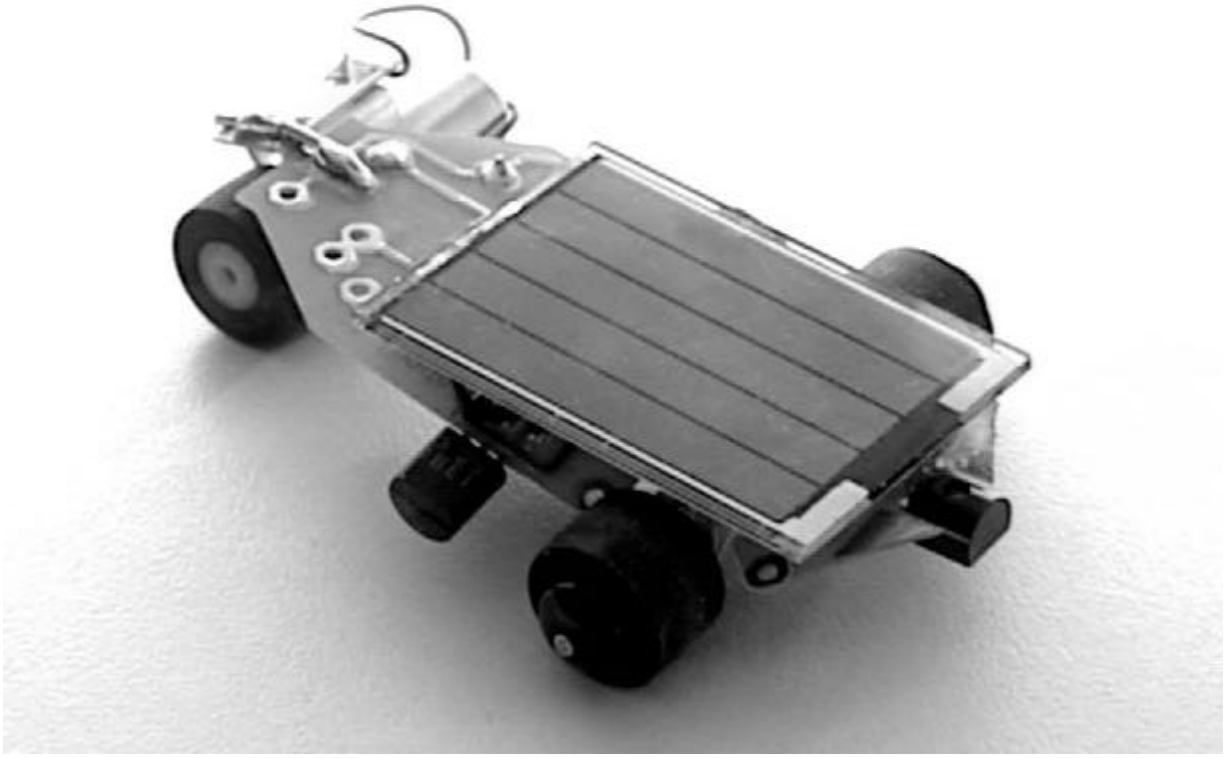
BEAM® Solar Kit #5:

The BEAM SolarSpeeder 1.0 Solaroller©



This BEAM® Solar-Powered Car is designed for high-speed racing, and can go over 3 meters (10 feet) in under a minute in direct sunlight! (Soldering skill required)

A Complete BEAM® Solar-Powered Car Kit Inside

Produced by

SOLARBOTICS Ltd.

Contents

SolarSpeeder 1.0 Parts & Materials List 1
Introduction - The SolarSpeeder 1.0 Solaroller 2
Circuit Overview 3
Construction - Electronics 4
Construction - PCB Trimming, Wheels, and the Motor 5
Construction - Motor Mount Support & Drive Wheel 6
Construction - Axles Trimming and Solarcell Preparation 7
Running, Tuning, and Fixing 8
- Running 8
- Tuning 8
- Fixing 9
  - Broken Axle Mount 9
  - "It Doesn't Go!" 10
  - "It Doesn't Roll Smoothly" 10

Final Notes 11

SolarSpeeder 1.0 Parts & Materials List

We *strongly* suggest you inventory the parts in your kit to make sure you have all the parts listed under the sections 'Mechanical Parts' and 'Electronic Parts'. Check off each box as you locate them. If anything is missing, contact us for replacement parts information.

Mechanical Parts

- (1) SolarSpeeder 1.0 Printed Circuit Board (PCB)
- (1) High-efficiency Coreless Motor
- (1) Motor Mounting Clip
- (3) Rubber Wheels on Nylon Hubs
- (1) 43mm long 1.40mm diameter (1.7" long, 0.055" diameter) Steel Rod
- (2) Black Plastic Wheel Retainers

Electronic Parts

- (1) 0.33F 2.5V Gold Capacitor
- (1) 3904 Transistor
- (1) 3906 Transistor
- (1) 1381 Voltage Trigger
- (1) 2.2kS Resistor (colour bands Red/Red/Red/Gold)
- (1) SC2433 24x33mm 2.7V Solarcell
- (1) Pair Solarcell wires
- (1) 25mm (1") length 18 Gauge wire

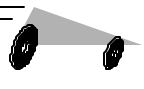
Tools Required

- A Soldering Iron
- A pair of Needle-nose pliers
- Side-cutters or strong Scissors
- File and/or Sandpaper
- Glue, Rubber Cement, or Hot-Glue (or Superglue, if you're *very* careful)
- Safety Glasses - VERY important when clipping and snipping!

Disclaimer of Liability (i.e.: stuff to keep the Lawyer happy)

Solarbotics Ltd. is not responsible for any special, incidental, or consequential damages resulting from any breach of warranty, or under any legal theory, including lost profits, downtime, goodwill, damage to or replacement of equipment or property, and any costs or recovering of any material or goods associated with the assembly or use of this product.

In other words - be careful! We will help you any way we can to assure the successful completion of your kit, but can't be responsible for putting band-aids on any burns and other ouchies you get while soldering, clipping, snipping, etc., etc...



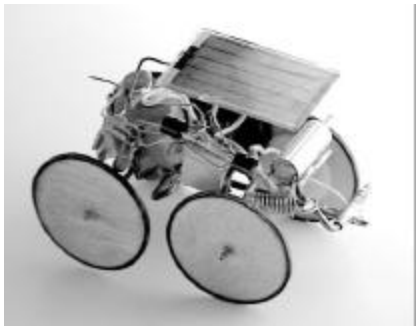
Introduction - The SolarSpeeder 1.0 Solaroller

The SolarSpeeder is a design that has a strong heritage in Solaroller Racing, which is a very popular event at any BEAM Robot Games.

Solaroller racing requires two solar-powered drag-racers that have a solarcell area no more than 1.25 square inches and fit in a 6" cube, that race down a 1 metre (3.3ft) track. When Solaroller Racing began, the 1 metre times were in the 10 and 20 minute ranges. As the electronics and mechanics advanced, the times lowered to 6 minutes, 2 minutes, and now there are Solarollers capable of a metre in under 30 seconds! The SolarSpeeder uses many of these new technology advances in it's design, which allow a well-built SolarSpeeder travel almost 3 metres (10ft) in under 40 seconds in direct sunlight.

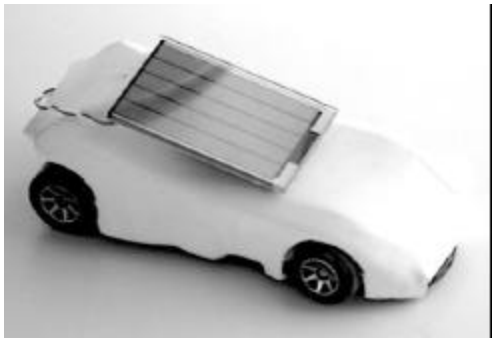
"Sluggy, Too" - Ex-champion Solaroller with a 2 minute 9 second metre record.

"Scooter" - Best competition time of 1 minute 4 seconds, narrowly beating out 3rd place by only a second. 1st and 3rd place were won by 11 year old boys!



"Herbie" - A 4-wheel drive Solaroller designed for the rough-terrain Class-B event. Almost as fast as "Sluggy, Too"!

"SC-1" - A modified Slot-Car racer. One of the first to use the new technology to make it quite quick.



"SolarSizzler" - This one is one of the prototypes to the SolarSpeeder. It uses a soft rubberized shell as it's body.

Circuit Overview

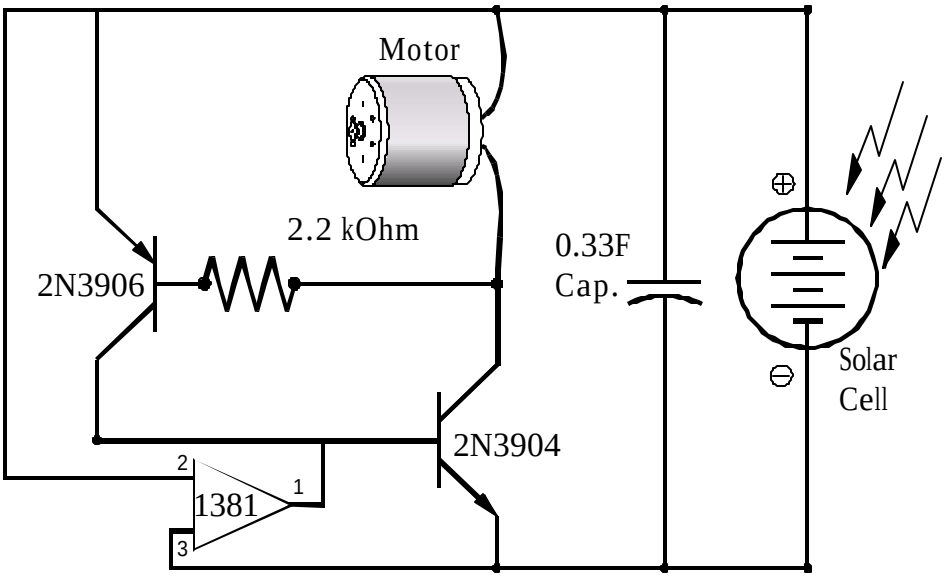
The heart and soul of the SolarSpeeder is the high-performance Solarengine. The three components that are most responsible for the increased performance of the Solarengine are the 0.33 Farad capacitor, the 1381 trigger, and the coreless motor.

The 0.33 Farad capacitor is deceiving power dense for it's small size. To put it in perspective, this storage cell holds 100 times the power of regular capacitors 5 times the physical size. These capacitors are specially designed for low-voltage, high power applications - perfect for Solarollers!

The coreless motor is a very small, efficient device that is specifically designed to run at approximately 1.5 volts. Since the Solarengine is designed to run at a maximum of 2.5 volts, this places the motor almost exactly in the range we want it to run. And being so small and compact, it is ideal for BEAM applications.

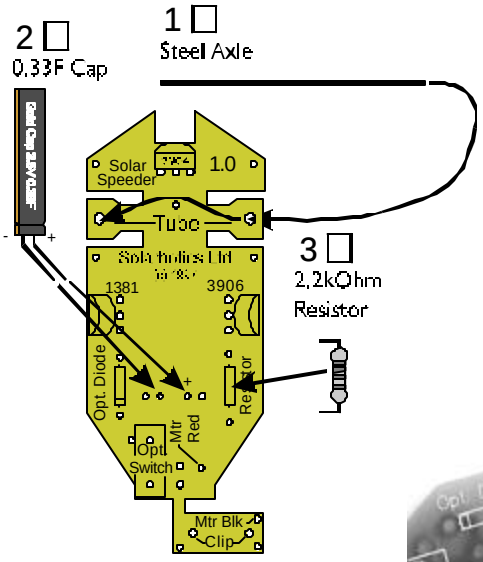
The 1381 voltage trigger is a small three pin integrated chip (IC) that looks much like a transistor. It was originally designed to detect low voltage levels in the batteries of portable electronic devices, like cellular telephones and portable computers. It uses very little power to monitor the voltage,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

Because of the 1381 voltage trigger, your SolarSpeeder will not run until there is sufficient charge stored up in the 0.33 Farad capacitor. 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 SolarSpeeder will be able to trigger in light levels that are still bright enough to read by (but you will have to be patient).



Construction - Electronics

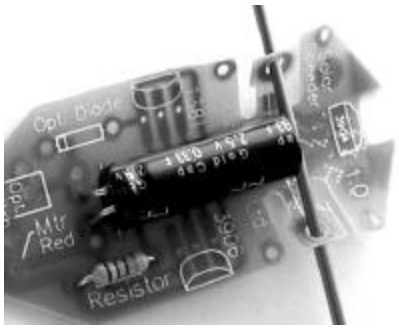
Now is the time to gather your tools and warm up your soldering iron. Remember, good soldering technique means you heat up the component and the solder pad before applying the solder. Assembly is quite straightforward - simply go through the numbered steps, checking off each box as you go. That way, you'll be sure not to miss any steps.



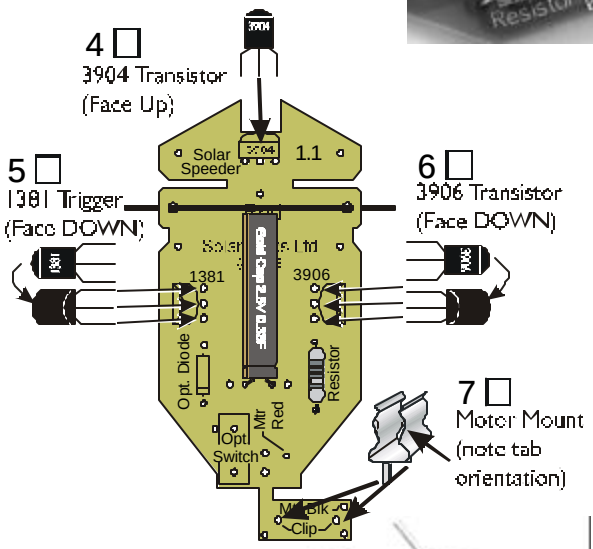
Step 1: Slide the **axle** through the holes labelled "tube" so it's about centered.

Step 2: Bend the leads of the **0.33F capacitor** down right against it's body and place the leads into the printed circuit board (PCB) as shown. Make sure it goes in with the stripe side (negative) on the left. Turn the PCB over and solder the leads to the solder pads. Trim off any excess.

Step 3: Put the **2.2kOhm resistor** in place as shown on the PCB. Same as in step 2, solder it in, and trim off the leads.



This is what it should look like when you've finished steps 1, 2, and 3.

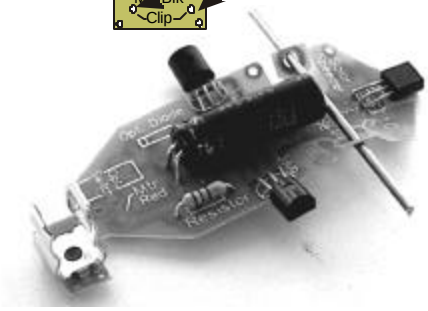


Step 4: Place the **3904 transistor** in place as shown, with the transistor facing upwards so you can read the numbers. Solder & trim the leads.

Step 5: Place the **1381 trigger** in place on the PCB, but **flip it over** so you can't read the numbers. It's shown face up on the diagram so it's easier to identify. Solder & trim the leads.

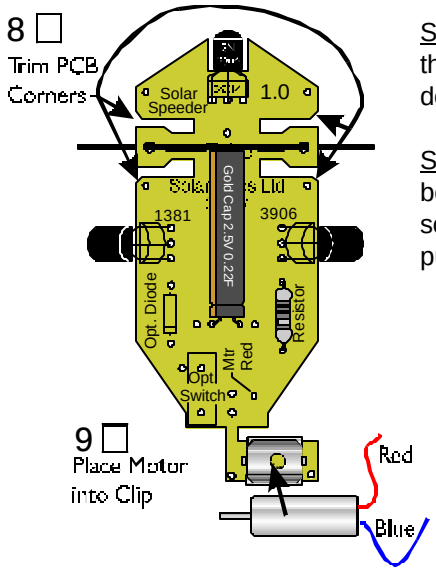
Step 6: Insert the **3906 transistor** into position, and again (just like the 1381 trigger), **flip it over** so you can't read the numbers. Solder & trim the leads.

Step 7: Push the **motor clip** into the holes labelled 'Clip', making sure that the tabs are facing to the left. This will align the motor when you install it into the clip.



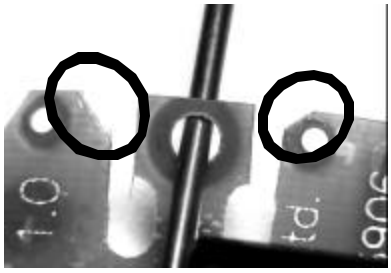
Completion of steps 4 through 7 looks like this.

Construction - PCB Trimming, Wheels, and the Motor



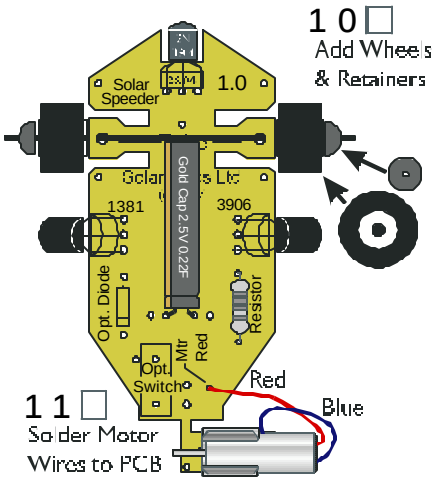
Step 8: Use your scissors or cutters to **trim** a small corner off the edges of the PCB where shown. This will avoid any possible rubbing the wheel may do against the edge of the PCB.

Step 9: Snap the **motor into the motor clip** as shown. Rotate the motor body in the clip until the red wire is closest to the PCB (makes it easier to solder later). Be sure to push the motor as far to the left as you can so it's pushed up right against the tabs on the clip.



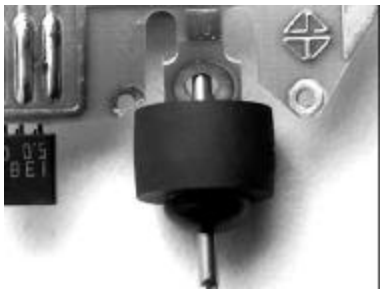
Clipping the PCB detail

Push the motor up against mounting tabs



Step 10: Place a **wheel** on the axle and give it a spin. Make sure the wheel isn't rubbing the PCB. If so, trim a bit more off the PCB. When it's spinning nice and free, push the **retainer** on. *Be careful!* It's easy to poke your finger with the axle when doing this!

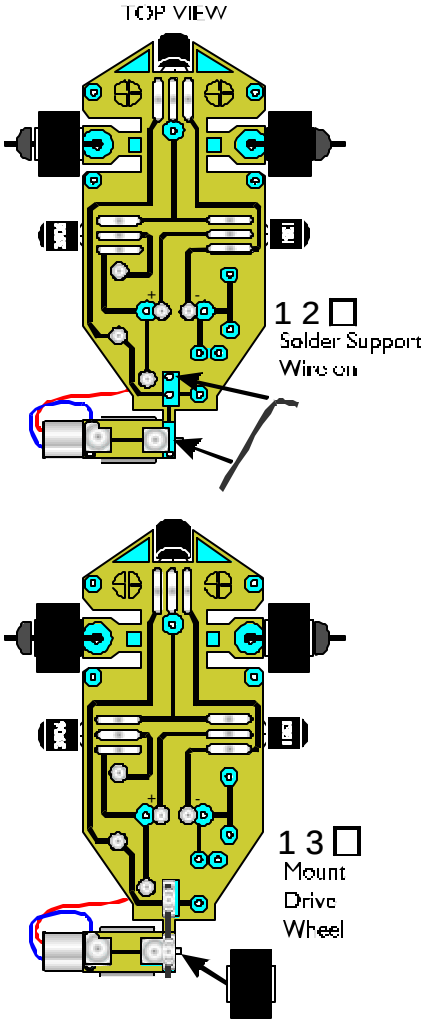
Step 11: Solder the red wire to the pad labelled "Mtr Red", and the blue to one of the holes right near to the motor clip.



Make sure the wheel doesn't rub against the PCB body!

Motor Soldering Detail

Construction - Motor Mount Support & Drive Wheel



Step 12: Find your small thick piece of wire, and pull the insulation off so you are left with a small piece of solid copper wire. Bend one end 90 degrees down, and **solder the wire onto the pads** shown on the illustration. Trim the excess off the back and **save it**. This gives your motor mount more strength, and allows you the option of aligning the motor so you can adjust where your SolarSpeeder goes. Useful for doing donuts on a countertop!

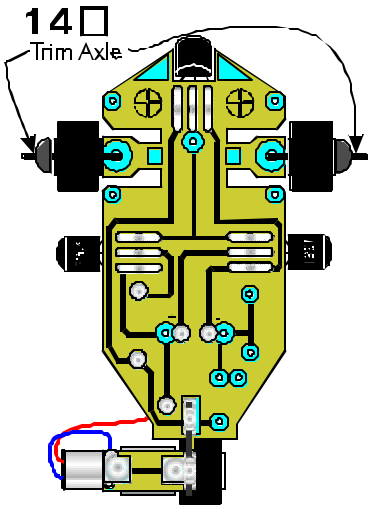
Close up of striped copper wire soldered onto motor mount support pads

Step 13: It is now time to **mount the drive wheel** onto the motor shaft. This takes a bit of patience, as it's *very* easy to gum up the whole motor with the glue, especially if you insist on using superglue. We recommend using epoxy, rubber cement, or a white glue for this operation. Simply dab a *very* small amount of glue onto the end of the shaft and slide the wheel on so it comes near to (but not touching) the motor mount clip. Let it dry, and we're almost ready to race!

Apply the dab of glue...

...and slip the motor on - but not too far!

Construction - Axles Trimming and Solarcell Preparation



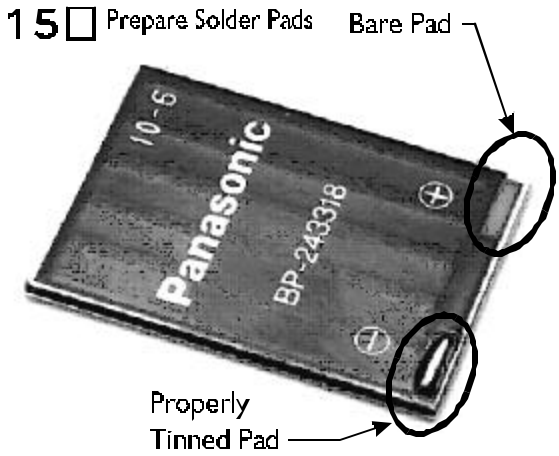
Step 14: All that you have to do here is **trim the extra axle off** with your snips. Then file or sand the edges rounds so it isn't sharp anymore, or pull the wheel retainers over the end of the wire so it covers up the sharp points.

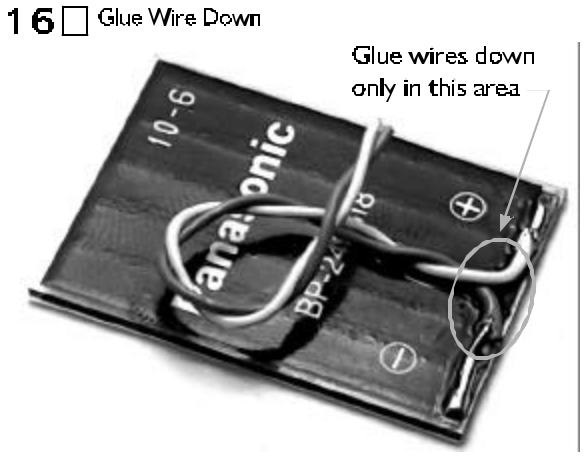
If you are finding that your wheel retainers are a little loose on the axle, now would be a good time glue them down, but only apply the glue on the side **away** from the wheel, so it doesn't get gummed up.

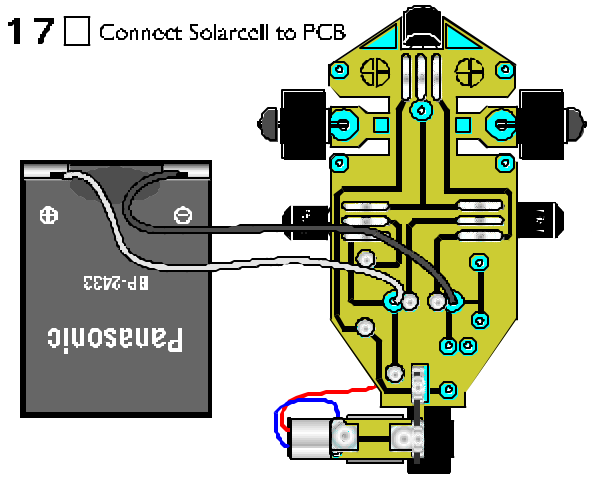
Step 15: If your solarcell doesn't have **pre-tinned solder pads** (ie: the solder is already on it), you'll have to do it yourself. This can be potentially the most delicate part of building your SolarSpeeder, so take your time.

Pre-tin the pad by melting solder to the pad in a quick, smooth motion. You don't want to apply too much heat to the pad, or you'll ruin it. You can tell when this happens, as it gets dark and no solder will stick to it.

Step 16: **Solder the wires to the solarcell**, red to '+' and the black to '-', and secure it to the solarcell by gluing it down to the back. THIS IS IMPORTANT. You can easily rip the wires off the solarcell if you don't!







Step 17: Connect the **solarcell wires** to the PCB, red to '+', black to '-', just like in the illustration. Once you've done that, your SolarSpeeder is "ALIVE", but not finished - you have to glue the solarcell to the PCB with epoxy, or similar gap-filling glue (use hot-glue only as a last resort - it softens under the heat of a desklamp).

Secure the solarcell to the PCB when you're sure it works. Make sure it doesn't rub on the wheels, and that the solder pads on the solarcell don't touch any of the solder pads on the PCB.

Running, Tuning, and Fixing

Running

Your SolarSpeeder is *very* quick for a solar-powered device, but it is slow compared to a battery powered car of about the same size. When it's first finished, you will have to be patient for it to make it's first mad dash across the table. Our tests show that your SolarSpeeder should activate from a dead startup (absolutely no power) in approximately 3 minutes when lit by a 100Watt incandescent bulb 20cm (8") above it. In direct sunlight, it should trigger in under 1 minute, and then under about every 40 seconds after that. Your times may vary a bit because the storage capacitors are rated 0.33 Farads, minus 20% to plus 80%. This means your 0.33F capacitor can range between 0.264F and 0.594F! Being smaller than 0.33F isn't a bad thing - it just means it will trigger more often, but not travel as far. And being larger than 0.33F...well, that means you'd better have quick feet to catch up to it!

If you have a voltmeter and you care to monitor the SolarSpeeder as it charges, you will notice that it will always trigger between 2.0 and 2.2 volts, which is the voltage the voltage trigger is preset to. After its first cycle of charging and triggering, it will dump all it's energy until the voltage drops to 0.7 volts, which is the voltage where most electronics naturally stop working. This is why all cycles after the first have shorter charging times - that 0.7V stays in the storage capacitor.

If you want to make your SolarSpeeder do donuts or run in curves, feel free to adjust the alignment of the motor. Don't worry about breaking the thin PCB neck - the thick copper wire we soldered in will be more than sufficient to support it after the PCB cracks.

Tuning

The design of the SolarSpeeder does not allow for much tuning, but if you are so inclined, you can experiment with changing the solarcell and bias (2.2kOhm) resistor. Changing the solarcell will make an obvious difference to the charge time, but the distance it travels should remain approximately the same. Changing the resistor for a 10kOhm trim pot or simply for a different resistor will modify the efficiency of the Solarengine. Higher values make the electronics more power efficient, but decrease the initial amount of energy it can provide to the drive motor. Lowering the resistance will give the motor much better starting torque (like peeling out a musclecar when you floor the gas pedal), but at the expense of a shorter distance run. The resistor we've included in the kit is a good compromise between power and endurance.

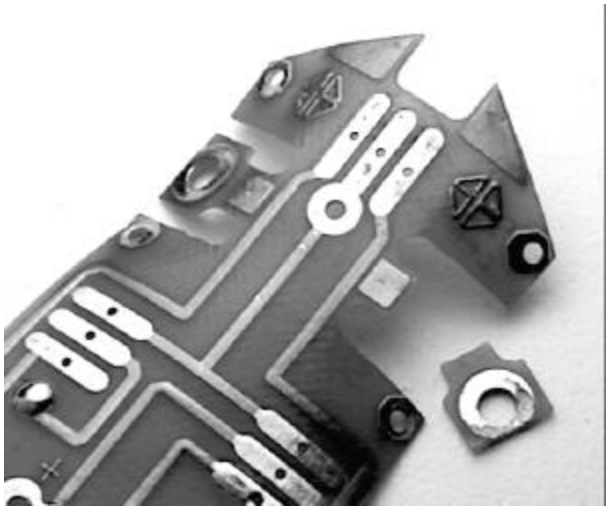
You will notice that there are some unused pads on the PCB. The pads labelled "Opt. Switch" are for adding a manual "impatience" trigger if you want to force the SolarSpeeder on before it has reached the trigger voltage. The "Opt. Diode" is an option for those who want to store up more power before triggering the Solarengine. This is done by using a diode to "trick" the voltage trigger into waiting an additional 0.7 volts before firing. Add the diode where shown on the PCB, and cut the vertical trace going up from the '-' pad. *PLEASE NOTE:* Both these options are described for your benefit, and implementing them on your own will void the return/repair policy on your SolarSpeeder. Solarbotics has an "Upgrade" kit to implement features properly, and cover the modifications in full detail.

FIXING

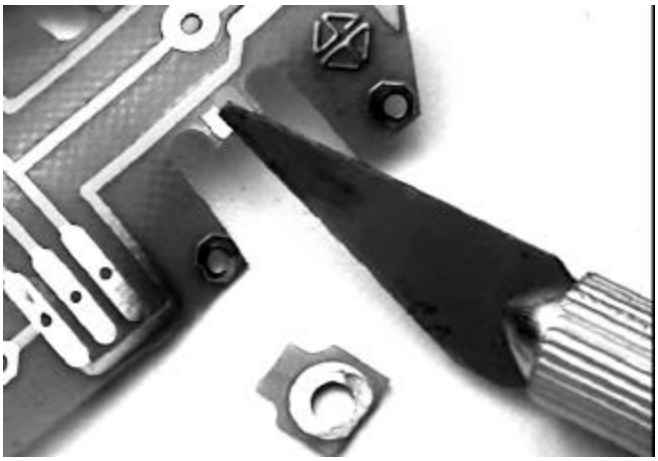
You should find your SolarSpeeder quite a robust device that should hold up for years, but here are some tips for any repairs that you may need to perform in the building of it.

BROKEN AXLE MOUNT

This is an ailment you may suffer due to rough handling of the kit or PCB during construction. To minimize the breaking off of these tabs, we have pre-formed the PCBs into curves to lessen the stress they experience. Fortunately, it's not a difficult repair to perform.



Broken Axle Mount - don't you just *hate* it when that happens?



Step 1: Scrape the green covering off the square pad above the broken tab.

Step 2: Solder on a piece of the extra copper wire for reinforcing the motor clip connection. (You did save the extra like we asked, didn't you?)

Step 3: Solder the broken tab onto the wire. It may take some patience to do so, but it will save your PCB.

"IT DOESN'T GO!"

Since your SolarSpeeder 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:

• Transistor/Trigger Placement and Orientation. **Make sure** that they're facing the correct directions, as they all don't face up. With your SolarSpeeder sitting on its wheels, make sure that:

- The transistor at the nose is the 3904 and facing **down.**
- The transistor on the left is the 3906 and facing is facing **up.**
- The transistor on the right is the 1381 trigger facing **up.**

• Perform a 'wiggle' test on all the components. 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 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.

• Make sure that the red motor wire is soldered to the correct pad on the main body of the PCB.

• Are the wire connections to the solarcell still good? A *gentle* tug on the wire will be enough to check this. If it comes loose, you probably have a wrecked solarcell solder pad. If you want to try to salvage the solarcell, try using automotive defogger paint, or a conductive ink pen.

• Lift the solarcell off the surface of the PCB - does it work now? You may be accidently shorting the electronics with one of the solarcell solder pads. Cover it with some tape or make sure it's insulated from the PCB with glue.

• Prop the SolarSpeeder up so the drivewheel is suspended off the ground. Does it run now? If so, check the drag on the other two wheels. You should be able to give your SolarSpeeder a flick with your finger and it should roll at least 15cm (6").

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.

"IT DOESN'T ROLL SMOOTHLY"

If something is rubbing, chances are it will be the storage capacitor. You can make more clearance underneath your SolarSpeeder by bending the drive motor downward.

Final Notes

We sincerely hope you had fun building your SolarSpeeder, and you have just as much fun giving your local neighbourhood cat something to chase after. But if you want to try your hand at Solaroller racing, here are the basic rules:

- Maximum solarcell area of 8.06 cm^2 (1.25 $inches^2$). Your SolarSpeeder's solarcell is 7.68 cm^2 (1.19 $inches^2$), 95% of the maximum allowed.
- The Solaroller must fit in a cube measuring 15.24cm a side (6 inch cube).
- The track is 1 metre long (3.3 feet) with two lanes separated by a lane wall 2.5cm (1 inch) tall, with a 15.24cm (6 inch) starting and finishing square at each end for each lane.
- The Solaroller must have shorting wires coming out from it that can cross a shorting bar that is placed at the back of the starting square. This ensures the competitors are fully discharged until the moment the race begins when the shorting bar is removed.
- Light is guarenteed to be a minimum of one 500 Watt halogen lamp placed 50cm (19.7 inches) above the race platform (often there is much more light).
- Devices must conform to a 2 second stationary rule which means the solaroller cannot move for a full two seconds after the race has begun. This is to ensure some sort of electronics have been implemented rather than NASA-quality solarcells connected directly to ultra-precision motors (it's been done!).

Your SolarSpeeder won't technically qualify for 'Official' Solaroller racing, as the general rules specify that kit-built devices (unless modified) are not elegible for competition. But with what you learn building the SolarSpeeder, you should be able to build your own!

If you are interested in finding out more about BEAM Robotics, the BEAM Robot Games, and what other products we have to offer, please contact us at:

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