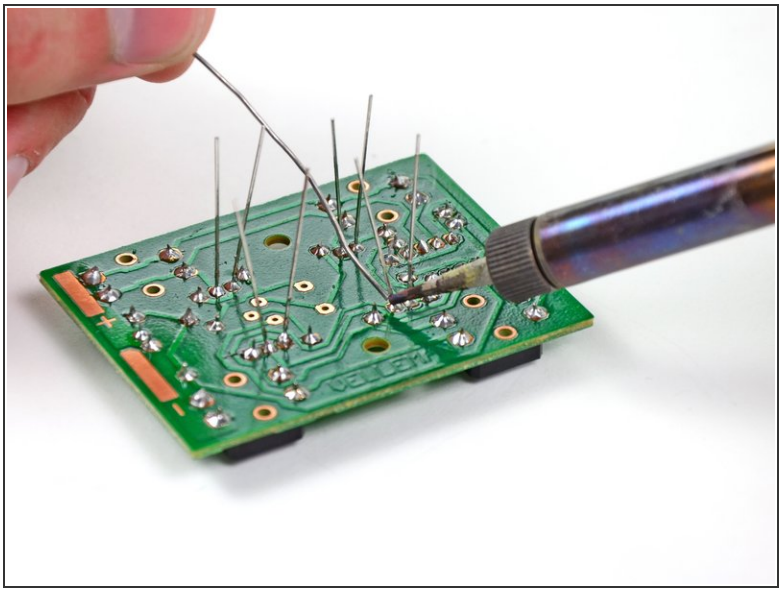
- The next components to install are the LEDs. Light emitting diodes are used in all sorts of electronics to provide bright, different colored lights.

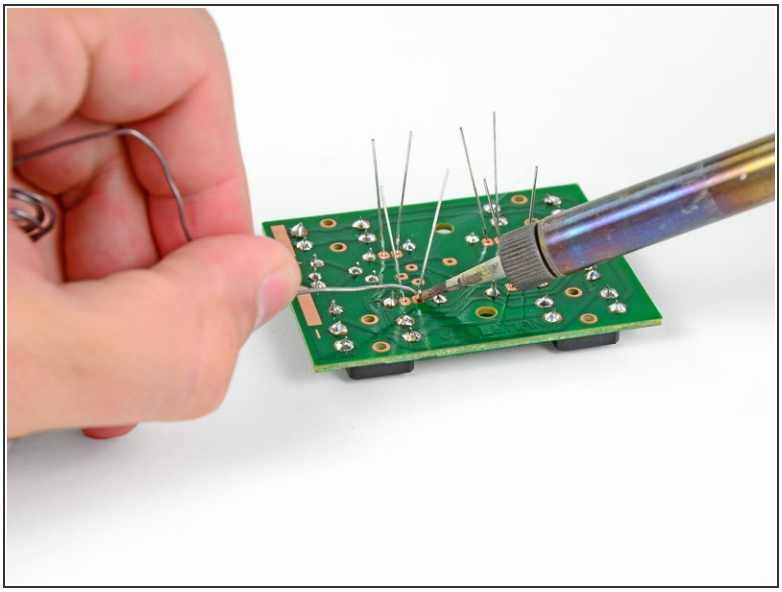
  Note that the two leads are different lengths. Since an LED is a diode, it only allows current to travel in one direction, so it is important to install the correct lead in the correct hole.

- The four LEDs belong in each of the four terminals marked **LD1** through **LD4**.

- When installing the LEDs, insert the shorter of the two leads into the hole next to the flat part of the printed circle.

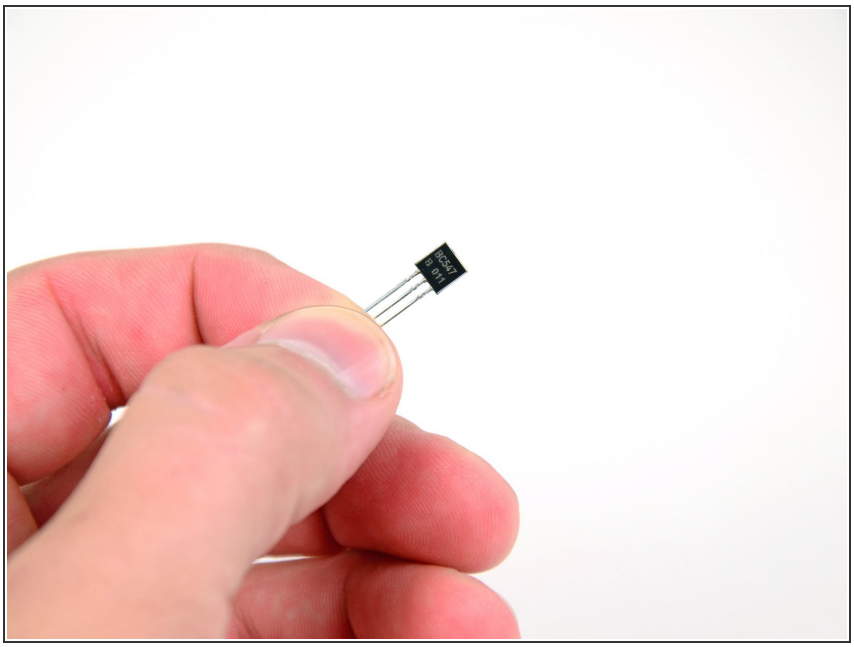
Step 21





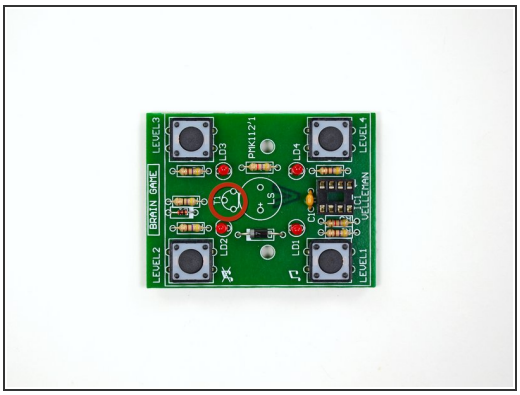
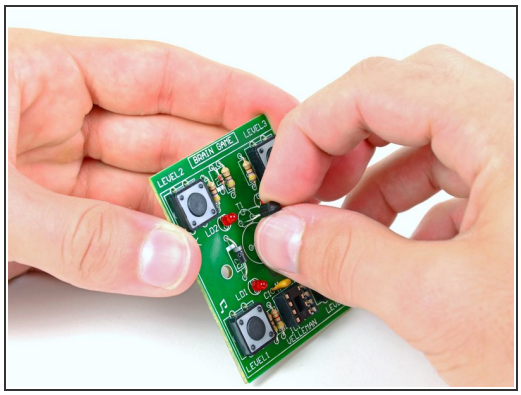
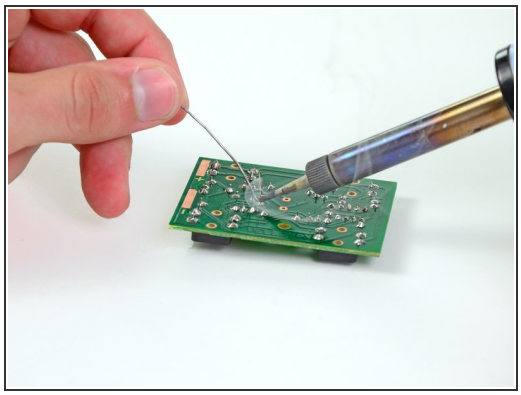
- Solder each of the LEDs to the circuit board and cut the excess off each lead.

Step 22



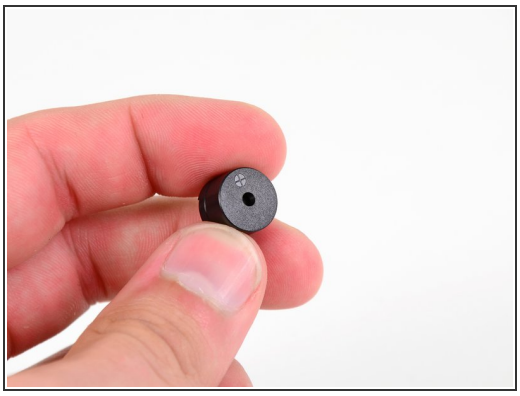
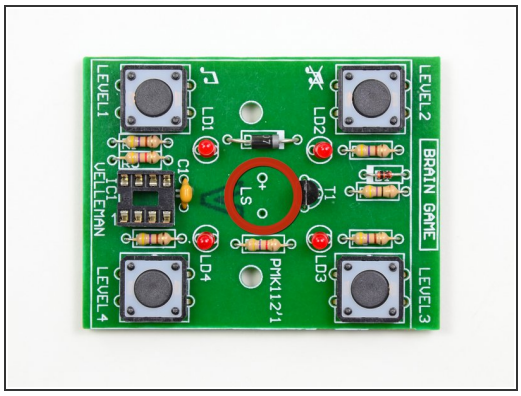
- Another cool electrical component? How exciting!
- Transistors are used to amplify and/or switch electrical signals. This means that they can either increase an input voltage, or be used as electronic on-off switches.
- The important thing to pay attention to when installing a transistor is that you solder each lead to the correct spot, because each one has a different purpose.
  - One is used as the current source.
  - One is used as a gate.
  - One is used as a current output.

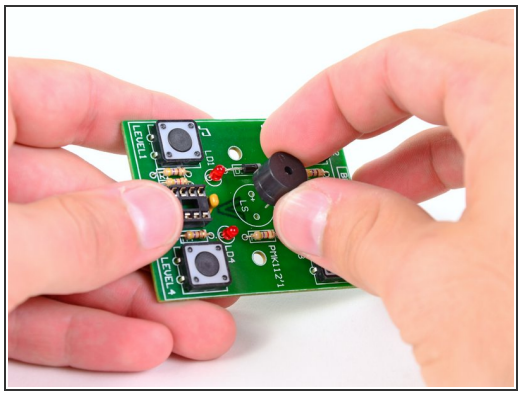
Step 23

- Locate the semi-circle labeled **T1** and insert the three leads through the holes.
  - Make sure that you line up the flat part of the transistor with the flat edge of the semi-circle on the board. The two end leads fit into the holes on the ends of the flat part of the drawing. The middle lead will need to be bent so that it feeds through the hole closest to the **T1**.
- Solder the three leads to the board and cut the excess off the leads.

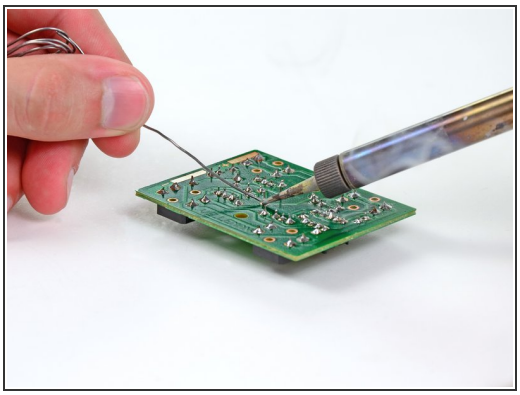
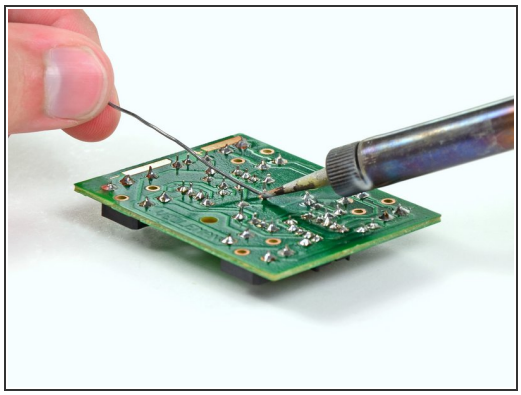
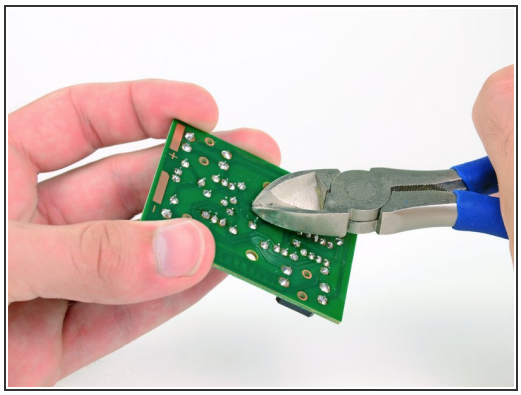
Step 24



- Obviously, your solder creation needs to have a super sweet sound system ... or this speaker. Close enough, right?
  - Note the **+** on the face of the speaker. When installing the speaker, be sure to line this **+** up with the **+** on the circuit board.
- Insert the leads through the holes located in the circle labeled **LS**, making sure to match up the positive terminals.

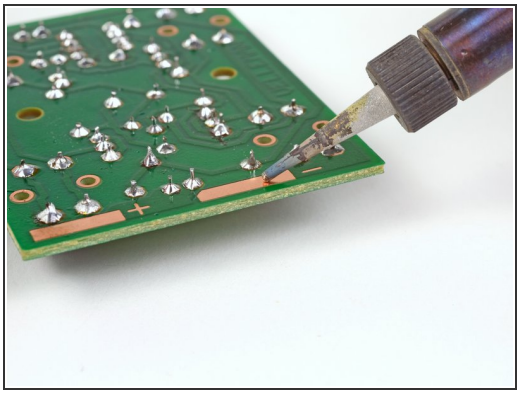
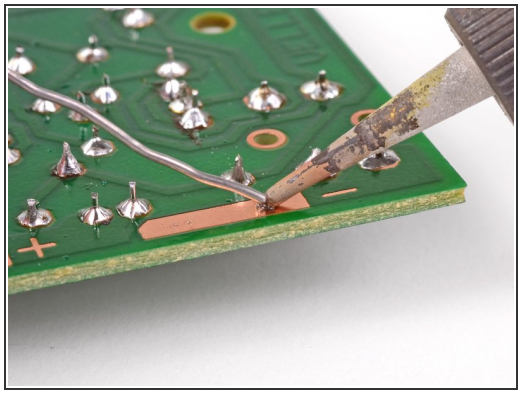
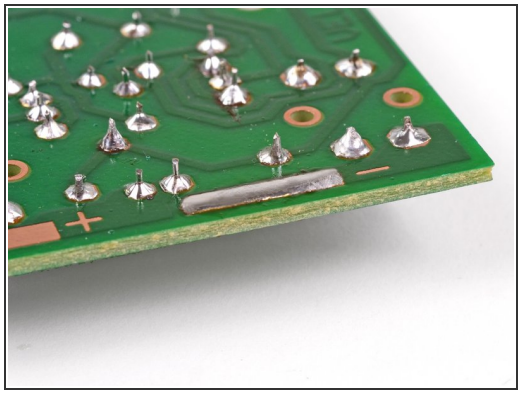
Step 25

- Solder the two speaker leads to the circuit board.

Even though the leads aren't excessively long, you'll need to trim them after soldering.

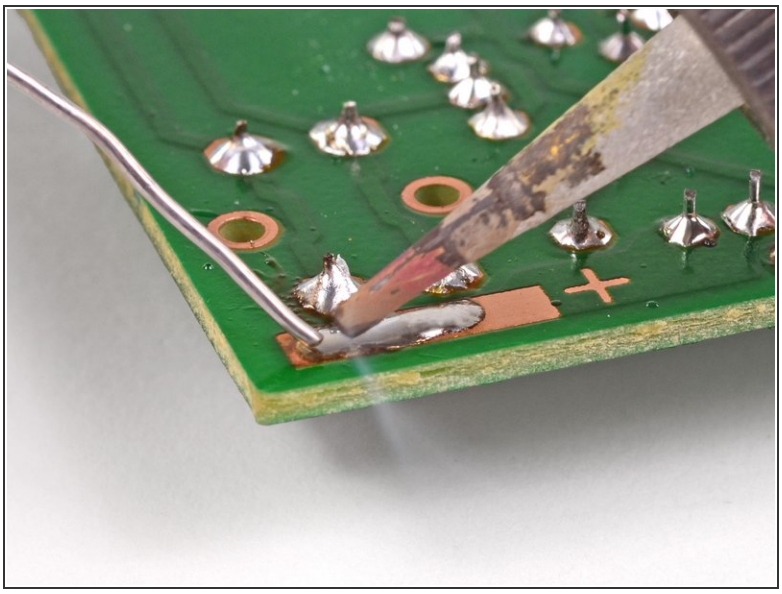
Step 26

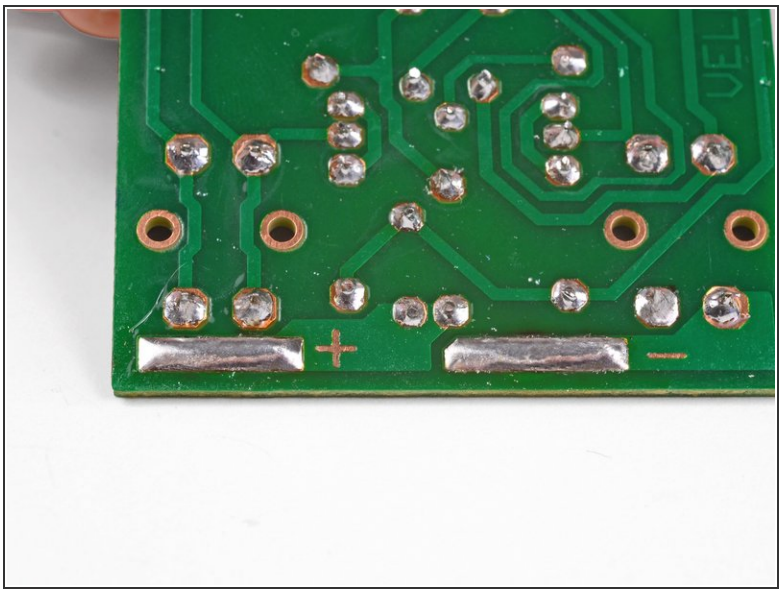




- **Bonus!** You thought you were just learning how to through-hole solder, but Included with this kit is a complimentary intro to surface-mount soldering. Surface-mount soldering is commonly used to attach batteries to circuit boards in some devices, such as iPods.
- Set the tip of your soldering iron on the large copper negative solder pad. This will allow heat to conduct through the solder pad, making soldering easier.
- Touch your solder to the tip of the soldering iron and keep feeding it until you have a smooth, convex solder dome on the copper pad.

If the solder doesn't come out quite right, you can always use the iron to melt it again or add more solder.

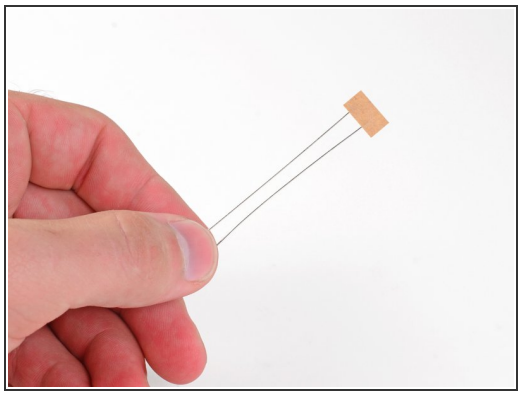
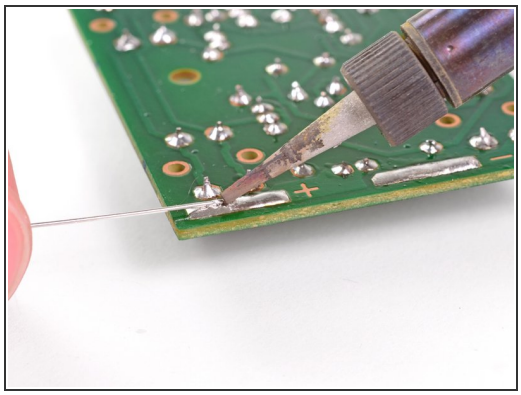
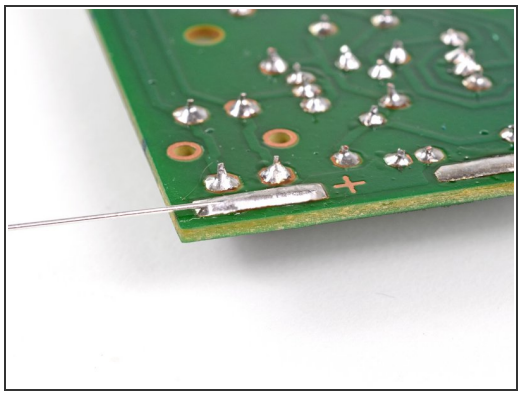
Step 27





- Repeat this process for the positive solder pad.
- You should end up with two long, smooth, convex domes of solder.

Step 28

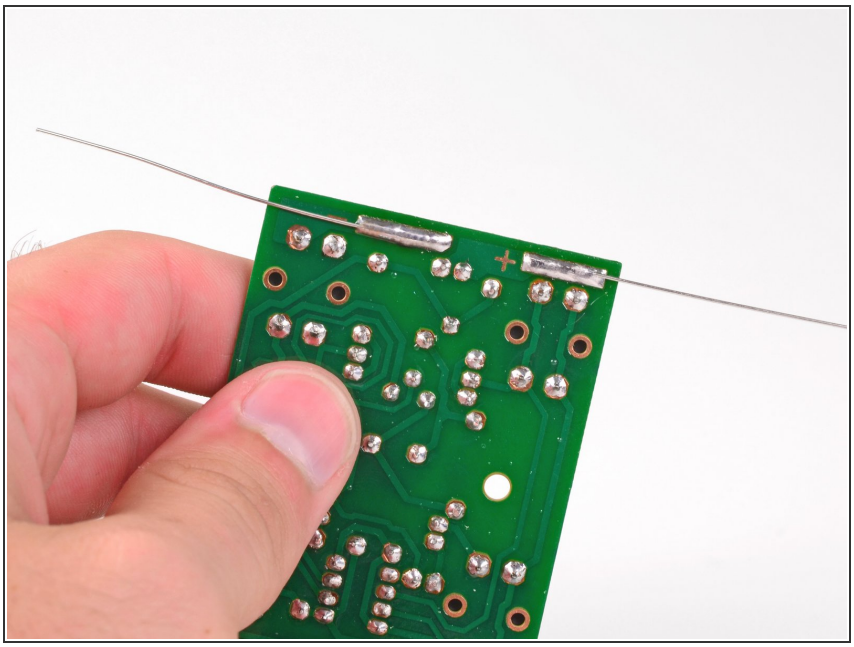




- No, you weren't ripped off; those two leads aren't supposed to have any components in the middle of them.
- To solder the battery leads to the circuit board, set the tip of the soldering iron on the solder that's on the positive pad.
- When the solder begins to melt again, quickly insert the end of the lead into the melted solder so that the lead hangs off the side of the board, as shown.

  ⚠ The leads will heat up and may burn you if you hold them near the soldering iron for more than a few seconds.
- Remove the soldering iron and let the solder cool around the lead.

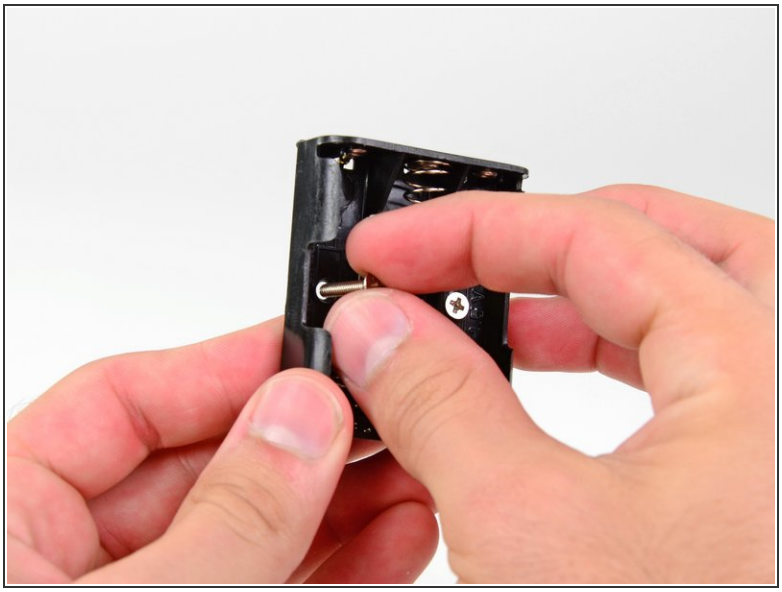
ⓘ You can melt the solder again or add more solder if you don't get it right the first time.

Step 29



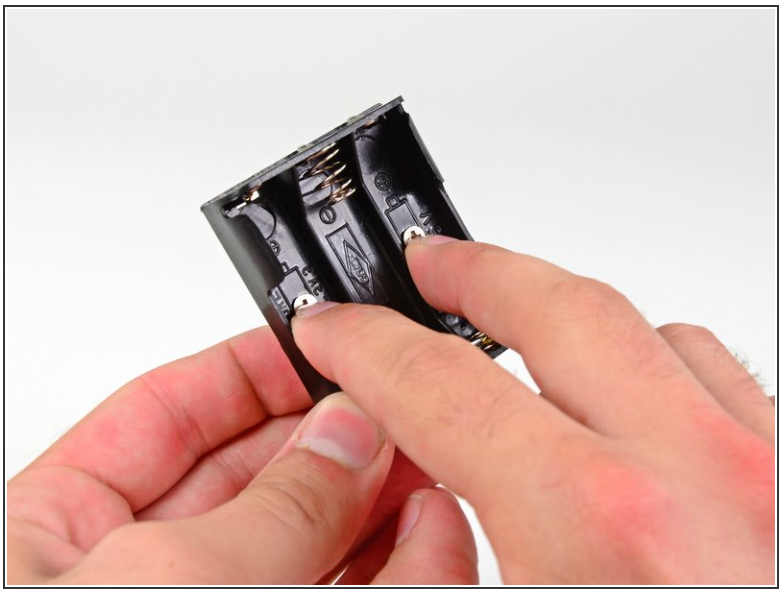
- Repeat the surface mount soldering procedure for the negative battery terminal lead. Be sure to install the lead so that the excess wire hangs off the opposite side rather than the positive terminal lead.
- Now that you have installed whiskers on your circuit board, it's time to pet it and buy it a scratching post. Wait, that's not right . . .

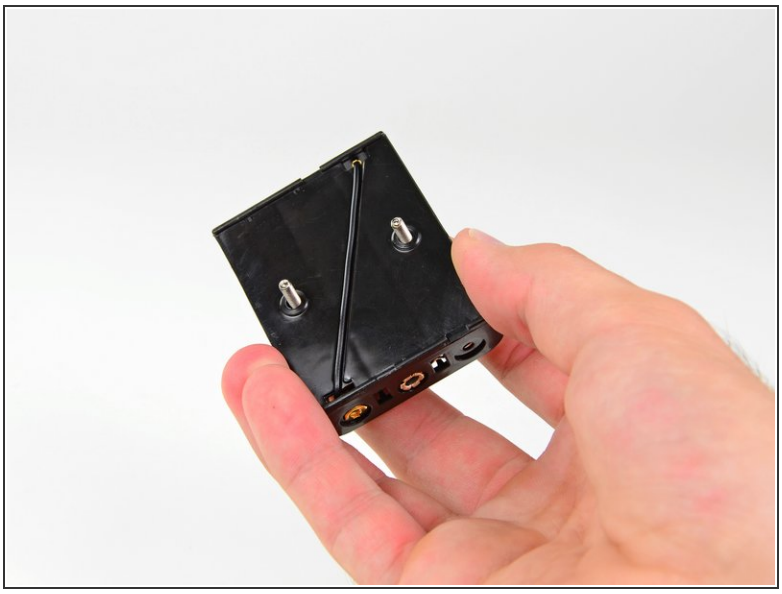
Step 30



- Insert the two Phillips screws through the holes in the underside of the battery compartment.

Step 31



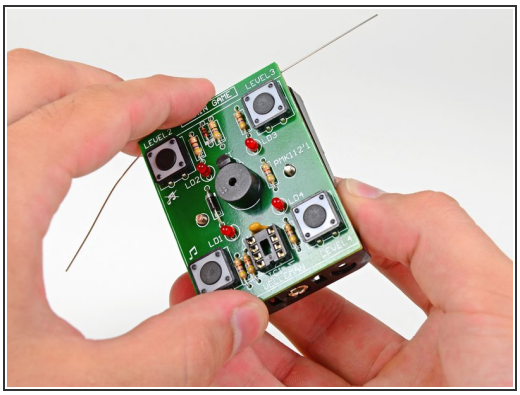
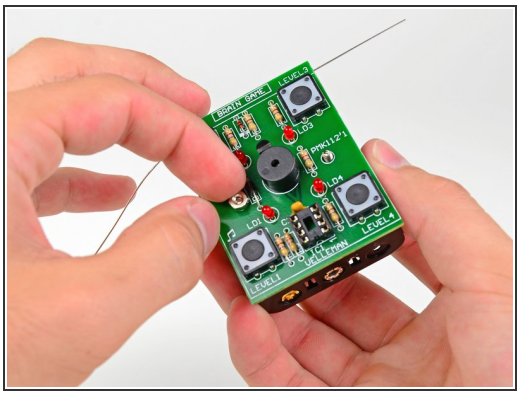
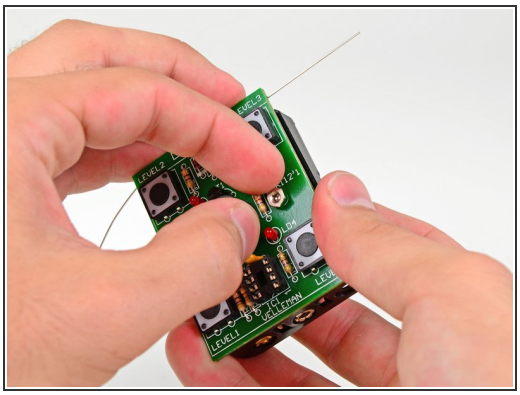


- Place two fingers of one hand over the screw heads.
- Keeping your fingers on the screw heads to hold them in place, grab the battery compartment with your thumb and flip it over. The screw threads should protrude out of the top side of the battery compartment.

Step 32

- Use your free hand to place the two metal spacers over the screw threads (one per screw).

Step 33

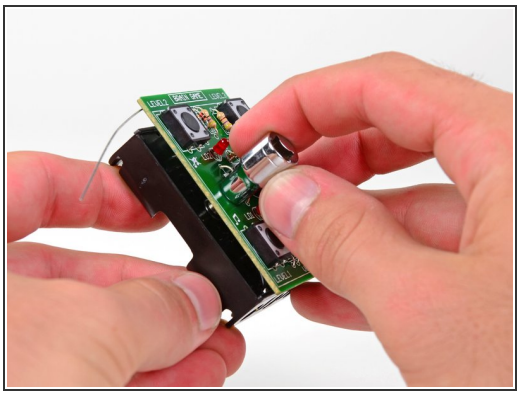
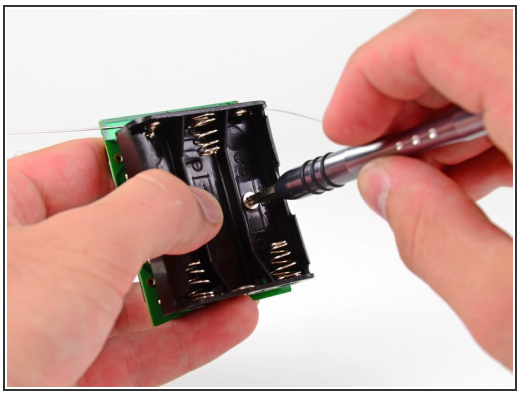
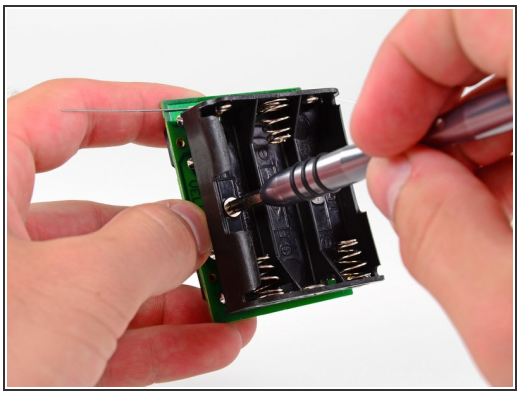




- Continue holding the screws in place and set the circuit board on top of the battery compartment so that the two screws are fed through the holes on either side of the speaker.

  Make sure that the top of the circuit board (the part that says **Brain Game**) lines up with the side of the battery compartment with three metal rings on the outside, as opposed to two.

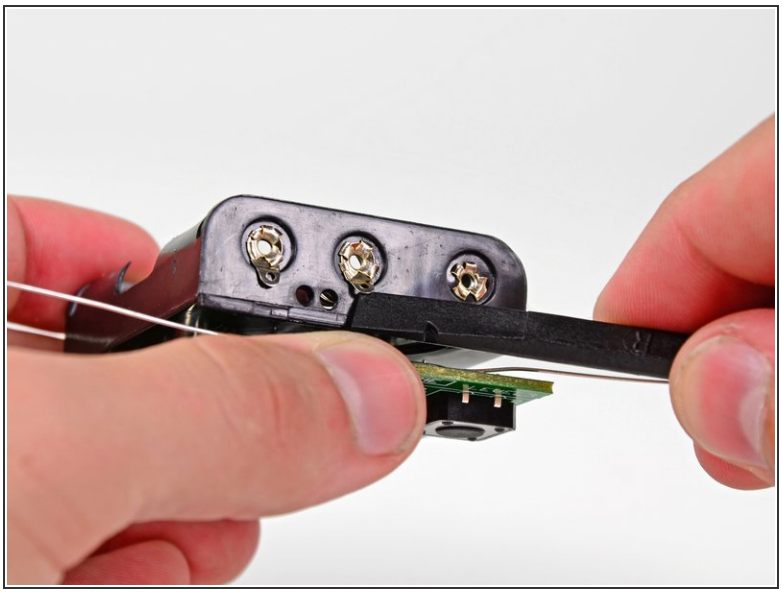
- Hand tighten the two nuts onto the battery compartment screws.

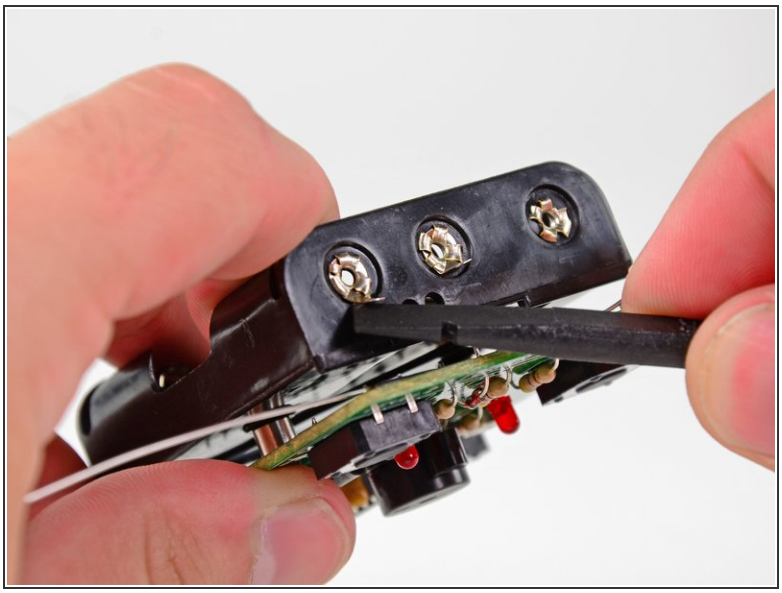
Step 34

- Place a 5.5 mm nut driver or socket over one of the battery compartment screw nuts.
- Turn the circuit board over.
- Use one hand to hold the socket in place and tighten the battery compartment screw with a Phillips #2 screwdriver.
- Follow the same procedure to tighten the other battery compartment screw.

Step 35

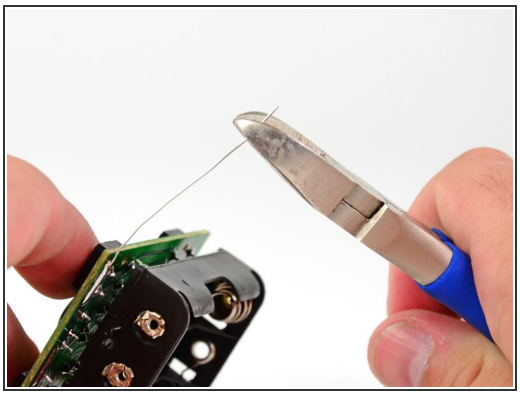
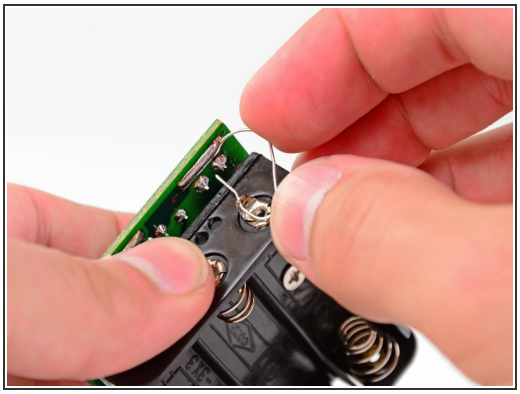
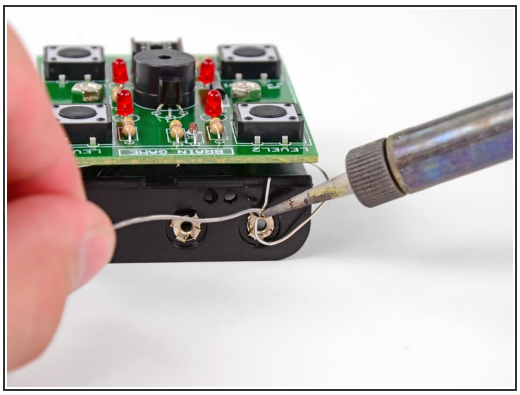




- Use a spudger to pry the metal rings on the battery terminals up so that they perpendicular to the battery terminals.

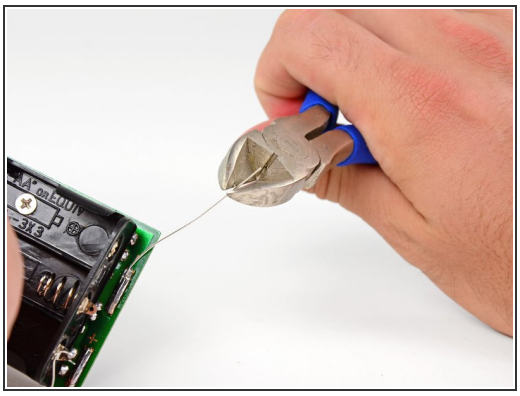
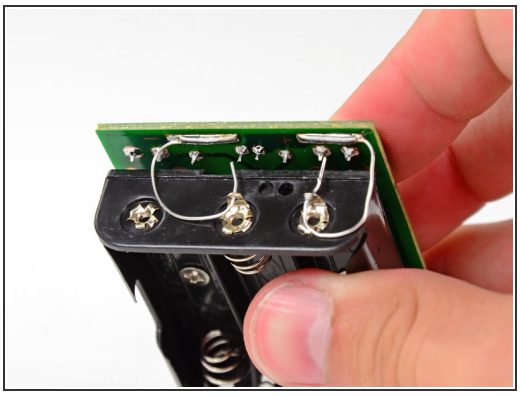
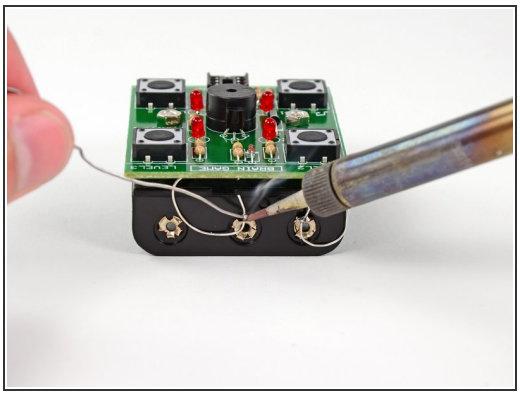
  These rings should be on the same end as the surface mount leads. If they are on opposite ends, the board is on backwards, and you'll need to unscrew the nuts, rotate the circuit board 180°, reinstall the nuts, and tighten the two screws.

Step 36

- Use a pair of wire cutters to remove about an inch of the positive terminal surface mount lead.
- Bend the lead around and through the positive ring terminal on the battery compartment.
- Use your now perfected through-hole soldering skills to solder the lead to the battery terminal.
- Cut off any excess lead.

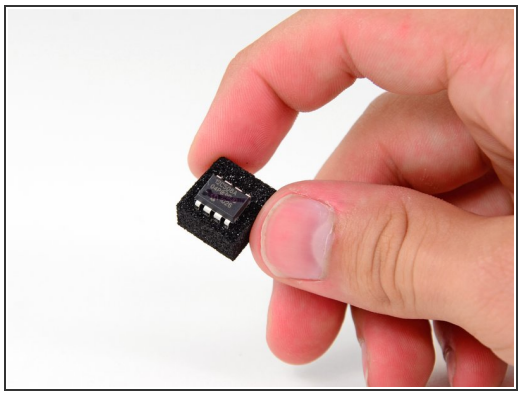
Step 37

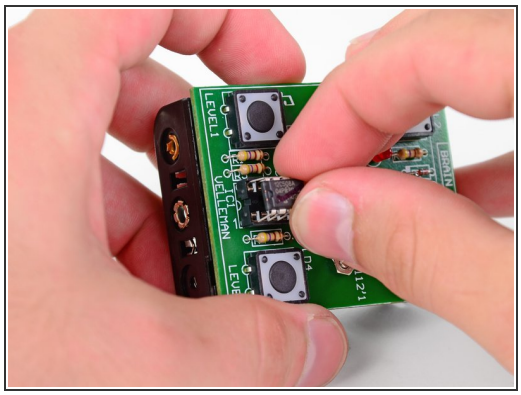




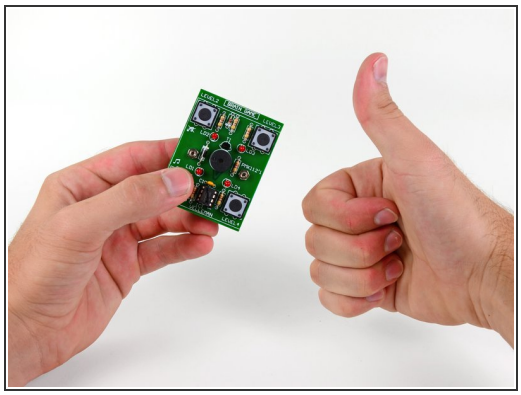
- Repeat the same procedure for the negative battery terminal lead.

Both leads can be any length or shape you would like, but they must not contact each other or any other components.

Step 38

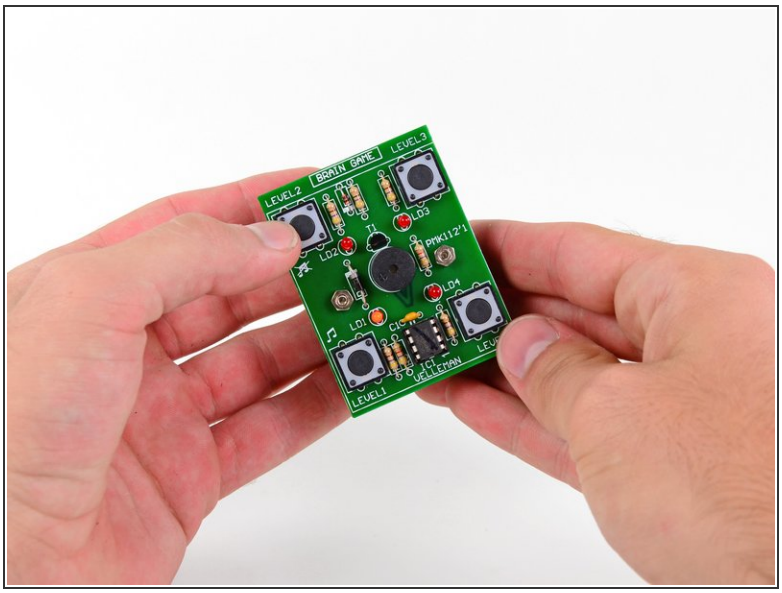






- The final component to install on the circuit board is the central processing unit, or CPU—the brains of the Brain Game.
- One end of the CPU has a small notch in it. When installing the CPU, make sure that this notch lines up with the cutout on the IC socket.
- Install the CPU by pressing the eight pins into their respective holes in the IC socket.
- Congratulations, you have completed the Level 1 Through-Hole Soldering Kit!

Step 39



- Install three AA batteries in the battery compartment.
- Upon inserting the final battery, the four LEDs should start flashing in a clockwise pattern. Congratulations, you did it!
- To play the game, follow these instructions:
  - Remove one of the batteries. Then, reinsert the battery while holding the Level 2 button for no sound or the Level 1 button for sound. Release the button a couple seconds after the battery is inserted. The game will eventually power off on its own. To wake it up to play, press either the Level 1 button to play with sound, or the Level 2 button to play without sound.
  - As the LEDs blink in a clockwise rotation, press one of the four buttons to select the level of difficulty (printed above or below the buttons).
  - After selecting your level, the game begins. It is a typical Simon Says-like memory game. The LEDs will flash one light, then you have to click that button. Then it will flash two lights and you have to click those two buttons in order.
  - The game progresses until you mess up the pattern or take too long to respond.
- Have fun! And be sure to tell us all about your high scores in our Story section.