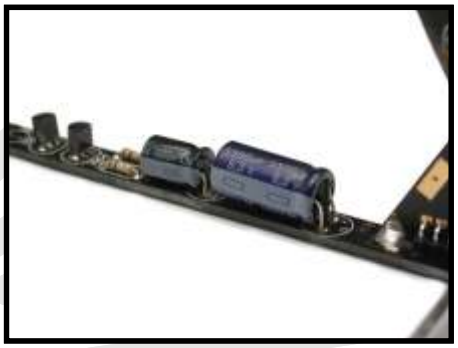
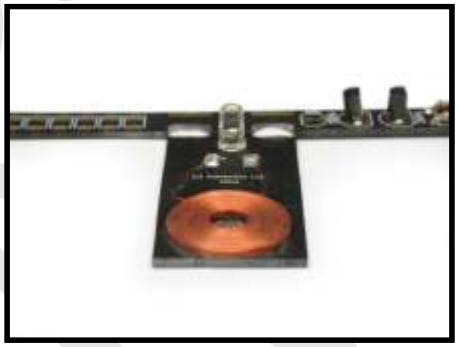
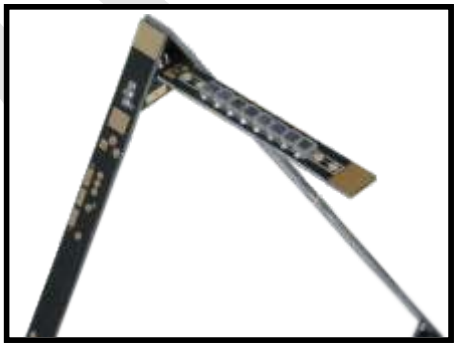
The SOLARBOTICS®

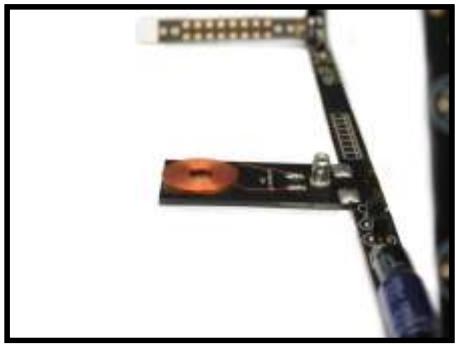
SunSwinger© Pendulum

(also known as "The Pendulum of DOOOOM!")









The SunSwinger is a self-starting, solar-powered pendulum derived from our research for the book "Junkbots, Bugbots, and Bots on Wheels."

The SunSwinger can be configured to be powered from light falling on the string of tiny solar cells, or for continuous operation using a DC power source like batteries or a wall adapter!

SOLARBOTICS® Ltd.

Skill Level: Beginner (Soldering Req'd)

2 hrs

Document Revision: January 8th, 2007

The SunSwinger Pendulum - Parts List

Qty - Location; Description
1 - SunSwinger PCB set; 3 shorts, 3 longs, 3 gussets, one circle, one rectangle
2 - Positions R1 & R2; 100kOhm resistors (Brown / Black / Yellow)
1 - Position D1; 1N914 Diode (clear glass cylinder with black band)
1 - Position 3906; PN3906 PNP Transistor
1 - Position 3904; PN3904 NPN Transistor
1 - Position C1 1000µF; 1000µF electrolytic capacitor
1 - Position C2 3300µF; 3300µF electrolytic capacitor
8 - Part SCPD; Solar Cell Photodiodes (small clear square solar cells)
1 - Position Coil; Red Coil (well, what didja expect? It's a *coil!)*
1 - Double-sided sticky tape (aka: "DSST"), coil & magnet mounting (cut it in half)
6 - 90° 3-pin strips for gusset connectors
3 - 90° 2-pin strips for short stubby connectors
1 - Silicone tubing for short stubby feet
1 - LED (for blinky light effects)
1 - Length of monofilament line (it's easy to lose, so keep track of it!)
1 - Magnet. A powerful one. Beeee careful!
1 - 1" length of wire; Used for making the magnet hook

Tools Required:
Soldering equipment (soldering iron, solder, sponge)
Side cutters (wire snips, or nail-cutters will do)
Wire strippers
Needle Nose pliers
A sense of humor. Hopefully a bad sense of humor, or an appreciation for bad humor.

We strongly suggest you inventory the parts in your kit to make sure you have all the parts listed (c'mon - there's barely a handful of parts, so count them!). If anything is missing, contact Solarbotics Ltd. for replacement parts information.

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The SunSwinger Pendulum started out as an experiment on different ways to implement "Magbot" technology, which is about creating motion with the essentials of an electric motor - a coil of wire and a magnet. If that's what a motor is about, why not simply slap one in there, connect it up, and let'er rip?!? Ah, my young apprentice, there is much to learn about BEAM and *appropriate technology...*

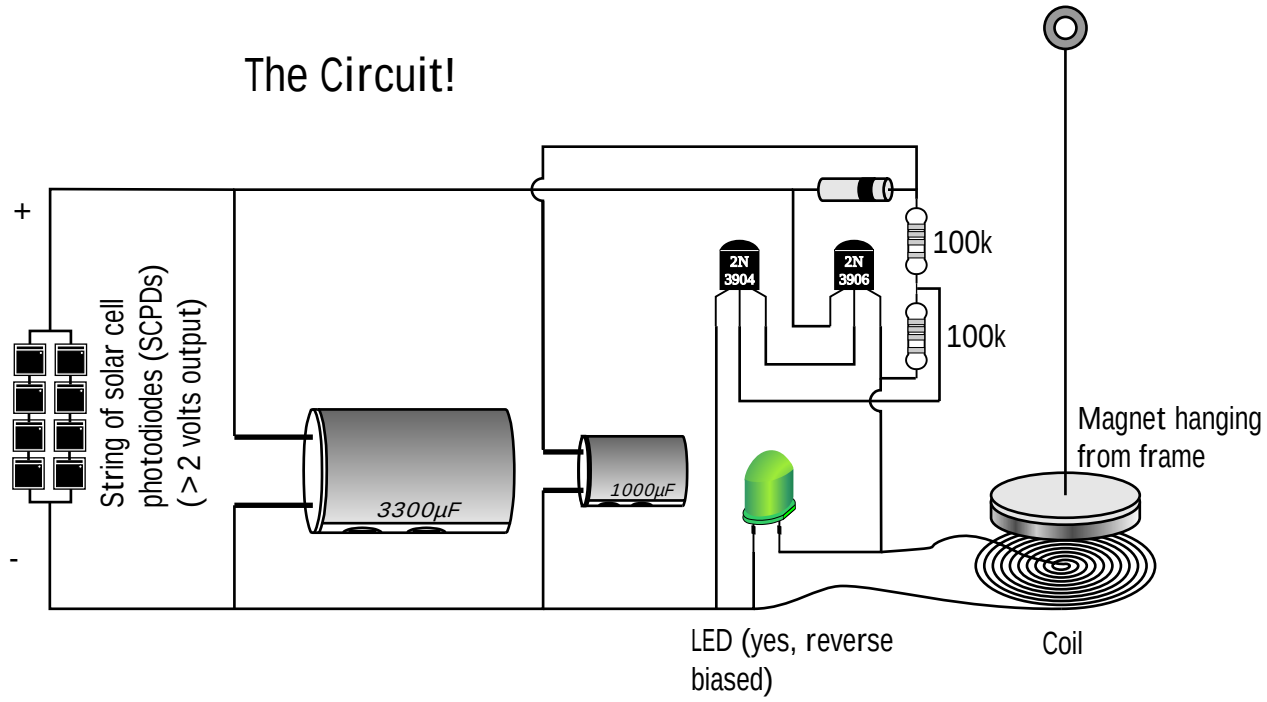
(Warning: Obvious statement alert) A motor is a device that turns electricity into rotational motion [Obvious statement alert finished). The basic principle of all electric motor motion comes from the fact that when you suspend a coil of wire in a magnetic field and shoot power through the coil, the coil pushes or pulls against the magnetic field to create motion. Electric motors are cleverly arranged and designed so that the reaction causes rotation. We are going to take that same basic force (a push or pull) and do something with it that doesn't involve rotation.

The Pendulum is an ancient device, whose actions were originally investigated almost 500 years ago by the great Galileo Galilei. He discovered that the pendulum mass doesn't matter - it's only the length of the pendulum that changes how quickly it swings to and fro. This principle was then adopted to advance time-keeping from sundials to actual clocks, which then evolved into something that let early explorers sail the oceans with a fair degree of navigational accuracy. Not bad for something that started as an observation of a swinging lamp in a Cathedral (Galileo must've been attending a boring sermon, lucky for us!).

Now that we have an elegant, simple device to apply magbot technology to, we need a way to implement it. If you've ever pushed somebody on a swing (I'll make the assumption that you don't live in a country that hasn't outlawed swings), you'll remember that it only takes a gentle push to create quite a bit of motion. The trick, of course, is *timing*. Push too soon, and your friend takes a face-plant into the sand. Too late, and you're shoving nothing but air molecules around.

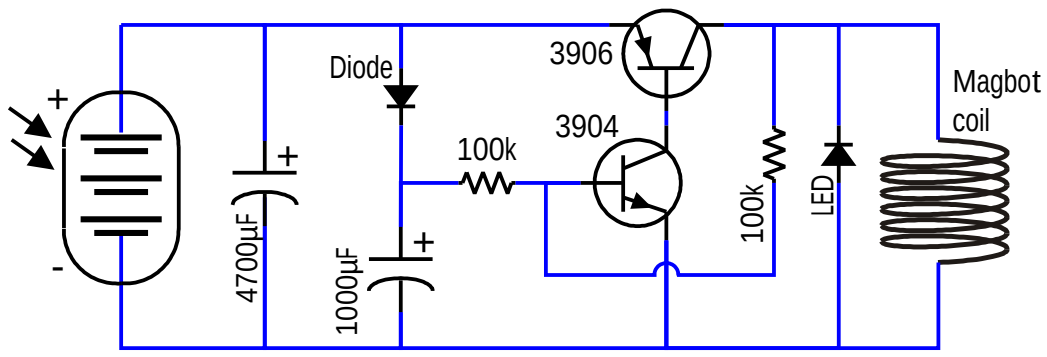
Of course, the way we do this is best explained over pizza and suitable beverages, but since you're not here, and I'm not there, check out "The Circuit Explained" on the next page.

Oh, and you can only call this project the "Pendulum of Doooom" only if you say it properly. Put emphasis on the "Dooom" part. Like this: "Pendulum of DOOOOM!" Sounds more ominous, doesn't it?



The circuit developed for this kit is quite ingenious, a shining example of when all the rarest forces in the Universe come together over a breadboard and coalesce. Cool word, eh? Coalesce - sounds better than "glommed together" doesn't it? Anyways, this circuit is simple, robust, will run on solar, battery, and DC adapter over a great range of power, and intuitively knows when to tug at the pendulum. We call this terrific circuit a "Force-Coil."

The Force-Coil circuit uses the motion of the swinging magnet over the coil to tell it when to activate. As you now know, an electrical current is generated when a magnet passes near a coil of wire. The neat thing is that the current flows in one direction as the magnet approaches the middle of the coil, then *reverses* as it passes over the other half of the coil. The Force-Coil circuit watches this current flow created by the passing magnet, and adds its own electrical "nudge". And what happens when you energize a coil? You cause a force - in this case, a force that accelerates the magnet faster across the coil. We then use the reverse-current generated by the magnet to shut the Force-Coil off, letting the magnet coast away with a bit more energy than it had before. If we didn't shut the coil off, it would try to suck the magnet back to the middle of the coil (a bad thing)!



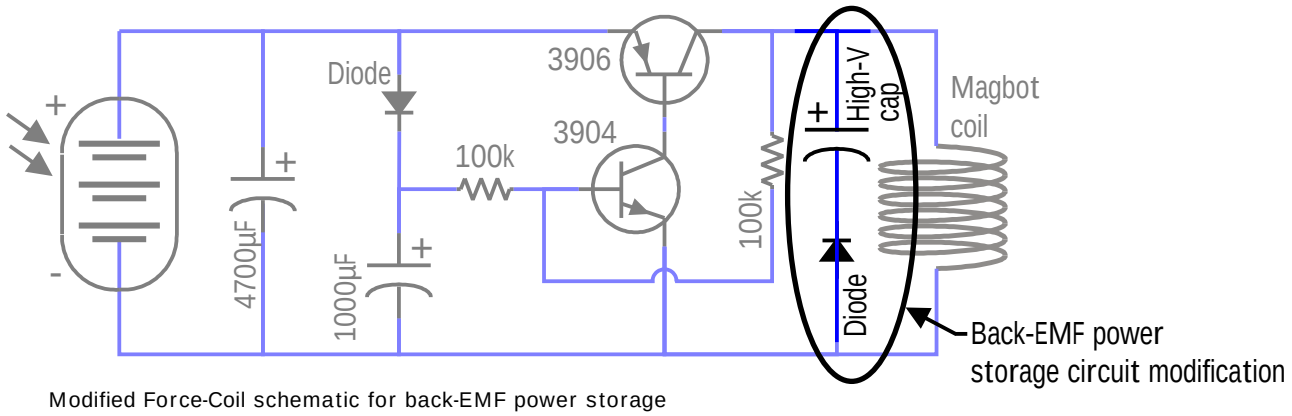
Done with the fluffy explanation? Good. Here's the Übergeeken explanation:

The PN3904 transistor is responsible for detecting the induced current from the magnet passing over the coil. When activated, it turns on the PN3906, which dumps the power to the coil to add swing to the magnet zooming by. The PN3904 is connected to a "voltage divider" made up of two 100k resistors which divide the voltage going to the base of the PN3904. Since we're running this resistor pair through a diode (a 0.4V drop), and the transistor needs approximately 0.4V to activate, we need to store up 1.2V in the main capacitor before this circuit starts to work. Remember, the resistor pair voltage divider needs to see 0.8V to turn on the transistor (because ½ of 0.8V = 0.4V, which is the turn-on voltage of the transistor), and since there's a 0.4V-eating diode on top of the voltage divider, that equals 1.2V total. So far, so good? Ok? Ok.

So we've let the circuit sit and charge a bit, and the small 1000µF capacitor starts to hover at 1.2V stored voltage, trying to activate the PN3904. The electromagnetic induction effect of the magnet swinging over the coil adds an additional voltage that firmly kicks the PN3904 transistor on, which in turn activates the PN3906, passing power from the main capacitor to the coil causing a pull force on the magnet from the coil. You'll also notice that because of one of the 100k resistors in the voltage divider, some of the power splits off from the coil and helps keep the PN3904 on.

Why the two capacitors? Well, the big one stores the coil-driving power, and the small one (with the diode) tries to always keep the PN3904 transistor near activation, even when there isn't much power stored in the big capacitor. Kind of like having a hair-trigger ready to fire at the slightest upset (being the magnet moving over the coil).

When the magnet starts moving past the middle of the coil, the induced voltage and current plunges to zero, and then negative. This quickly clamps off the power to the PN3904, which in turn shuts off the coil-powering PN3906, letting the magnet coast freely away from the coil. Well, not entirely - the purpose of the LED at this point is to shunt, or divert this negative-going power into something more useful. In this case, a quick "blink". If you *really* want to put this power to more use, you can substitute the LED for a diode and charge up a third capacitor with this magnet-induced "back EMF" energy. Surprisingly, our experiments showed we can store up to 30 volts over many swings of the pendulum!



Modified Force-Coil schematic for back-EMF power storage

The neat thing about the Force-Coil circuit is that if the main storage capacitor only has a bit of power, just that little bit is dumped to the coil each time, just like how a lots of little pushes add up to big motion on a swing. On the other end of the spectrum, if you have LOTS of power available, the coil is *always* energized and trying to attract a coil, but still is shut off when the magnet swings past center.

So everything up until now has been about moving magnets - what happens at the first light of day, with absolutely no magnet motion to tell the Force-Coil when to activate?

Good question.

Remember that small capacitor/diode/PN3904 hair-trigger we mentioned earlier? As the system power rises, the circuit becomes more and more sensitive. If you take the magnet entirely away from the coil, you'll see that the indicator LED may start to blink erratically. The coil starts acting as an antenna, and any minor electromagnetic (EM) energy disturbance like radio or tv signals activate the hair-trigger. With a dead-still magnet hovering just over the coil, it needs only the slightest wind current to make the magnet move enough to cause an EM disturbance that'll kick the circuit into gear.

Too much power? No problem. Not very much power. No problem. Need self-starting? No problem. See why we love the elegance of this circuit?

Ready to start building? Good. We're going to make the really important parts of each step printed in bold (see how that worked?). These are the really important parts of the instruction, so don't ignore them!

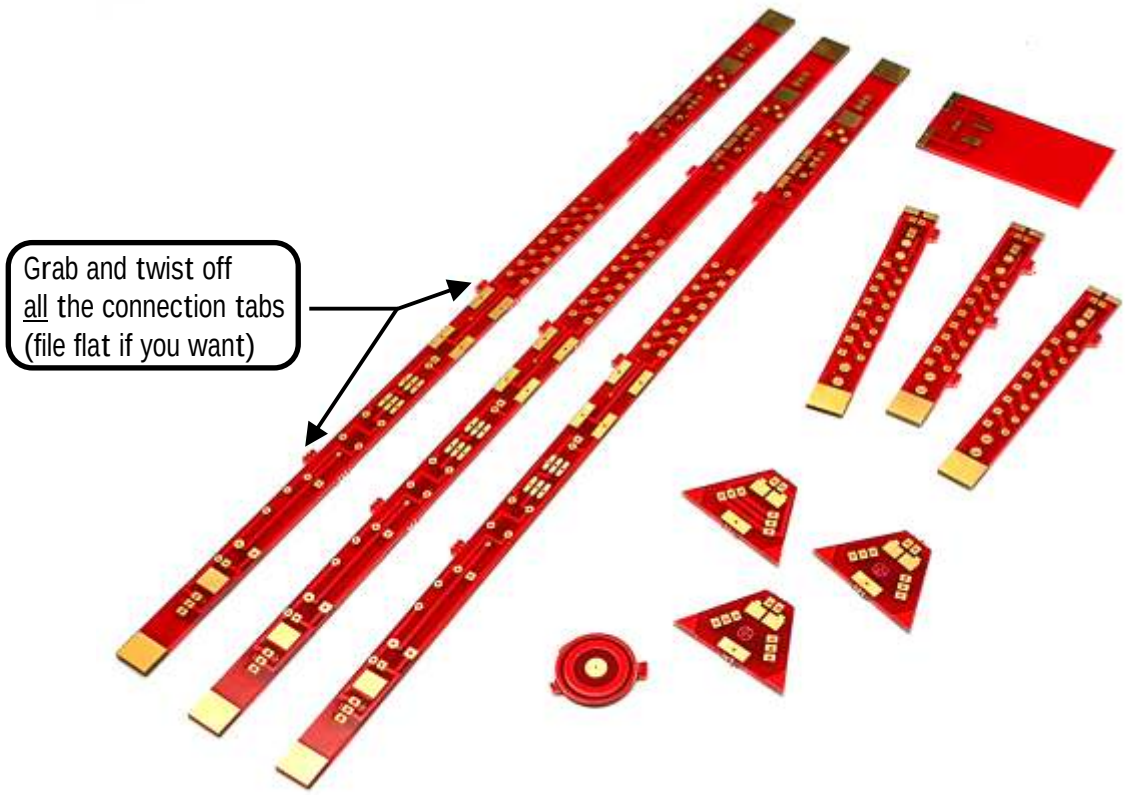
Enough of this froo-froo - you want to get building, right? Well, let's get to it: The first thing we're gonna do is look at the parts of the frame, because it's obviously what you're most fascinated by, right? If the parts aren't already snapped apart, feel free to break them apart now. Twist the tabs off, and file them flush for best effect. *Just...don't...lose...ANY PARTS!*

- The long, long pieces make up the main frame of the pendulum, and the place you'll be assembling most of the electronics.

- The trio of stubbier PCBs are the feet of the frame which poke out and make the base stable. One will also be where you mount the solar cell photodiodes.

- The three little triangles are the frame gussets, and are where the stubby feet PCBs get soldered to the main frame.

Oh, that little round one? Well, that's a secret (ok,we'll tell: You stick the magnet to it!)

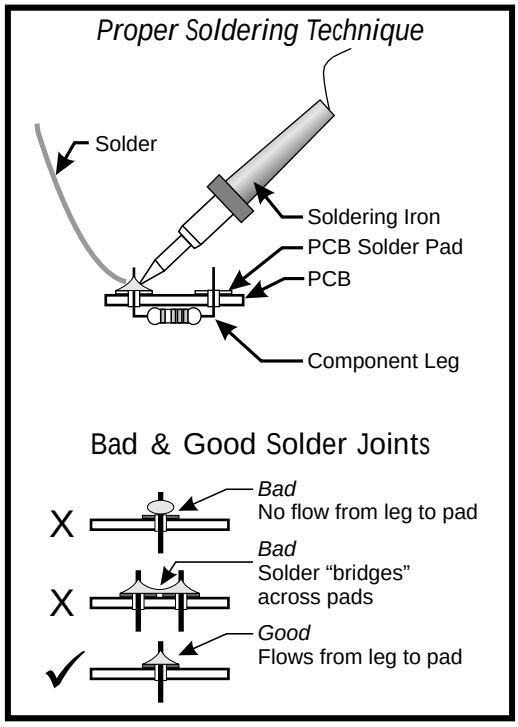


Note: The long, short, and corner PCBs are all identical. Triplets. Maternally identical, like little babies that all look the same. Nooo difference. No difference between all the long ones, no difference between all the short ones, no difference between all the corner pieces.

Capeesh? Good.

Ready to start soldering? Ok. Let's start by... what? There's a question from the back - yes? Oh - you've never soldered?!? Whaaat? Go stand in the corner!

Sorry, sorry - we sometimes forget that everybody has to start sometime, and this is as good a time as any. Let's take a quick lesson / refresher before continuing with the electronics assembly.



Soldering is the process of melting metal between two other metals, creating a mechanical and electrical connection between the two parts.

Pretend you're a little bit of solder, made of lead and tin, and goop called "flux" and you're happy in your solid form. BUT when melted, you're attracted to heat. You loooove heat. Heat is good...

So what does this have to do with soldering? Simple. You want to use the soldering iron to put heat where you want the solder to go, in this particular case, on the *solder pad*, and the *component leg.* The solder pad is the little silver circle (or oval) on the circuit board that you want to connect to, and the component leg is...the component's leg!

By sticking the component leg through the solder pad hole and then jamming the soldering iron into that corner, you're heating up both the leg and the pad at the same time. When you stick the solder into this corner, the solder melts, and goes to where the heat it: the leg and the pad. Don't mind the bit of smoke (well, don't breath it in), as that's just the flux melting and making it easy for the solder to flow from one metal to the other.

Now, if the leg and pad *aren't* sufficiently hot, where does the solder go? To the hottest place it can find - the soldering iron tip! You'll just get a solder blob on the iron - exactly where you *don't* want it. And don't think you can just paint it into the corner you want, as it won't work (or work very poorly). You're a roboticist, not Picasso, so don't paint with solder!

How to Solder - The Basic Process:

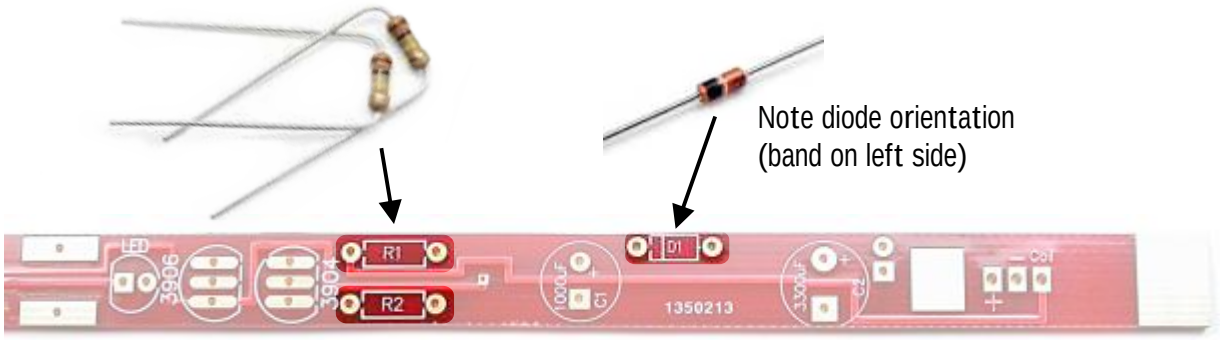
1) Install the component leg in the hole (bend it a bit to make it stay put)
2) Wipe the tip of your soldering iron on a wet sponge or cloth to make it clean and shiny.
3) Press the tip of the iron into the junction between the leg and the hole.
4) Count to 5
5) Apply solder to the other side of the junction (not the soldering iron tip!).
6) Let the solder melt until you have a nice, smooth fillet between the leg and pad.
7) Remove solder and the iron.
8) When done your soldering session, go wash your hands! Most solder has lead, and lead poisoning makes your brain stupid! Lead on your hands transfers to the food you eat, so clean up!

The SunSwinger Pendulum - The Resistors, Diode, and Transistors

1) We're going to start soldering components onto one of the long PCBs. Choose one (they are all the same), and that'll become your main circuit board. You'll notice that one side has white writing on it - that's called the *component side*, or the *side with white writing on it* (either term works).

❑ Start by bending the leads over on the two 100k resistors (they have the Brown / Black / Yellow / Gold stripes) and insert them into the spots labelled R1 and R2. It doesn't matter which way it goes in. Don't do anything else yet - just insert them, and bend the legs poking out the backside apart so the resistors don't fall out.

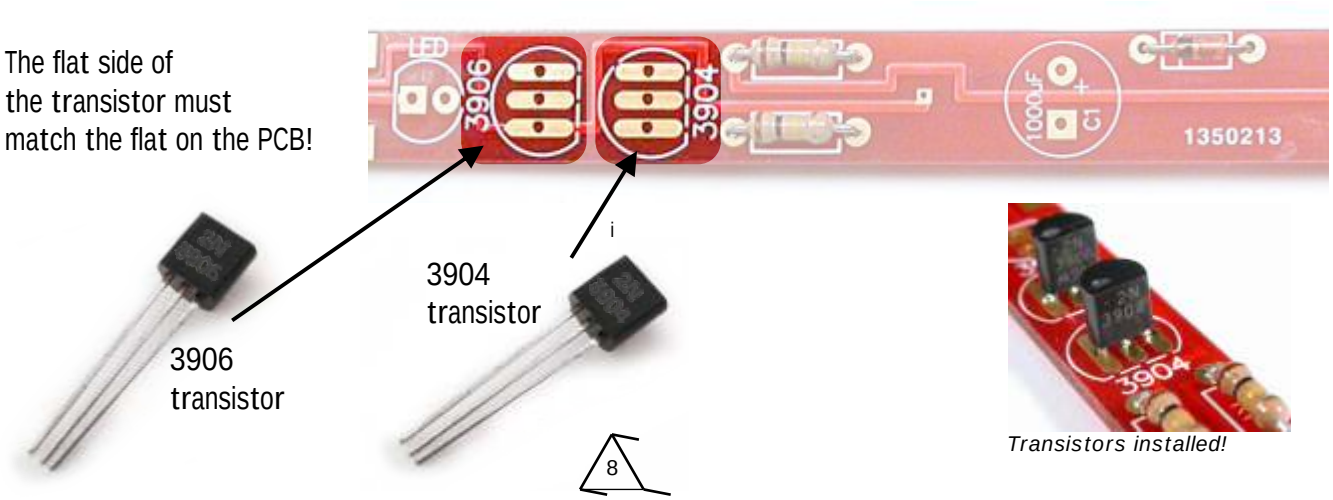
❑ Find your diode, which is the little glass thing that is resistor-sized, and with a black ring on one end. Bend the diode legs down, and insert the diode into spot D1, making sure that the side with the band goes nearest to the band printed on the PCB.



2) Time to tuck the transistors into their snug little homes. These get installed just beside the resistors, but remember - there are two types of transistor, so don't get them mixed up!

❑ Take the 3904 transistor and identify the flat face. That should be easy, as it's the ...flat side. And it has writing on this face that says 3904 on it. Splay the legs apart a bit, and insert it into the spot labeled 3904, making sure the flat side matches the flat line on the outline symbol on the PCB. Solder it in, and snip off the excess leads.

❑ Do the same thing for the 3906 transistor, which sits directly behind the 3904 location. Same procedure, just like you did with the 3904 (but in the 3906 position).



Transistors installed!

3) The capacitors are another polarity-sensitive device, so careful with the installation! Things tend to *not work* when installed backwards!

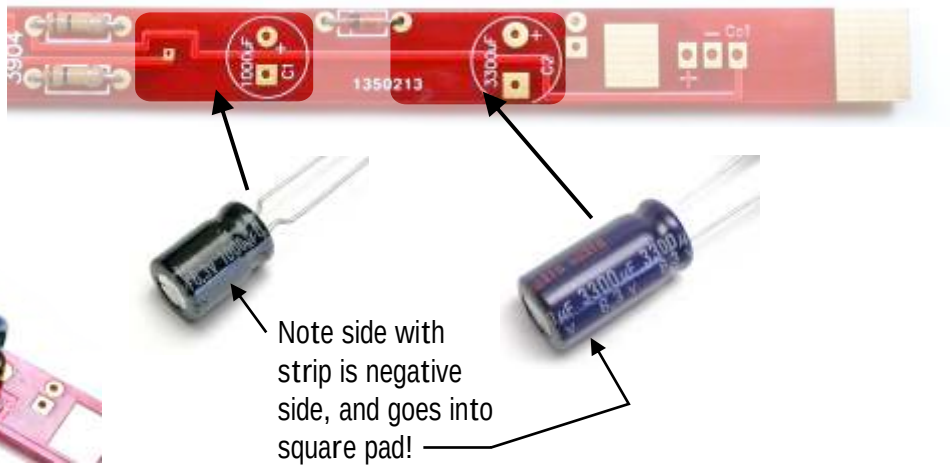
❑ Start by identifying the *cathode (negative)* side of the capacitors by finding the stripe down the side of the capacitor can. The lead nearest this strip is negative (making the other one positively positive).

❑ You can install the capacitors straight up, or bend the leads over so they lay flat (the way we have done it). Bend the leads over so the cathode lead (the one near the stripe) goes into the square pad. Remember, these have to go the right way in, or they won't work! Start with the 1000µF capacitor, and install it in the spot labelled "1000µF" (funny how that works). Solder it in, and clip off the excess leads.

❑ Find the 3300µF capacitor, and repeat the process, but mounting the capacitor in the location marked "3300µF".

❑ Don't worry about the LED *yet*. That'll be installed at the end of assembly.

Finished capacitor installation. Nice, clean and tidy!



Note side with strip is negative side, and goes into square pad!

4) Time for another polarity-sensitive device - the tiny "solar-cell photodiodes" (aka: SCPDs). These 1/8" square plastic blobs were originally designed as light sensors, but when treated like a solar cell, they generate a fair bit of current, at about ½ volt each. When wired up in a series of eight, we've got an elegant, sturdy, 4 volt solar array!

Look closely at the blue square itself, and you'll see that there is a bar *inside* the cell on one side - this is the POSITIVE side. Learn and remember this fact! If you get any of the 8 SCPDs installed backwards in the next step, you won't get any power!

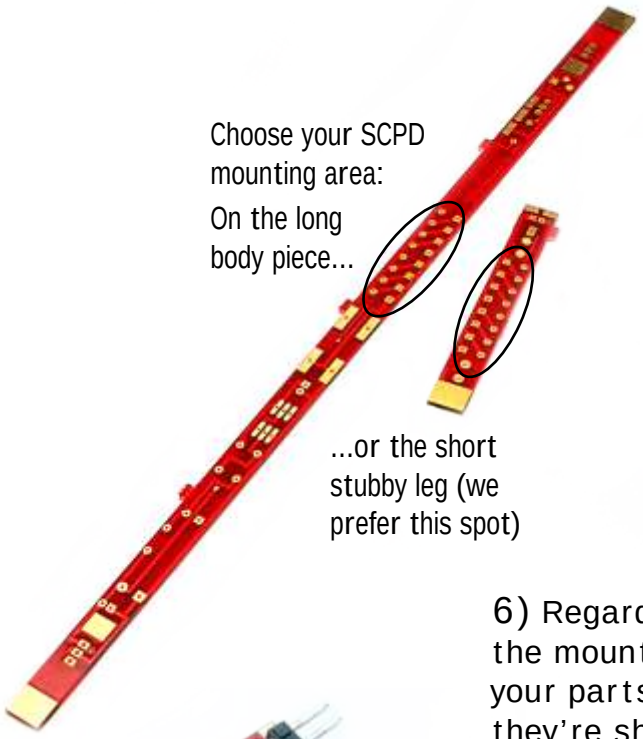
Bar = Positive (anode) side (goes to round pads)
Also, leg on other side has a little "tab" on it that the positive side doesn't have

5) Let's solder these SCPDs down, but first you have to decide to where? We have to ask this question, because we've made the SunSwinger with multiple ways of doing the same thing. No, not to make your life difficult, but because the SunSwinger is a device will cool aesthetics - you can make it different ways to suit your purpose.

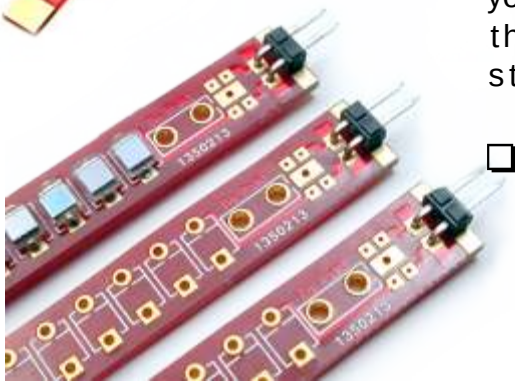
Your choice is to either mount the SCPDs on one of the three long body pieces, or on one of the three short stubby leg pieces. Either location works, but you'll get best overall performance by mounting on the short stubby piece, which will lay flat in the sunshine. You can elect to use the long body piece if that's the side of the SunSwinger that will get most light.

❑ Choose either a stubby leg or long body piece to be where you want to install the SCPDs. If you want to use the long body piece, it *does not* have to be the same one that you soldered the electronics too (we've cleverly added connectors to each piece so they're all electrically joined).

❑ Install and solder each SCPD into the positions shown. See, we even draw a bar at each location that matches the bar in solar cell.



6) Regardless where you soldered your SCPDs, let's add the mounting pins to each of the stubby legs. Dig into your parts bag, and find the three 90° pin pairs (ouch - they're sharp!). We're going to mount one to each of the stubby legs

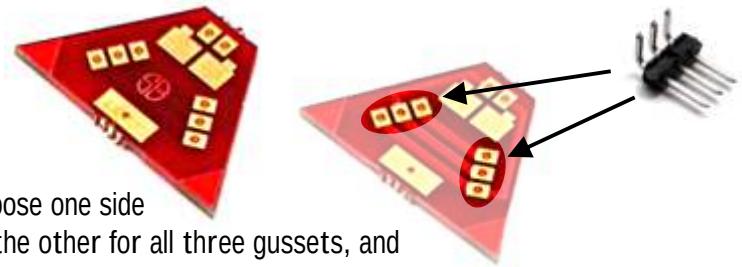


❑ Install the pin pairs into the stubby leg so that the side with the bend go into the holes on the same side as the SCPDs. These holes are a bit tight, so you might need to use some pliers to force them in.Make sure the assembly looks like the image before soldering it up! Do it for each of the 3 legs.

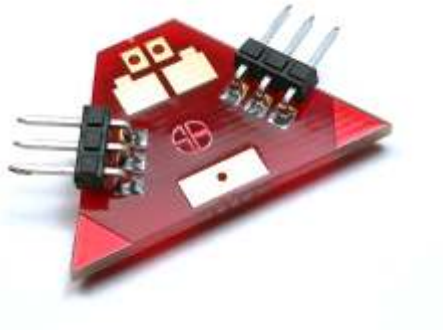
7) While we're dealing with those sharp 90° pokey bits, let's keep going and prepare the triangular corner gussets with two triple-pin 90° strips. These will mechanically and electrically join all the long and stubby pieces together. If you haven't already done so, file/sand down the nubs off these gussets to make them fit together better. Just like with the previous step, install two 3-pin strips into each gusset. Repeat it for each of the three gussets, then take a break and eat a cookie. You've worked hard - you deserve it.

Note: We found working on a piece of corrugated cardboard quite useful during this step. Put the gusset down, and press the pin strip through the holes into the cardboard. It holds everything in place while you solder the pins in (but from the top-side). Be careful - pins are dang sharp!

Another Note: The 'SB' labled side of the gusset is the side the *stubby legs* get soldered to. You can solder the triple-pin to either side of the gusset (from the rear looks neater, but we're showing them on the front for clarity), but be consistent and make the gussets all the same way. Make sure the bent pin side is soldered to the gusset!



Choose one side
or the other for all three gussets, and
solder in the 3-pin strips

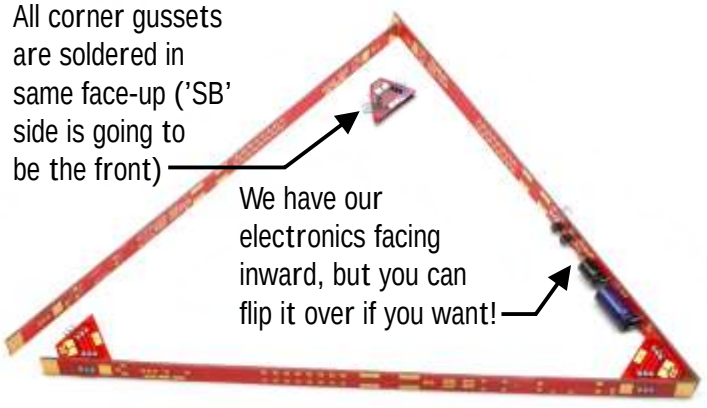


Finished gusset pin installation

8) Let's get this frame together, shall we? Time to take these pieces, and ...piece them together! Decide if you want the component side (with the white writing) or solder side facing out on your SunSwinger, and be consistent when soldering them together. This is a purely aesthetic decision, so do what you think looks best - it doesn't affect the circuitry.

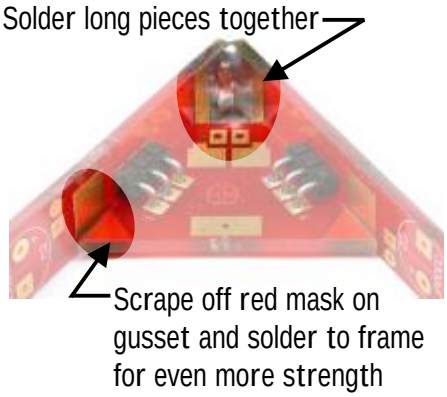
❑ Choose what side of the long body pieces you want facing in or out, and be consistent between all of them (no effect, but looks better). Insert two gussets into one of the long body pieces. Make sure the gussets all face the same direction. If you have to, use some tape to hold the pieces together while you solder them.

❑ We bet you know what's coming now: Yup - solder on the remaining long body pieces to the gussets so all three gussets and three body pieces are all soldered together. Your Sun Swinger frame is taking shape!



9) (Optional) If you want to increase the strength of your corner connections, use a fair amount of solder to bridge the gap between the two long PCBs where they meet at the peak. Remember - heat up the big pads, and let the solder melt to them, NOT your soldering iron tip. If you're gonna do it, now's the time, before the stubby feet segments get attached!

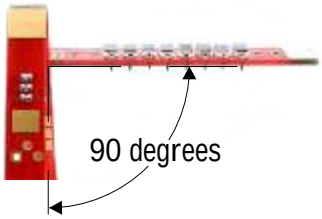
You can also scrape the protective coating off the pads on the gusset corner gussets, and solder it to the frame for even more strength.



10) The three stubby PCBs have multiple purposes. They act as feet, SCPD mounts, and as the mounting point for the pendulum to swing from. Fortunately, they all get mounted to the main body all the same way, so gather up the stubbies (are you old enough to remember what a "stubby" is? Think "Bob'n'Doug McKenzie", hoser!), and let's get working!

Now that your long body pieces and gussets are all soldered together, pick which point will be the top of the triangle. The gusset at this top corner will be the pendulum hanging arm. If you're building your pendulum like we did here, it'll also be the same piece with the SCPDs soldered on.

❑ Take the stubby piece that will be the pendulum hanging arm, and install it into the two holes in the gusset. Shove it in as far as it'll go, align it so it's pointing straight out, and solder it on place from the backside.

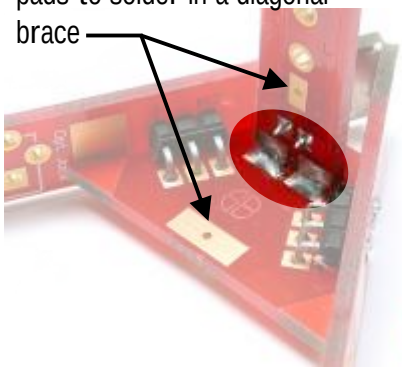


❑ We're going to now add more solder to make the joint even stronger, sorta like we suggested for step 9, but this time, it's mandatory! Reinforcing this connection will keep the arm from flexing while the pendulum swings. See the pads under the stubby piece, and how they're right next to pads on the gusset? We're going to melt solder from the stubby pads to the gusset pads. Don't be afraid to use up 2 or 3 cm (3/4"~1-1/4") of solder on each connection - it takes a bit of solder to make a successful solder-bridge!

Stubby mounting pads...

...stubby pins soldered into pads...

If you want to, use these two pads to solder in a diagonal brace



...and reinforcement solder added to the bottom!

❑ Now repeat the process 2 more times for the remaining stubby leg pieces!

11) Now it's time to put some silicone rubber booties on the stubby feet. Yup, booties. They are not "anti-water"booties, they are "anti-walking" booties. Yes, we know how strange that sounds, but it's true. If you don't put these booties on your SunSwinger, it'll tend to "walk" across your table when in full swing. We've seen enough of our own SunSwingers fall off a window-sill because each swing of the pendulum makes the whole thing move a bit. Pendulum walking machines have been built by other people, but for *this* project, walking is bad!

❑ Take the silicone tubing out of the kit, and cut it in half. We're going to stretch each one of these over the ends of the two stubby pieces.

❑ Moisten the tip of your needle-nose pliers (don't lick it - yuck!) and slide the tubing on. *Gently* pry open jaws so you slip the pliers onto the end of one of the bottom stubby pieces.

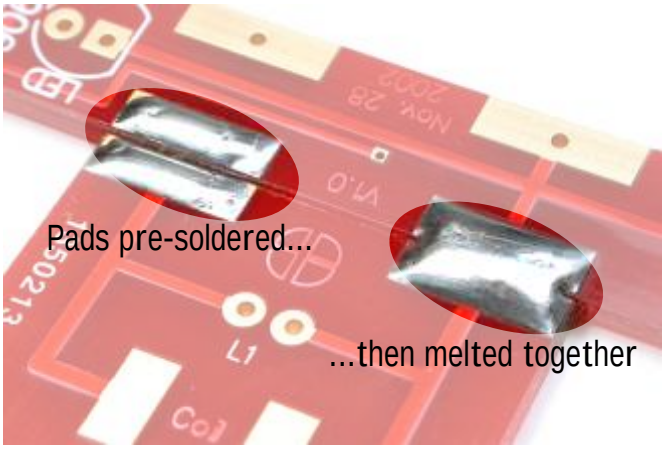
❑ Stretch the pliers over the edge of the stubby, but don't go crazy - you can snap the silicone tubing in half. If you do, you'll have to cut your remaining half in half again, and try it again (but with more care).

❑ When the tubing is in position, turn your pliers 1/4 turn. This makes removing the pliers while leaving the tubing in place *much* easier.

❑ See? All done. Now do it again on the remaining stubby foot.

12) We're getting close to finishing the SunSwinger base - just a little bit more work. Next, we're going to connect the coil platform and install the coil. This is where things actually happen - where the magnet gets the power to do its pendulum-thang!

❑ The small rectangular PCB with the circle on it is the coil base. You can install this face up or down - it doesn't matter. We're going to solder it to the long body PCB that will be the bottom of your SunSwinger. Start by melting solder onto the long rectangular pads on both the coil base PCB and the bottom body piece. This coil base PCB gets soldered on so it's on the same side as the stubby feet PCBs.



❑ After you've pre-soldered the four solder pads, butt them up against each other, and melt a *bit more* solder across the two sets, so they melt into a pair of big solder-blobs. This acts as the mechanical and electrical connection between the two PCBs.

❑ Find your coil and take a close look at the ends of the wire on the coil. See how it goes from red to silver? We're going to solder that silver (bare) wire to the coil pads. It doesn't matter which wire goes where, just be aware that you *can't* solder to the red insulation on the coil wire. Pre-solder the coil solder pads (like you did for the coil base PCB), lay the coil wire on top, and melt it into the solder just by simply pressing it into the solder pad. Repeat for each side, and you're good to go!

Soldering on the coil leads

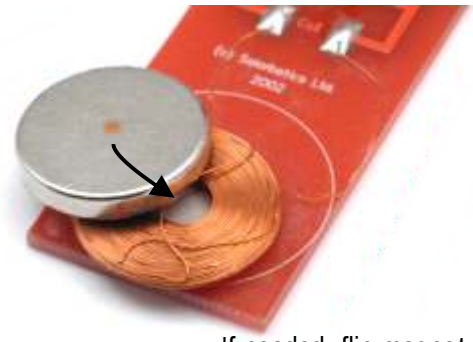
❑ Glue or use 1/2 of the double-sided-sticky-tape to secure the coil down to the platform as shown by the circle. Don't make it too permanent though - you may want to slide the coild forward or backward later to position everything just right. Pretty soon we'll have a magnet swinging! (Woohoo!)

Finished coil platform installation and coil mounting

13) It's magnet-time! A coil of wire and a magnet are the essentials of an electric motor, and we're about to start playing with the physical interactions between them. This is pretty neat - have fun with this step!

❑ Find your magnet. Can't find it? It's most likely either still wrapped up in several layers of bubble-wrap, or stuck to a metallic object. These sneaky things will often attach to a metal chair's leg instead of falling directly to the floor, so if it's missing, inspect all nearby metal objects!

❑ Now that you have your magnet, take your SunSwinger and put it under bright light. Put the magnet on the coil, off to one side a bit . You want it to jump to the middle. If it's on right-side up, it'll vibrate and shimmy towards the middle of the coil. If it's upside down, the coil will go "Ptwoo!" and spit it off. Having the magnet push against the coil is bad, as over time, the repeated "pushes" tend to weaken the magnet, making performance worse. Having the magnet pull against the coil reinforces it, keeping it strong.



If needed, flip magnet so it moves toward middle

❑ Note what side of the magnet is the top by marking a dot on one side of the magnet as an indicator. Just remember "dot UP" or "dot DOWN" when you get the vibrate/pulse/shimmy toward the coil middle. That'll be your magnet's "top". Don't be testing this over a spot on your desk/table that may have a metal support or screw underneath! Even a small metal screw can throw off the action of the coil and magnet!

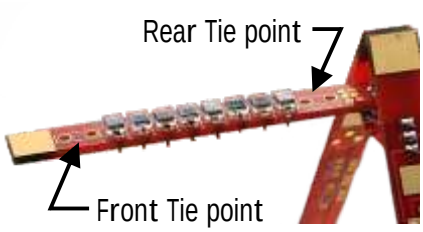
14) Now that we know which side of the magnet is right-side up, we're going to mount it on the magnet mount.

❑ Find the round, red PCB with the hole in the middle - this is our magnet mount. Strip off some (or all) the insulation off the short piece of thick solid wire in the kit, and nice, thick, short chunk of wire in the kit and solder it into the pad hole. If you lost the wire, use a resistor or diode clipping instead - no big deal. We don't want the wire to poke through the bottom - this is where we'll mount the magnet. If the wire *does* poke through the bottom, snip it off as flush as you can.

❑ Take some double-sided sticky-tape (let's call it DSST, ok?) left over from the coil mounting step and stick the magnet "top" to the bottom of the mount.

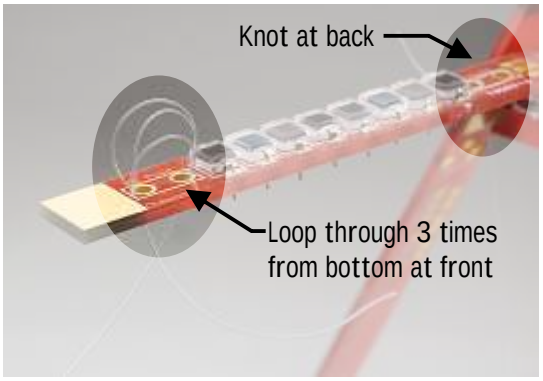
❑ Bend a little hook around the top of the clipping, so it almost makes a complete circle. Don't trim anything off yet, as you may need some of the extra length to fine-tune how high the magnet hangs over the coil in the next step.

15) Funny enough, hanging the magnet can be one of the trickiest parts of the assembly, as monofilament line isn't the easiest thing to tie. Get your line, the magnet, and your SunSwinger frame, and let's finish this project up!

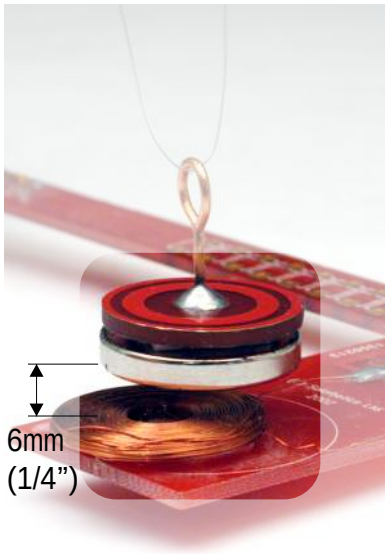


❑ Start by tying the monofilament line to the rear holes (near the gusset) of the top stubby arm. Feel free to use a comfortable amount of line, but make sure there's enough to loop down near the coil and back up again.

❑ Loop the other end of the line through the other pair of holes at the end three or four times. We'll use the friction of these multiple loops to hold the line in place while we get everything aligned.

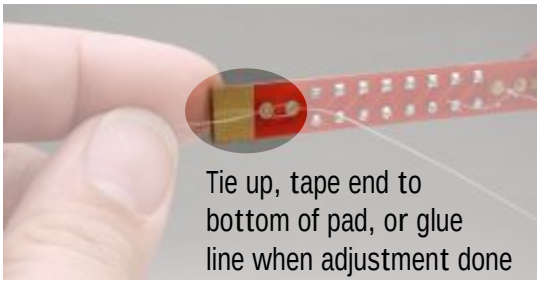


Note: Builder Bob Frankland adds this useful tip: *"Use a round toothpick to wedge the filament in the hole - works great and is fully adjustable!"*



❑ Hang the magnet from the line, and adjust its position by snugging up / loosening off the triple loop at the front of the stubby hanger. You want the magnet to be about 6mm (1/4") above the coil. Any closer, and the magnet may strike the coil when the frame flexes!

❑ Secure the front line by taping the line across the bottom tip pad, or by using a drop of super-glue in one of the holes. Or if you like a challenge, try tying a knot. When you give up on that, use the tape or glue!



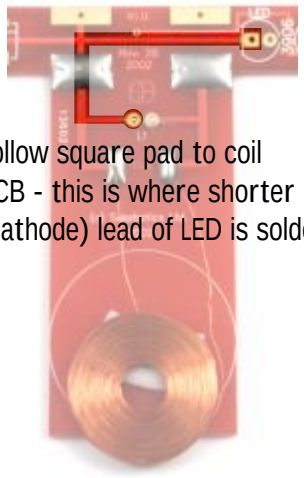
❑ Double-check that the magnet is still hanging just over the coil. If not, adjust the bend in the magnet wire hook to fine-tune the hanging length.

You're practically done! If all was assembled properly, your SunSwinger should be functional, but there's still a few things to finish up and discuss, so keep going - we're almost finished!

16) The LED isn't *essential* to the operation of the circuit, but there is a two-fold benefit to including it. The first is that it "snubs" the back-EMF pulse of the coil. Any coil that is suddenly turned off sends a considerable reverse-pulse of power that can damage electronics. The LED (acting as a diode) keeps the pulse from becoming a problem. Secondly, the LED blinks, and as we all know, blinky lights are a good thing... By watching the LED, you should be able to determine what the circuit is doing, especially in bright light. Rapid flickering indicates that it's "on the edge" and ready to trigger. No flickering means, well, something's wrong, and it's time to check your soldering.

Here are your LED mounting options (choose one):

❑ If you want your LED front and center by the coil, you can use the mounting pads on the coil-mounting PCB above the "Coil" label. Since this pad can be installed upside down, there isn't a orientation symbol at this location. You'll have to follow the line from the square pad in the LED location on the long body PCB to the appropriate pad on the coil mount - this will be the cathode (shorter lead).


Follow square pad to coil PCB - this is where shorter (cathode) lead of LED is soldered

OR

❑ You can mount your LED *anywhere* you see an LED symbol / label on any of the three long body pieces (in the position marked 'LED') - even on the PCBs that don't have the electronics. You can install the LED on either side side of the PCB, as long as the shorter lead (the 'cathode') is soldered to the square pad.


Install the LED at any LED symbol location, right on top of the symbol...


...or behind it on the other side of the PCB.

There! You're officially finished your SunSwinger Pendulum! But (if for some bizarre, unimaginable reason) your SunSwinger isn't working, take a look at the troubleshooting page...

What do you *mean* it doesn't work? Did you swing a purple onion over your head under the light of a full moon chanting "Wagga Wagga Wooooo"? That didn't work either, hmmm? First and foremost - make sure you have enough light. Fluorescent lights don't work very well, but natural light (even indirect light from a window) and practically any regular light bulb 20cm (7") above will be fine. Flashlights will barely to the job.

1. The two transistors can look identical, so don't mix up a '3904' with a '3906'. And they have to be installed so their shape matches the shape on the circuit board.

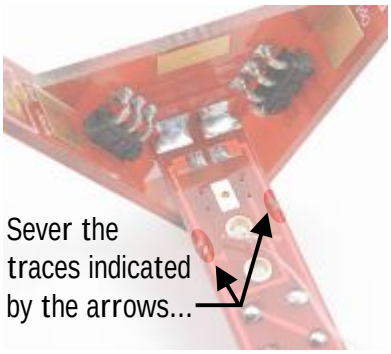
2. Unlike the resistors, the diode has to go in the right-way around, with the black band on the diode matching the position shown by the band on the symbol on the PCB.

3. The two electrolytic capacitors also have to be installed the right way, with the lead nearest the stripe going into the *square* pad.

4. Still can't see anything wrong? Check the solar cell photo-diodes (SCPDs).

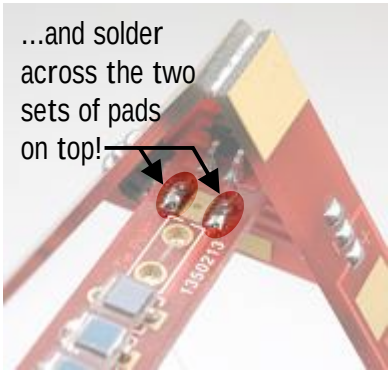
A) First check to see that they are all soldered in the right way around. Even if just one is in backwards, it will stop any power from flowing. Make sure the bar inside the SCPD matches the bar position printed on the circuit board.

B) Is the power to the larger 3300µF capacitor coming in with the right polarity? If you have a voltmeter, check the voltage of this capacitor. If it's measuring negative, then you may have reversed the power from the SCPDs, especially if you installed your SCPDs on the stubby leg like we did. If you soldered the stubby PCB to the *wrong side* of the gusset, the power connections are reversed. The stubby should be soldered to the gusset face with the 'SB' symbol. If you got this wrong, don't fret - we've got a quick fix for you. Look on the underside of the stubby, and you'll see two little arrows near the rear tie point holes. Use a knife, and gouge out a gap into the track the arrows are pointing two, severing the connection.



We put the SCPD stubby on the wrong side (see, no 'SB' symbol on the gusset), so here's how to reverse the power connections easily

Turn it over to the topside again, and use some solder to jumper the two sets of pads on the left and right. This effectively swaps the power connections from the solar cells to the rest of the circuit, so you don't have to massively de/reconstruct your SunSwinger! (Pretty smart of us, eh?)

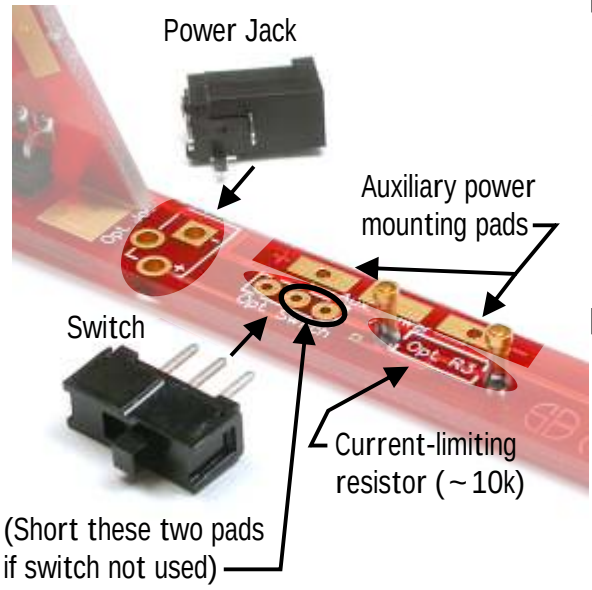


5. Is the LED flickering? That's a good sign. But if you're not getting much "kick" out of the system, you might either have the LED in backwards (where it's absorbing most of the power), or the magnet may be hanging too high above the magnet. The LED shouldn't be very bright - if it is bright, that indicates it's getting a bunch of power from someplace (power that should be going to the coil!).

6. Strange/no action from it? Metal nails, support beams and the like will throw off the behavour of your Pendulum, like the nails in a window frame, or screws in your desktop!

The SunSwinger Pendulum - Add-ons

We've got a few tricks left with that you can do with your SunSwinger. Live in a dark cave without power? Here's a battery add-on with switch. Live in a dark office *with* power? Here's a AC-adapter add-on. Got another type of solar cell you want to use? Mount it here! Pick your modification, and do the steps listed below!



❑ The power jack is only necessary if you're wanting to us a DC power adapter. The mounting holes should be adequate to fit almost any receptacle jack that mates with your adapter. Note: Practically *any* DC adapter able to provide 1.5V to 6V will be fine (any current rating), just don't mess up your '+' and '-' connections, which can vary from adapter to adapter!

❑ A power switch is only needed if you want to want to be able to turn the SunSwinger on and off when using the additional power jack or auxiliary power (battery). Important!: If you don't have a switch, solder the middle and right pads together with a short wire, or a solder-bridge.

❑ Add the 'R3' resistor only if you're using a power adapter. Any resistor between 1k and 100k will be fine (we used 10k). Note: If you're adding an auxiliary *solar cell*, just put a wire shunt across these points, as solar cells are pretty low-power already.

❑ If you're *really* creative, make the PCB / solar cell the pendulm, and hang *it* over a magnet!

Jack, switch and limiting resistor installation (resistor sockets not necessary)

Using a DC power adapter (3~6V)

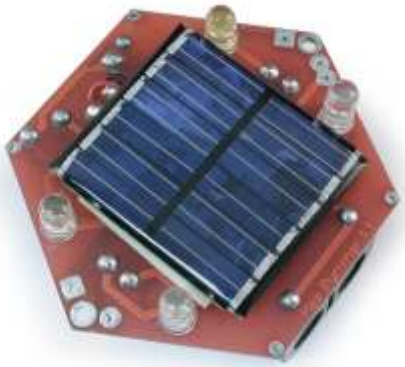
The auxiliary power pads can accommodate a battery pack or additional solar cell. A pair of AA's should last for about 2 months of continuous swinging!

Liked the Pendulum? Want more?

There are several more kits Solarbotics offers for any skill level!

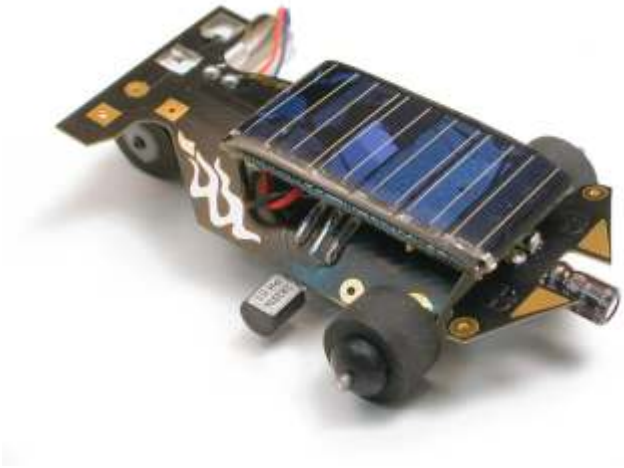
HexPummer Kit is a solar-powered, night-activated dazzler. Comes with four high-intensity LEDs that "PUMMM" when the lights go out. They cycle on STRONG, then slowly fade away.

K HP HexPummer $27.50USD/CAD



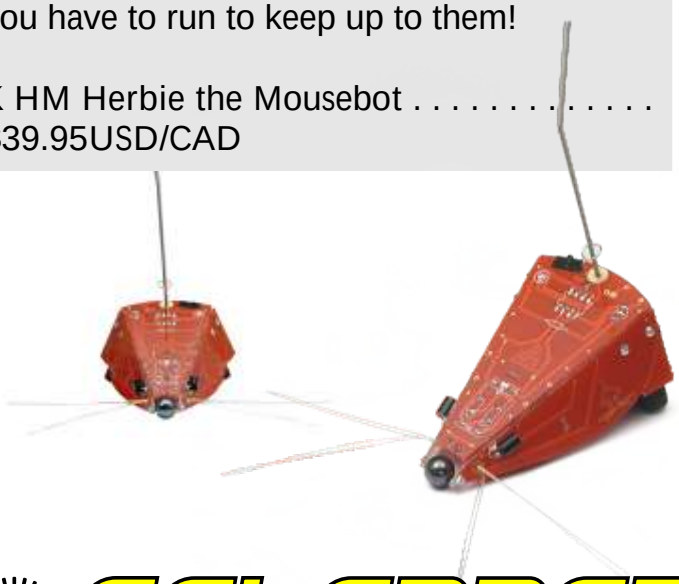
The SolarSpeeder 2 Kit is a very quick Solaroller that can cover 3 meters (10 feet) in under 40 seconds in direct sunlight. Simple to construct and a blast to watch, this is a great kit for all beginners!

K SS Solarspeeder $27.50USD/CAD



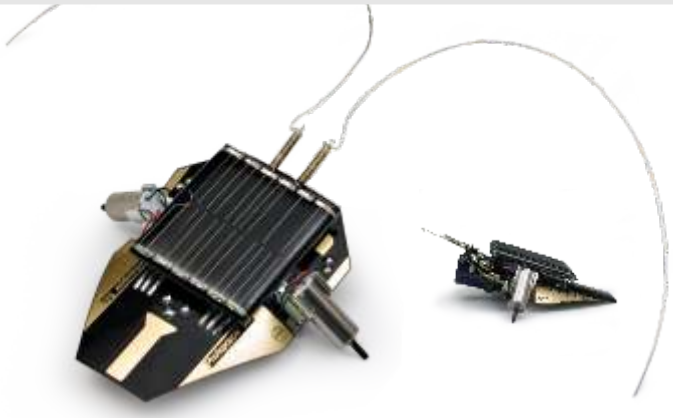
Herbie the Mousebot is a 9-volt battery-powered robot that loves to chase flash light beams. If there are several Herbies in the same area, they can be configured to chase each other! These little robots are so quick, you have to run to keep up to them!

K HM Herbie the Mousebot $39.95USD/CAD



Like the Mousebot, the *K PP Photopopper* seeks light and avoids obstacles but is solar powered! It's pretty quick, covering a meter per minute (that's 3.3 feet!). Newly upgraded with better electronics and gold circuit board!

K PP Photopopper $45.00USD/CAD



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