BEAM Robotics® Solar Kit #3:

1 2 3 4 5
Skill Level

# The BEAM Magbot SunDancer 1.3©

This BEAM Gizmo is a *solar-powered desk/windowsill ornament*, and does not have an off switch. It is a techno-looking bug that will sit and sway from a self-induced magnetic "wind" while absorbing light energy from it's surroundings! (Some soldering skill required)

***A Complete BEAM Solar-Powered Gizmo Inside!***

Produced by

SOLARBOTICS™ Ltd

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# SunDancer 1.3 BEAM Magbot Butterfly

## Parts List

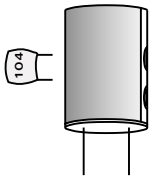
(1) Printed Circuit Board
(1) Gold / Silver Foil Square
(1) Coil
(1) Solarcell
(1) 2N3906 Transistor
(1) 2N3904 Transistor
(1) 1381 Trigger
(1) 0.1 $\mu$F Capacitor
(1) 3300$\mu$F Capacitor
(1) 2.2k$\Omega$ Resistor (colour bands red/red/red/gold)
(1) Oak Stand
(1) Oak Rod
(1) High Strength Magnet (and we mean HIGH STRENGTH - keep away from disks & computers!)
(1) Augut Socket Pin

Before starting, identify and inventory the parts included with this package. If any are missing or damaged, contact Solarbotics Ltd.

To complete this kit, you will need soldering equipment, scissors, glue, a ball-point pen, and a small set of snips for trimming the component leads.

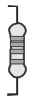
# SunDancer 1.3 BEAM Magbot:
## Circuit Components

The heart and soul of the SunDancer is the high-performance Solarengine. This allows much better low-light performance, making your SunDancer active in almost any light level.




The capacitor is like a very efficient, but small battery. It is designed to be charged and discharged hundreds of thousands of times. Compare that to a regular nicad battery, which usually wears out after 100 or so cycles.


The transistors are the actual electronic switches that route the power from the storage capacitor to the motor. The transistor's left and right legs (the "emitter" and "collecter") are the actual pathways for the majority of the current, while the middle leg (the "base") is where you put the tiny signal current to turn the transistor on. The SunDancer uses 2 types of transistor, a NPN (2n3904), and a PNP (2n3906). The only difference is that one is turned on by current being pushed into it, and the other by pulling the current out.

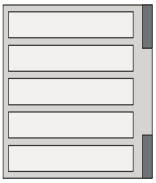


The resistor is simply an electrical constrictor, which resists the flow of electrons. In the SunDancer kit, it is used to divide the current between the transistor switches and the motor.

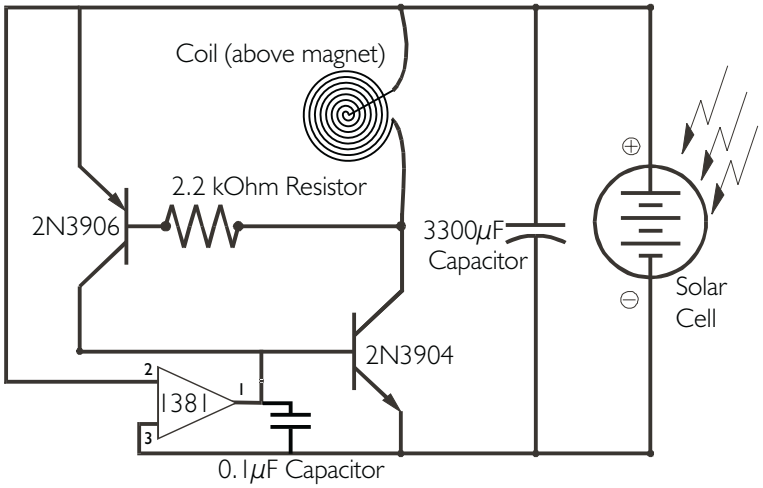
The coil (in conjunction with the magnet on the base) makes the SunDancer move. When the Solarengine dumps its power through this coil, it becomes an electromagnet, which is attracted or repelled to the magnet on the base (attracted is better for life of the magnet).


The 1381 voltage trigger is a small three pin integrated chip (IC) that looks much like a transistor. It was originally designed to detect low voltage levels in the batteries of portable electronic devices, like cellular telephones and portable computers. It uses very little power to monitor the voltage, making it much more efficient than older trigger devices like zener diodes or flashing LEDs.

The 1381 voltage trigger makes your SunDancer wait until there is sufficient charge stored up in the capacitor before it starts. This means that you can expect to get much more action in direct sunlight than under an incandescent or halogen desklamp. This doesn't mean that you are restricted to placing it under concentrated light, as your SunDancer will be able to work under light levels suitable for reading (it will work, but take longer to charge - patience required!).



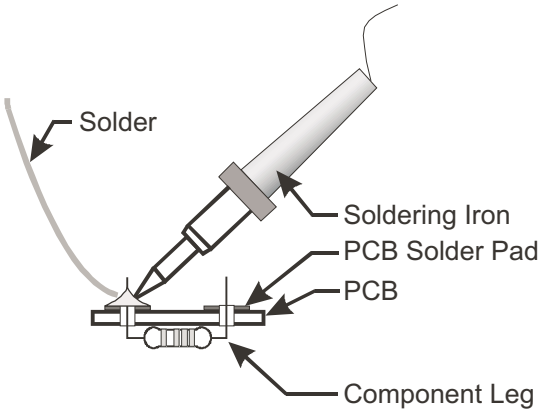
The Solarcell is what turns the light into electrical energy. Presently, solarcells are *not* a very power-efficient way of generating power, turning only a very small fraction of the light energy falling on them into electricity. This low efficiency is why we need a solarengine to store up this low-level power, and turn it into a powerful kick that makes the SunDancer move.

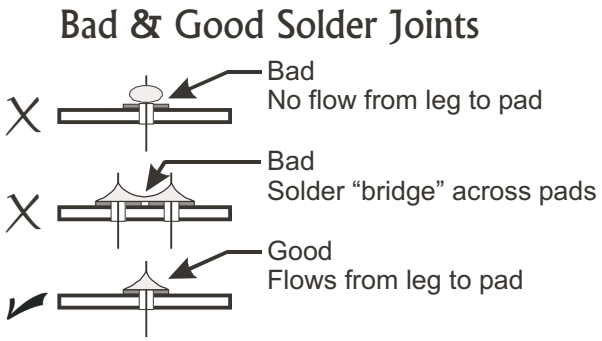



When the circuit starts charging, the 2N3904 transistor is off, so the current can't go through the coil back to the solar cell. Instead, it charges the storage capacitor. While this is happening, the 1381 monitors the voltage climb through its pins 2 and 3. When the voltage level matches a preset point in the 1381, it sends a pulse out to the 2N3904 transistor, turning it on. As soon as it turns on, some power splits off through the 2.2k resistor and goes into the 2N3906 transistor. This transistor keeps the 2N3904 on even when the 1381 turns back off, and keeps the whole circuit running until the power runs out. The 0.1μF capacitor helps reset the 1381 after each trigger cycle.

The most important skill needed to successfully construct your device is soldering. Make sure you start by using electronics solder, **not** plumber's solder. The main trick to getting a successful solder connection is to heat the junction up before applying the solder to the heated area. Do NOT try to melt some solder onto the tip of the iron and smear it onto the joint - you won't get a strong joint. This is *soldering,* not *painting*, and strong joints are needed to make your SunDancer work.

If the heat is applied unevenly, you will get solder blobs (see below). To better apply heat, keep your soldering iron tip clean by wiping it frequently on a damp sponge or cloth. The tip should always be shiny, and not covered in burned flux.

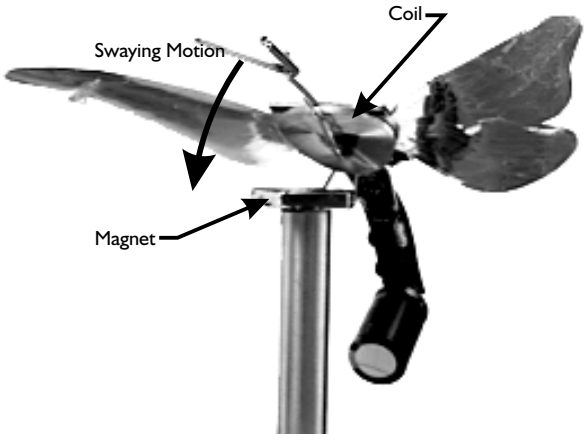


# *SunDancer 1.3 BEAM Magbot:*
## *Introduction and Principles of Operation*

The Magbot "SunDancer" is a device probably unlike any other piece of artwork you've seen before. It is a solar-powered, self-mobile ornament that is most elegant in it's appearance and function. The SunDancer moves in a gentle, swaying motion, like it's moving on a gentle breeze (which is kind of hard in an indoor, office environment).

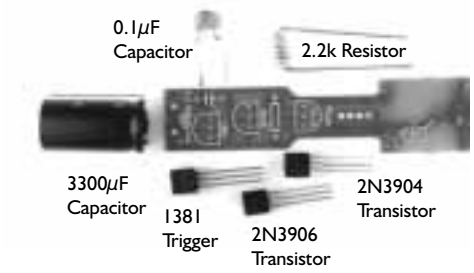
The principle of operation is quite simple. Like other BEAM devices, it digests light through it's solarcell and stores it in a capacitor. When enough charge has been stored, it triggers, dumping the power (in this case) through a coil. The basic principle of an electric motor is a coil in a magnetic field, and all we have done here is separate the two - the coil in the Magbot, the magnet on the base. When the coil pulls down against magnet on the base, it causes it to rock and sway.

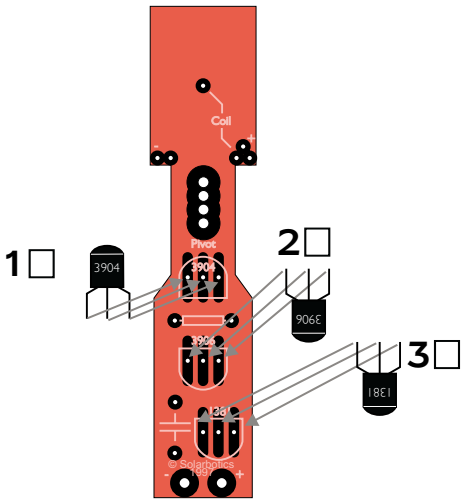


# SunDancer 1.3 BEAM Magbot:
## Assembly

Constructing the circuit board is straightforward, requiring only a soldering iron & solder, glue, and snips. Once you have this portion finished, you can move onto the really neat portion - designing and building the wings!

**Identifying the Components**
These are the parts you'll be using to build the electronics of your SunDancer butterfly, so refer to this picture if you have any problems figuring out what part is what.




**Install the Transistors/1381**
Start by identifying the underside of the printed circuit board ('PCB') - it's the side with all the text printed on it. We'll be first installing the transistors, inserted from this side. Try to push the components in as far as possible, so the part is snug up against the PCB. This is important, as it will aid the balance of your SunDancer when you're finished.

**1 -** Insert the 3904 transistor in the top position as shown. It's *very* important to get all these components in the correct way around, otherwise they won't work. Just make sure that the curve of the transistors match the curve on the PCB, and you won't go wrong. Snug it up to the PCB, and bend over the legs on the other side of the PCB so it stays in place while you solder it in. Solder it in place, making sure your solder connections don't accidently short out the legs.

**2 -** Next find the 3906 transistor, and do the same as for the 3904, except this transistor goes in a half-turn around from the 3904, so it "looks" in the opposite direction. Solder it in place, and carry on!

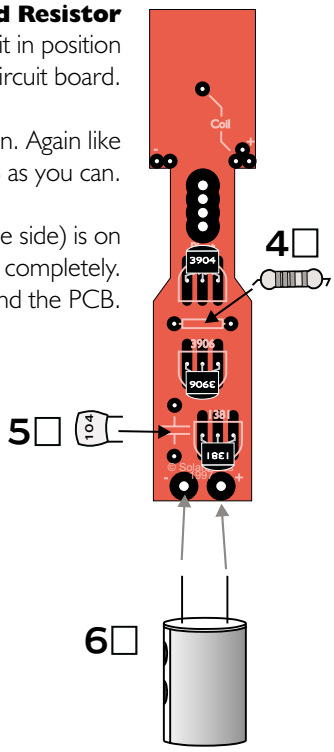
**3 -** The 1381 goes in the bottom position, facing the same way as the 3904 above it.

**Install the Capacitors and Resistor**

**4 -** Find the little cylindrical resistor, and bend its legs over 90 degrees, as close to the body as possible. Put it in position shown (the direction doesn't matter), and pull it down so it sits nice and snug next to the circuit board.

**5 -** Find the little "chicklet" capacitor labeled '104' (it stands for 0.1 microfarads, or μF), and insert is as shown. Again like the resistor, the direction it is put in doesn't matter, but you should try to get it as close down to the PCB as you can.

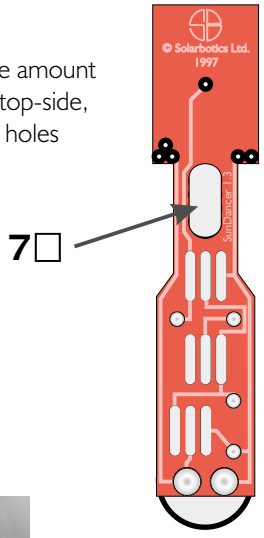
**6 -** Watch the polarity of the 3300μF capacitor when you install it - make sure the capacitor stripe (negative side) is on the left side when you put it in. Also, this is the only component you shouldn't try to snug up to the PCB completely. Leave approximately 4mm (1/8") space between it and the PCB.




When the parts are correctly assembled, they should look like this. Note again, that the components are snugged right up against the PCB. After everything's securely soldered in, clip off the excess leads going through the other side.

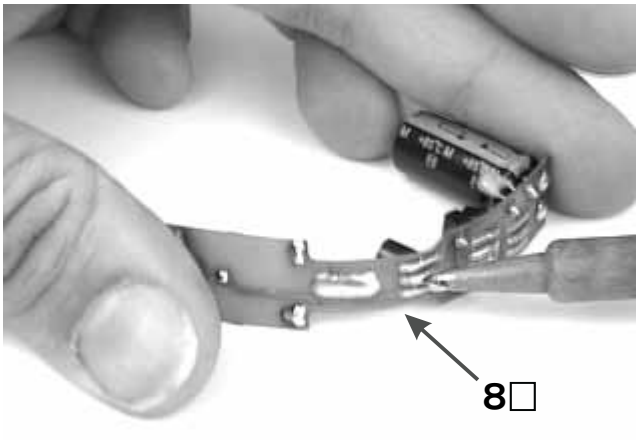
**Bridging the Pin Rocker Pads**

**7 -** This part takes some bravery. Melt a considerable amount of solder on top of the four pads *on the other side* (top-side, where no components are). This caps the balancing holes with a hard metal surface.





This is what the topside of your PCB should look like after soldering over the four pads near the neck. Don't be afraid to use lots of solder - a nice shiny mound is what you're aiming for. You should use enough solder to fill the pad in a nice smooth lump.



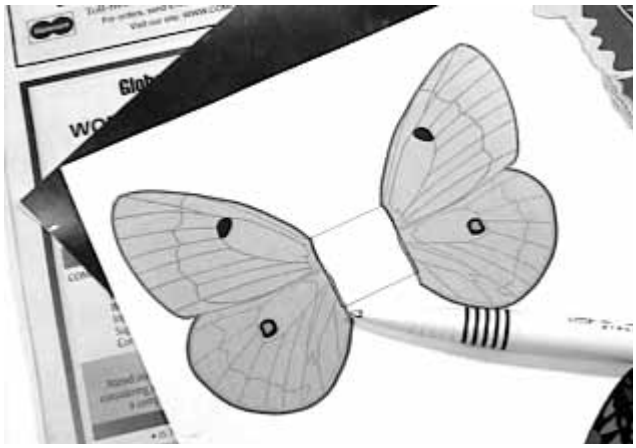

**Flexing the PCB**

**8 -** Remember all that solder you put onto the transistor and trigger pads? This is where it comes into a secondary use. The PCB must have a slight curvature to it to balance correctly, so take the ends of the board in your fingertips, and remelt the solder on one set of pads at a time. Once you finish the transistor/trigger pads, also remelt the four circular pads at the top to help keep the curvature too.

This is approximately the degree of curvature you're looking for. It doesn't have to match exactly by any means, just as long as there's a gentle curve to the PCB.

This view also shows how close the components are snugged up to the PCB.

# SunDancer 1.3 BEAM Magbot:
## Assembly - Contd.

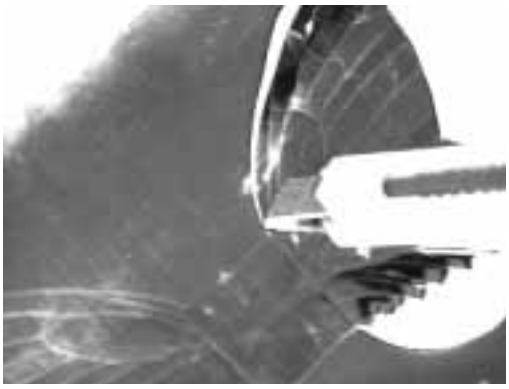


9 ☐

**Tracing the Wing Pattern**

Now for the fun part! Select a wing pattern you like (or design your own), and place it on top of the foil (select which colour side you like best and use that side face up under the pattern). Place the pattern and foil on top of several layers of newsprint (that's important!), and trace **hard** over the pattern, putting in as much detail as you want on the wings.

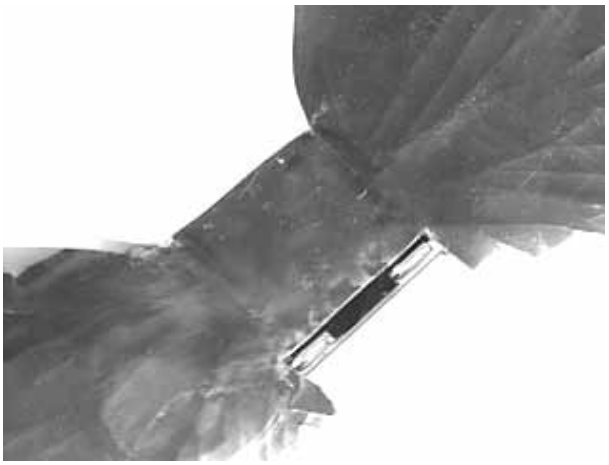
On the longer wing patterns, cut both wings out - we'll glue them together when we put the wings on the SunDancer.



10☐

**Cutting the Wing Pattern Out**

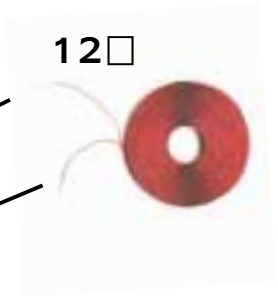
Carefully cut the wing pattern out of the foil using scissors or a razor blade. You can see how tracing over the pattern left an embossed line in the foil. Be sure to include the square in the cut-out - that's where the wings will be glued to the solarcell.



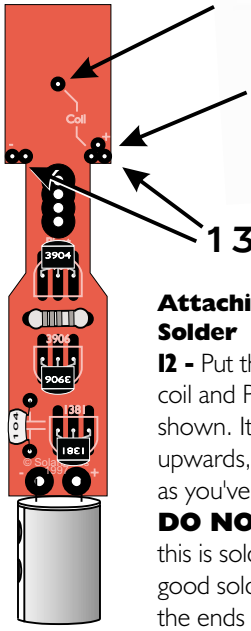
11☐

**Gluing the Wings to the Solarcell**

Check to see if the wings fit on the backside of the solarcell and **clear the solderpads** (they must be exposed after the wings are glued on). If they do, glue the wings (favorite colour side **face down**) onto the back of the solarcell. Use superglue, not hot-glue which will melt in direct sunlight.



12☐

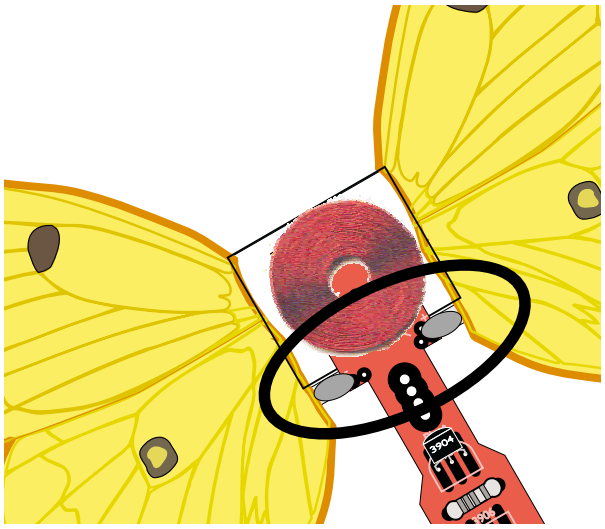



13☐

**Attaching the Coil to the PCB & Additional Solder**

**I2 -** Put the solarcell/wing assembly aside and find your coil and PCB. Solder the coil to the PCB at the points shown. It does not matter which side of the coil faces upwards, or which wire gets soldered where, so long as you've got secure solder connections. This means **DO NOT** solder to the coil wire where there is red - this is solder-proof enamel insulation. You will only get a good solder joint by soldering to the silver wire that is at the ends of the coil.

**I3 -** At this point, you should also add some more solder to the "+" and "-" pads on the other side (no-writing side), as this will help attaching the PCB to the solarcell/wing assembly.

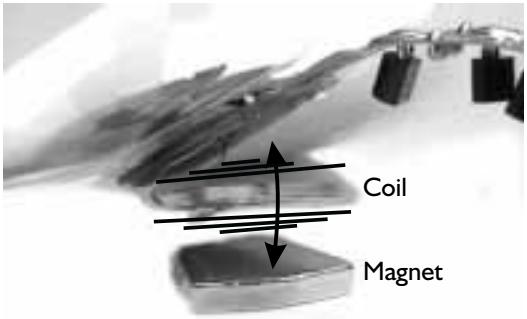


## 14☐

**Attaching the Wings/Solarcell to the PCB**

Now you are ready to connect the PCB to the solarcell, which will give life to your SunDancer. Lay the PCB (writing side up) squarely over the solarcell (writing side up) so that the PCB pads lay over the solarcell's pads. Carefully heat the PCB pads so it melts the solder and the solder underneath so they join together. BE CAREFUL - it will be very easy to ruin your wings by accidently touching them with the soldering iron, or destroy the solarcell solderpads by using too much heat!

DO NOT glue your coil to the PCB yet.




## 15☐

**Testing the Pull of the Coil to the Magnet**

The Magbot is now active - just hold it over your magnet to watch the action. You want it to pull down towards the magnet, as pushing against the magnetic field will make it lose effect after a while. We've got magbots that have ruined the magnets after 6 months of "pushes"! So if it is pushing up, flip the magnet over and put a “this side up" mark on that side.

If your Magbot does NOT move, do not continue until you trouble-shoot the circuit and make it work by using the procedures at the end of this manual. Trying to fix it after this point gets fairly difficult.

## 16☐

**Gluing the Coil to the PCB**

Now that you know it works, and which side of the magnet to have face upwards, GLUE the coil to the PCB. That is, use the wicking properties of the superglue (IE: it seeps into cracks easily), to glue the PCB to the solarcell/wings, and the coil to the PCB. There's no graphic for this, because....it looks just like the graphic for step 15....

## 17☐

**Assembling the Stand**

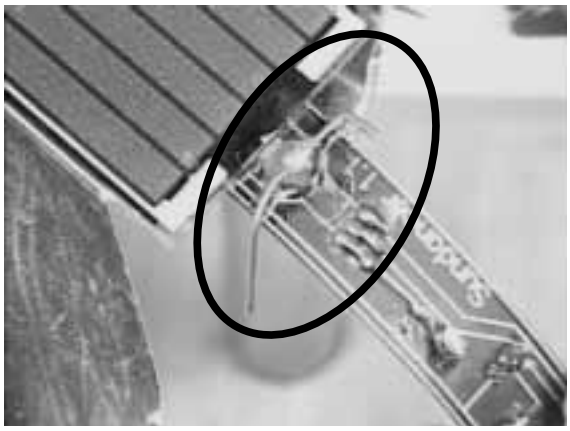
Assembly of the stand couldn't be much simpler. Take the oak rod and put it in the oak base hole. It may need some minor "persuading" to get in (use a hammer to tap it in), but not too much force should be needed.

# SunDancer 1.3 BEAM Magbot:
## Assembly - Contd.

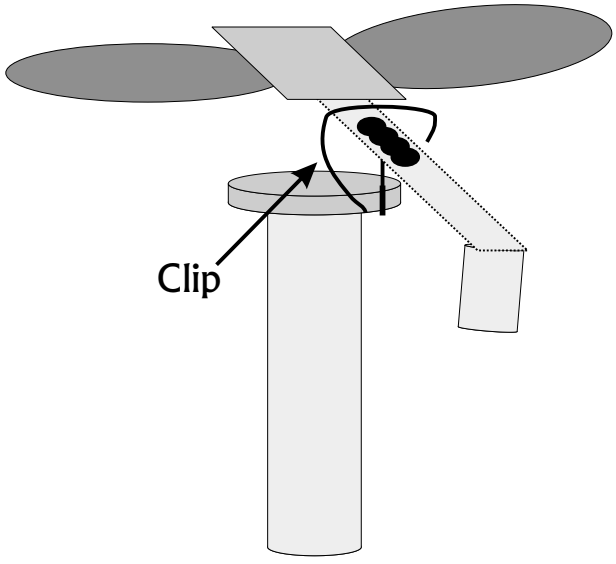
18☐
**Soldering on the Rocker Pin to the Magnet**
Remember which side of your magnet was "up"? Keep this in mind when you solder the rocker pin in place. Solder the pin to the magnet, about ½ way down the pins length. Clip off the lower portion, and glue the magnet onto the oak rod stand.

19☐
**Bend the rocker pin**
You will need to do this to increase the stability of your Sundancer. Otherwise, it is *much* more susceptible to spinning around on the stand because the magnet is not directly under the Magbot's coil. Be careful to make the first bend just above the neck of the pin - it may snap if you make the bend too close, and you'll have to resolder it back on.

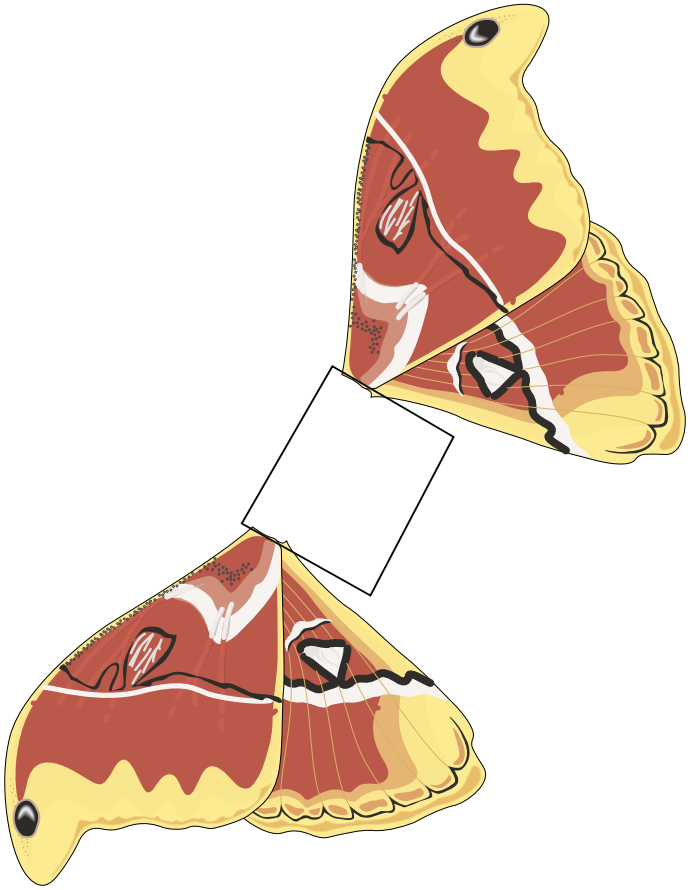
There - you are essentially finished! All that remains is to place your Magbot SunDancer on the pin, using the four balance holes to find the point that makes it balance the best. Your SunDancer should last an incredibly long time, and operate even in dim light conditions. But depending on how active your own SunDancer is, you may need to make one of the following alteration....

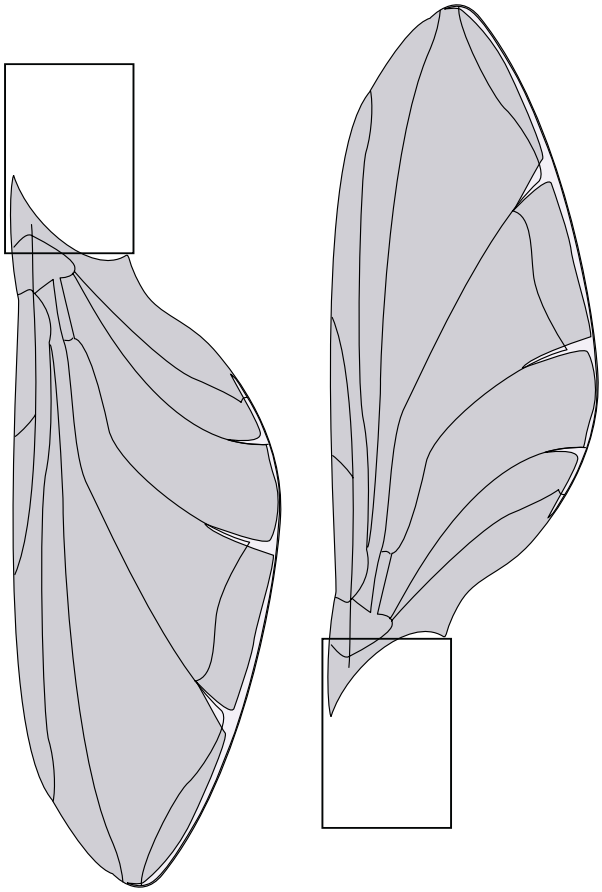


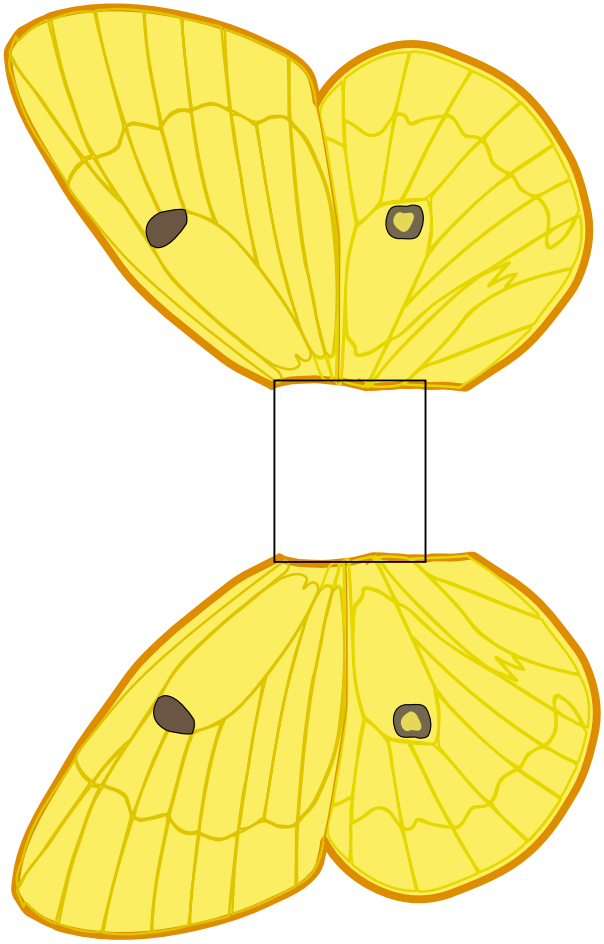
19 ☐
**Swing limit Bracket**
Particularly active SunDancers can get spun around on the stand and fall off. To stop this from happening, take one of the excess leads you clipped off the resistor and solder it across the top of the PCB on one of the balance-point pads (Note: This technique only works if the clipped-lead you want to use is NON-MAGNETIC. If it's magnetic, use the other version of the bracket!). Bend them down so that they will strike the edge of the magnet and keep the SunDancer from spinning around.

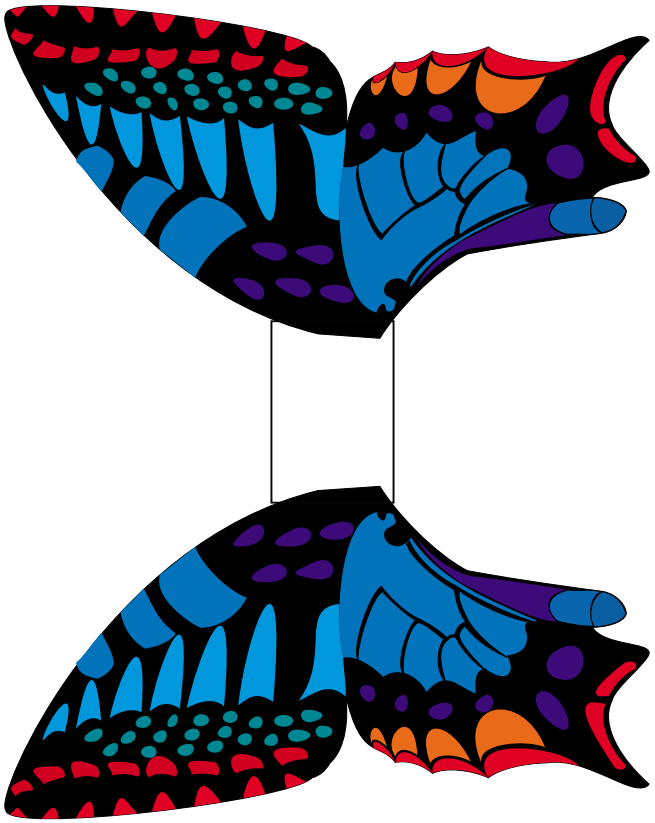



**Swing Limit Bracket - Another Version**
An alternative to putting the bracket *on* the SunDancer, is to put the bracket on the stand itself. Take a paperclip, and bend it into a large "C" shape, and solder it to the magnet as shown here. The idea is to make the clip open on one side so you can still slip your SunDancer in and out, but when it's swinging side-to-side, it only rotates as far as the clip will allow.









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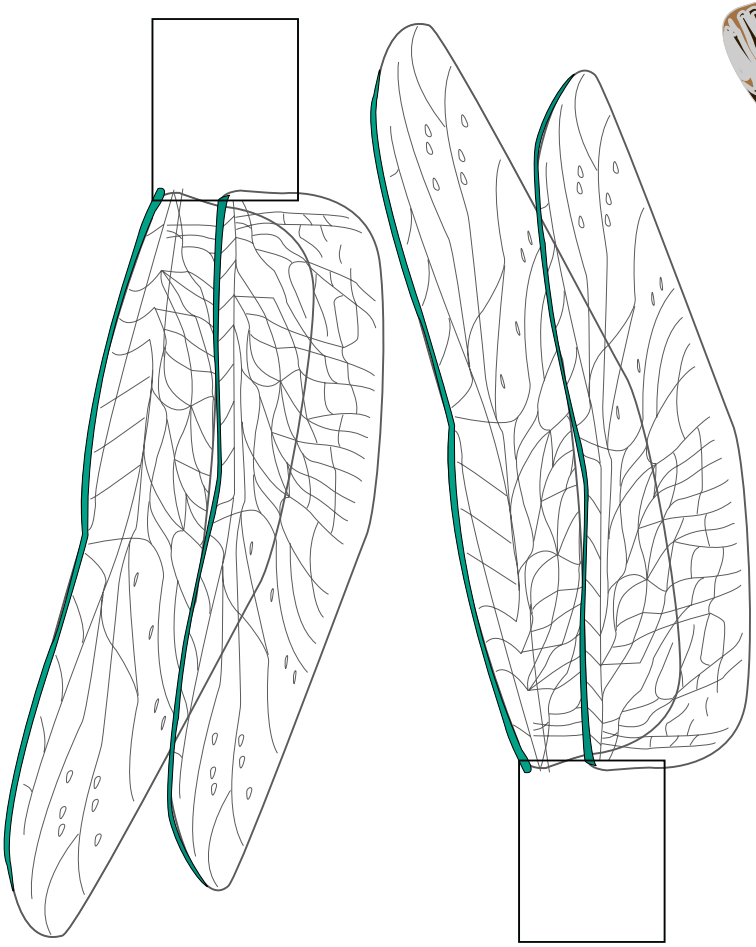

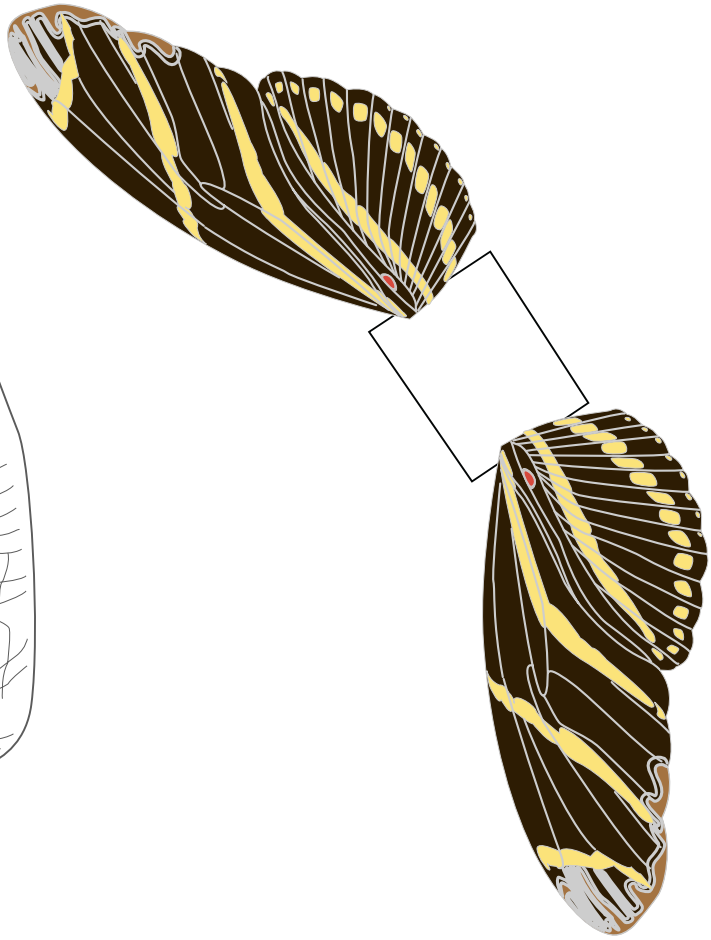

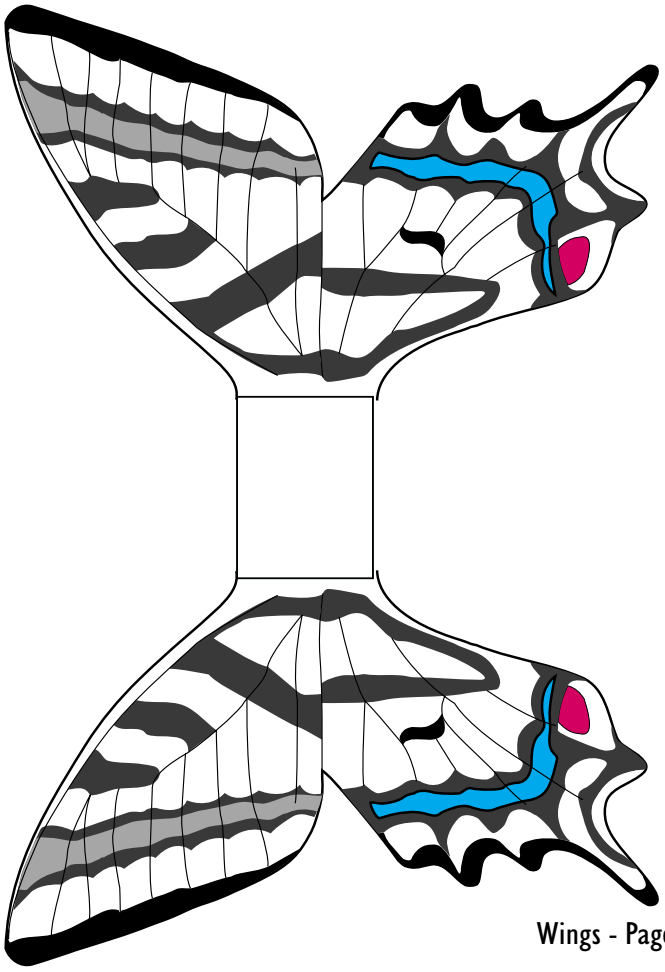

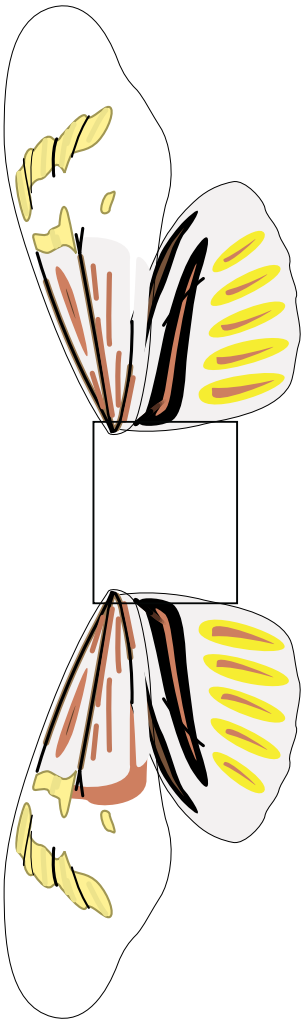

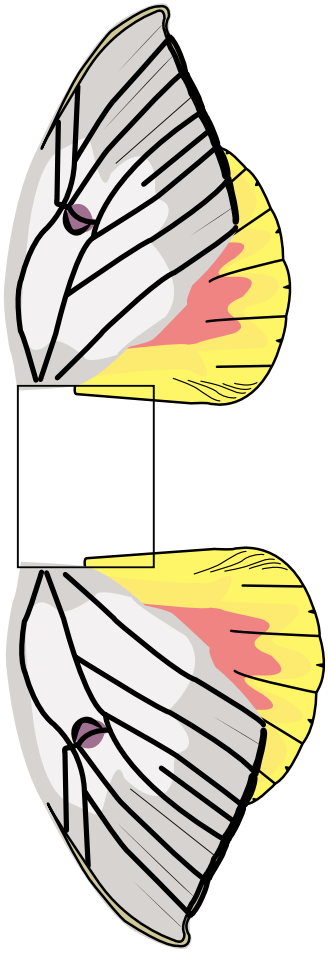

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# *SunDancer 1.3 BEAM Magbot:*
## *Troubleshooting*

**"It doesn't do anything!"**
Since your SunDancer is a relatively simple circuit, there are only a few things that can go wrong. Go through the list and see if any of these answers fix it:

• Coil soldering - *Make absolutely positive* that you haven't pushed the wire too far through the hole before soldering. Give it a gentle tug to make sure the solder connection is solid. If you accidentally break off the solderable silver portion of the wire, you can use a knife to scrap off some of the red insulating enamel, and solder to that instead. You only need about 3mm (1/8") bare to solder to the wire successfully. If you have a voltmeter, you can check the voltage being stored on the main 3300$\mu$F capacitor. If it doesn't go over 0.8V, then you can be sure that one of the coil connections is bad.

• Solarcell - This can be a fragile connection to the PCB. Any time you drop your SunDancer, you risk breaking the solarcell pad right off the solarcell, so *be careful* with it! Inspect it by *gently* bending the PCB down from the solarcell while inspecting the solder connections to the solarcell. If one is separated, you'll see it open up immediately. If you did break the pad off the solarcell, you might be able to resolder it on, but there's no guarantee. You may be able to fashion a metal clip in the shape of a "C"to slide onto the solarcell where the pad should be. Check it with a voltmeter - if you read a voltage, then you should be able to glue the clip down, and solder the SunDancer PCB to the clip.

• Transistor/Trigger Placement and Orientation. Make sure that they're facing the correct directions, as they all don't face the same way. With your SunDancer on it's back (solarcell facing down, furthest away from you), make sure that:
- The transistor at the middle of the board is the 3904 and has the flat-face facing *towards* you.
- The middle transistor is the 3906 and has the flat-face facing *away* from you.
- The transistor nearest you is the 1381 trigger and has the flat-face facing *away* from you.

• Perform a 'wiggle' test on all the components (except the solarcell). That is, grip each of the components on the PCB and give it a firm wiggle. Closely watch where the wire legs are soldered to the PCB. They all must be firmly soldered to the pads, and not sliding through the holes or wiggling at all.

• There cannot be any jumpers between the solder pads. These are blobs of solder that cross from one pad to the next and short out the electronics. Examine the sets of three pads that each of the transistors are attached to - these are most likely to have solder jumpers.

If nothing else, you can send it back to Solarbotics for free repair (or replacement if necessary). We stand 100% behind our products, and will do everything we can to make your kit perform like it should. When returning your SunDancer from international destinations, mark the parcel customs form with "Returned goods for repair - value $5". This will alleviate the need for us to pay customs fees for something those fees are not applicable to. **We will NOT pick up parcels with customs fees owing, and they will be returned to you unopened.**


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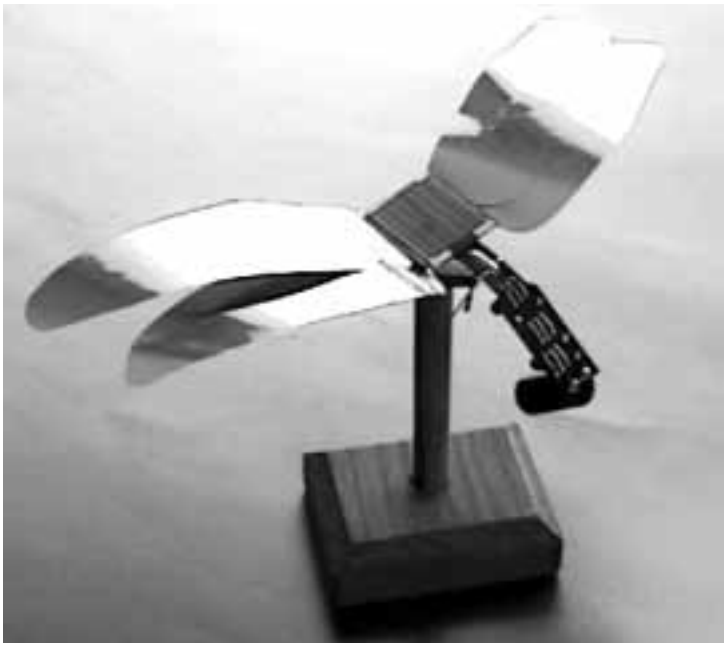
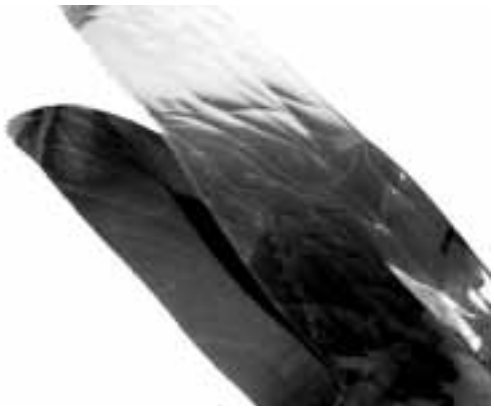
The **SunDancer Magbot** is a desktop implementation of technology being researched for miniature orbital satellites! By using solar energy from its environment, the SunDancer reacts against a magnet to sway on a pivot against a self-induced electromagnetic field. The gold/silver wing foil reflects sunlit patterns onto your ceiling, which make for tempting targets for household pets! Select a dragonfly, butterfly, or bird wing design for your SunDancer, and put as much detail as you want into them.



This SunDancer Dragonfly was constructed with four wings, and very intricate wing detail.



A SunDancer Butterfly resting on its oak stand.