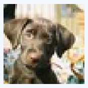
Solar Science Station

by JoshuaZimmerman on October 1, 2014



Author:JoshuaZimmerman BrownDogGadgets
I used to teach middle school science, but now I run my own online educational science website. I spend my days designing new projects for students and Makers to put together.

Intro: Solar Science Station

Solar activities are interesting to learn about and explore, but are often seen as a tad dull and lifeless. Wind Turbines move, hydro-electric plants have gushing water, hand crank generators require muscle, and solar just... kind of sits there. Like a cat in a beam of sunlight, generating solar electricity requires very little activity.

This provides an interesting challenge to anyone trying to teach youngsters about the joys of solar power. Like many educators, we decided that the best way of doing this was by having students create, explore, and apply solar energy. The solution: the Solar Science Station.

The Solar Science Station is a fun, all-in-one package for learning about solar energy. We tried to anticipate student, teacher, and parental needs while still allowing room for experimentation and expansion for all you tinkerers out there.

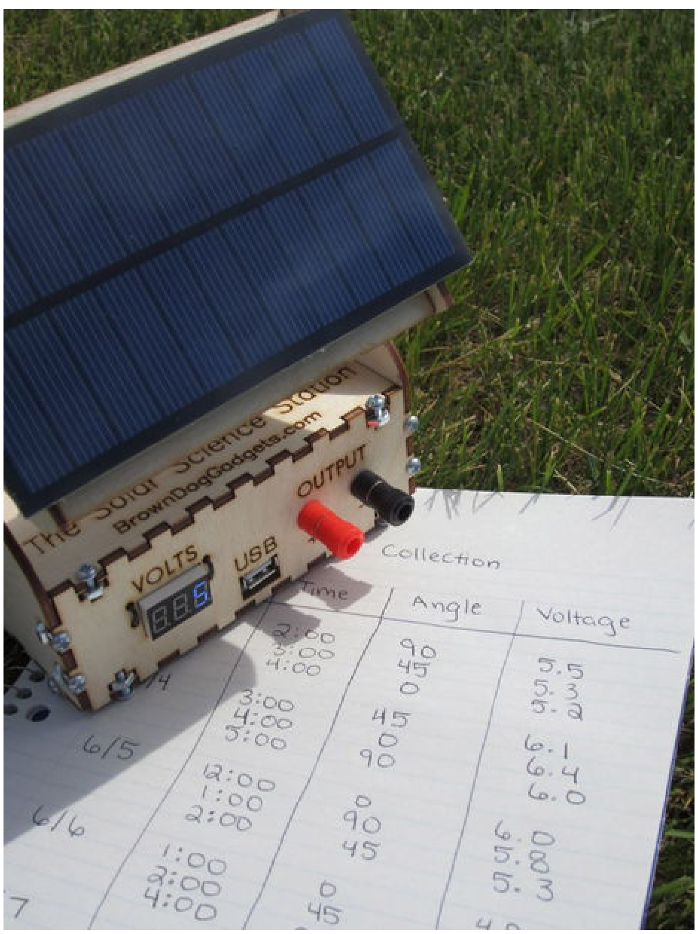
First, we made it non-soldering. This was a big request from teachers and parents, as many students are too young or are unable to solder. So, we designed it to be assembled using only a screwdriver.

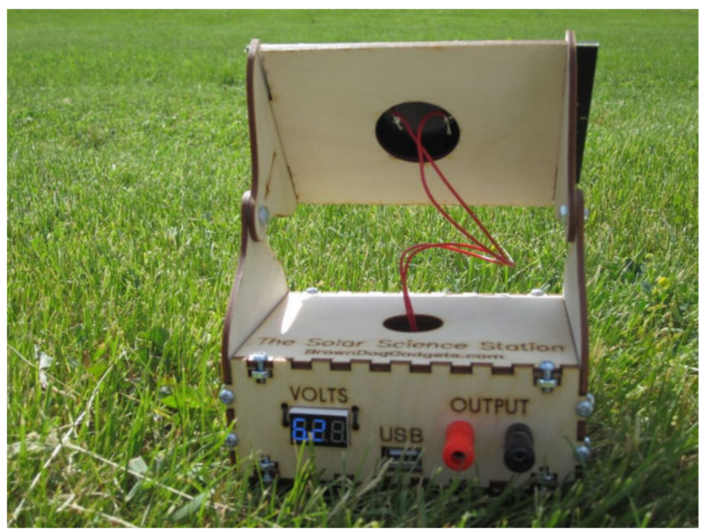
Second, since the project is non-soldering, it's also 100% reusable (another big request from teachers). Therefore, students can disassemble the kit when finished and teachers can use it again the following year.

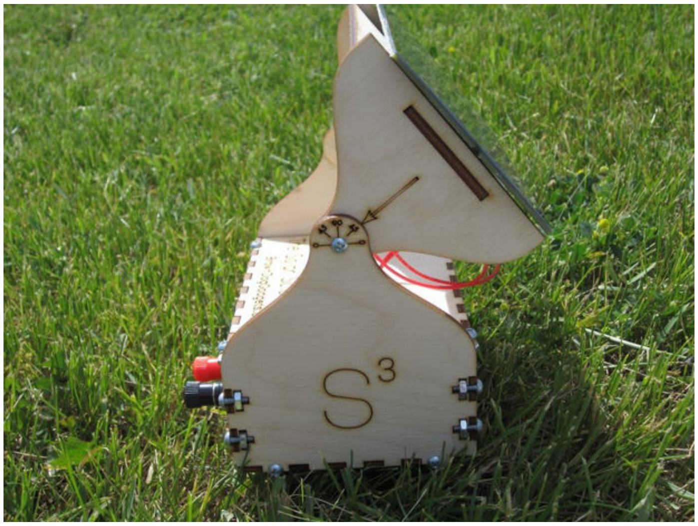
Third, it's engaging. We wanted students to be able to observe and record data about solar energy through the use of the voltmeter and the angle of the solar cell. We also wanted students to be able to apply solar energy to their daily lives, so we added a USB output and power-out terminals. So, students can plug their phones in or power other electrical projects. You could even power an Arduino project using the science station since Arduinos can be powered off USB.

Lastly, we made it easy enough so that adults can understand it. Parents and teachers are busy and often don't have the time to learn about electronics on their own. We wanted this activity to be something that teachers and parents can use right along side the youngsters for more engaging learning experiences.

While we do sell a kit of this project, complete with a fancy laser cut enclosure, we're going to outline how this project can be created from scratch at home. We will also be sharing some basic lesson plans and science faire activities that can be used with this project as well. Stuff that will knock the socks off any teacher who comes around.





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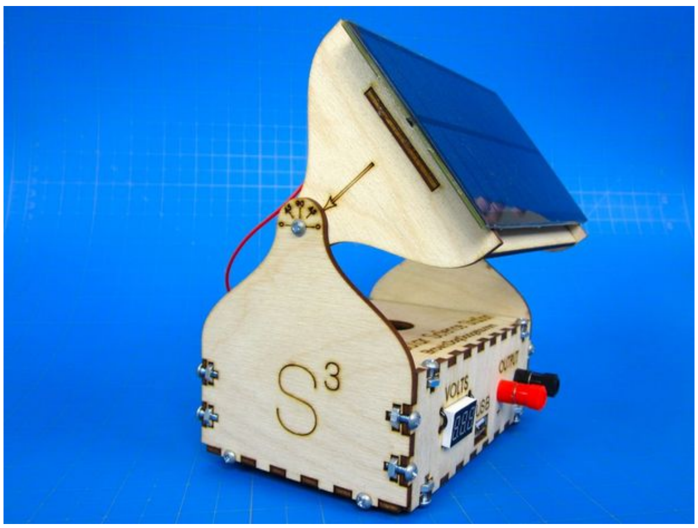
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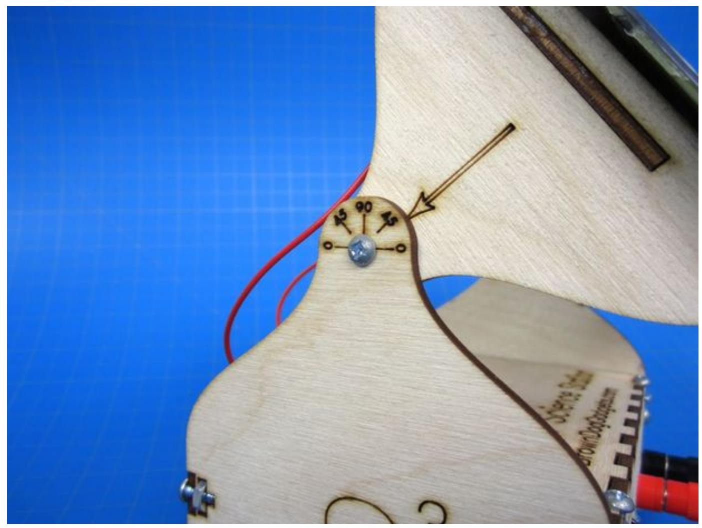
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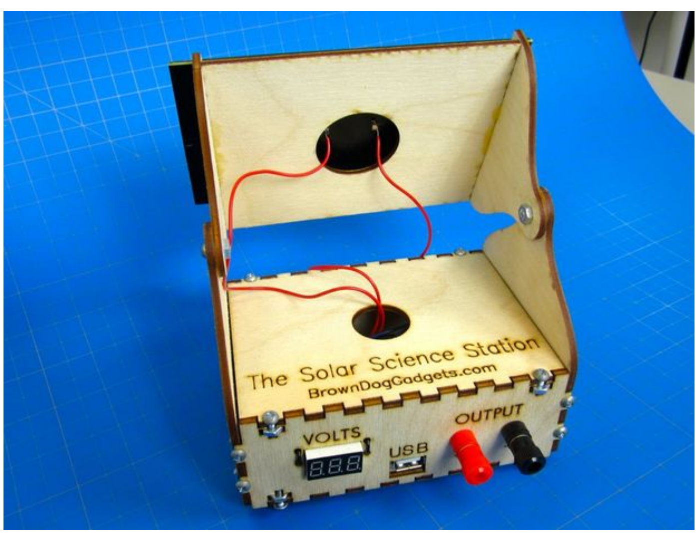
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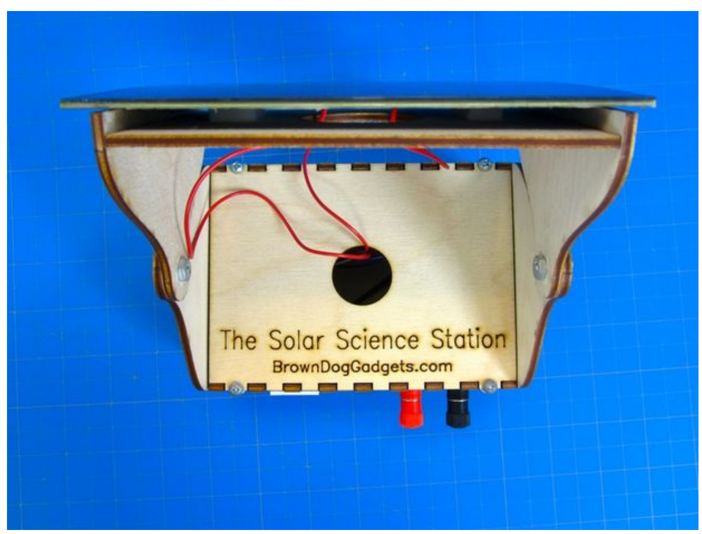
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Step 1: Parts and Tool List

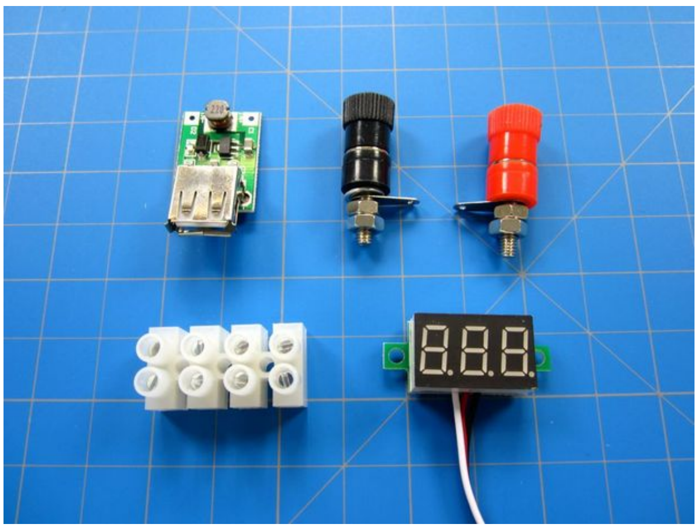
Listed bellow are all the parts found in the Brown Dog Gadgets Solar Science Station Kit. If you're creating this project from scratch, you can still find all these parts over at Brown Dog Gadgets or from other suppliers such as Adafruit, All Electronics, and Electronics Goldmine.

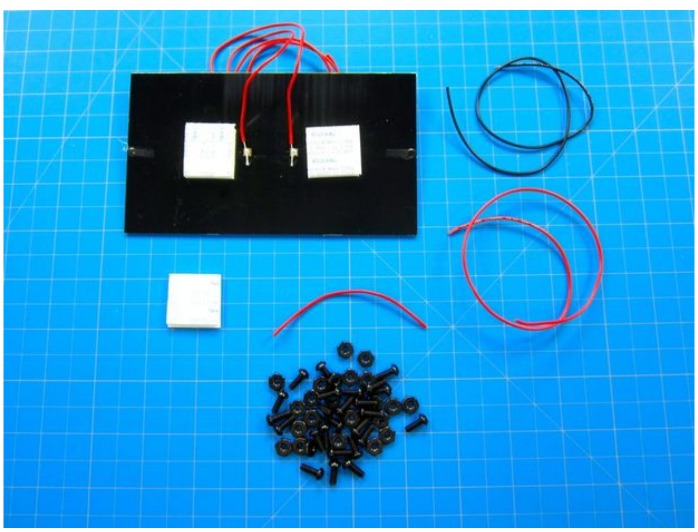
Tools:
Screwdrivers
Scissors
Wire Strippers/ Cutters

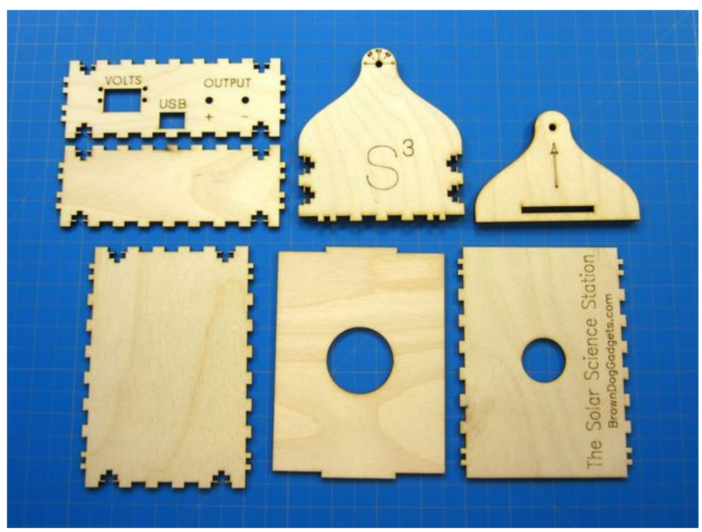
Electronics:
5.5V 320mA Solar Cell
USB Charging Circuit
LED Volt Meter (Blue LEDs)
6 Port Screw Terminal Block
Screw Terminal Ports (Black and Red)
Stranded Wire
Solid Core Wire

Optional Electronics:
1N914 Diode
3 AA Holder With Switch
3 Rechargeable AAs

Other Supplies:
Laser Cut Enclosure
Screws
Foam Mounting Tape (or hot glue)







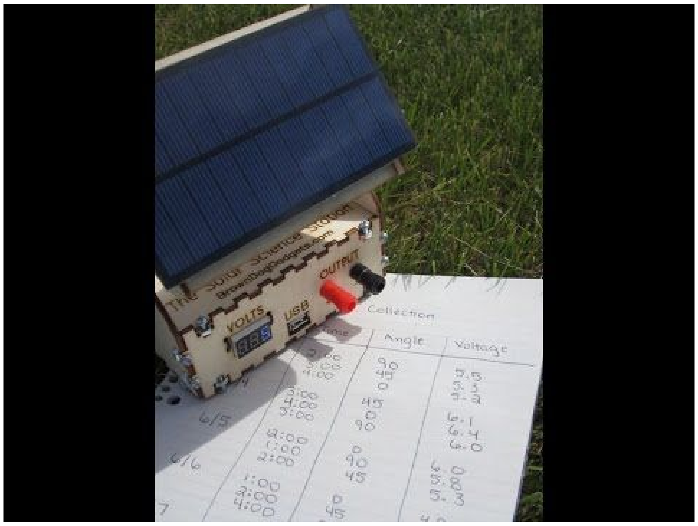
Step 2: Laser Cut Design and Video!

We love laser cutting parts for use in our projects, and if you have access to a laser cutter of your own you can use our files. Typically we use 1/8th inch Baltic Birch Plywood since it's inexpensive and looks nice. Acrylic would also work fine for this project just be carful screwing things into place as the small joints will crack..

In our shop we use a 90W Laser Cutter and this project takes about five minutes of cutting. It will take less if you remove our etchings on the side. (Or add your own! Every project needs a good dinosaur on it!)

Linked here is a PDF of our cut files. We'll add more file options on our website in the future.

Also, if you're the kind of person who would rather watch a video instead of read directions, we've included a nice step by step video of this project. Click here for a direct link to the video.



Step 3: Wire Preparation

In our kit, we provide several wires which need to be cut down and stripped.

As a general rule in this project, all red wires are **Positive** and all black wires are **Negative**. The parts are also marked as **Positive** and **Negative** using the standard + and - symbols. The one exception to this rule is our solar cell, which probably has two wires of the same color (though these wires are marked as + and - on the solar cell itself).

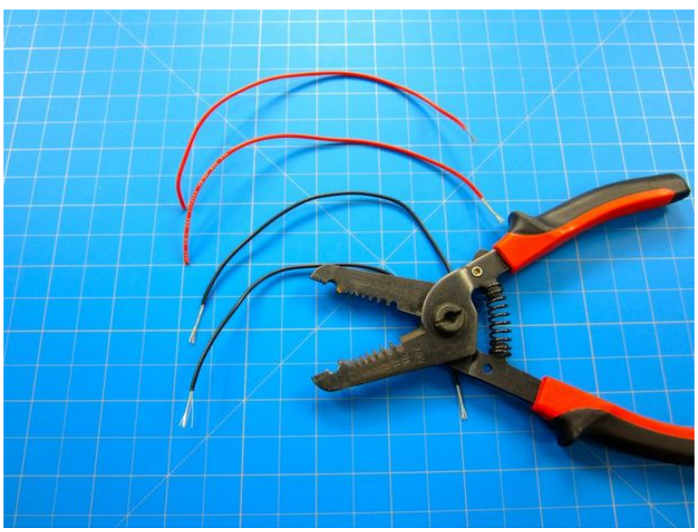
First, strip the ends of both wires coming off the solar cell.

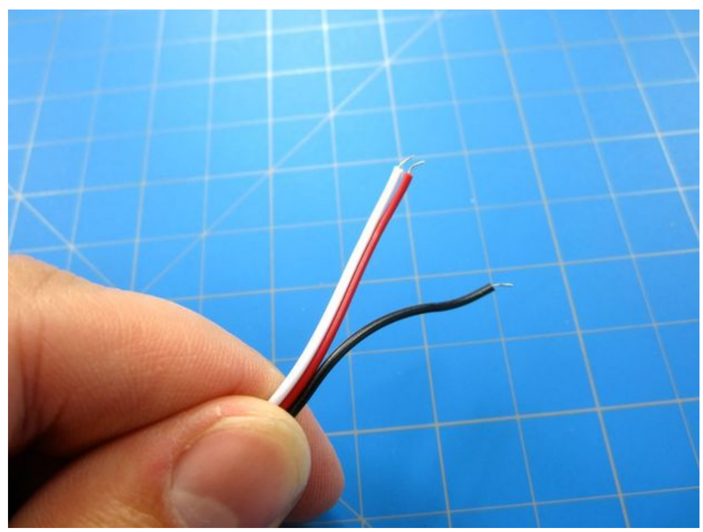
Second, find the red and black long wires. They'll each be about one foot long. Cut those wires in half and strip both ends. You should now have two black wires and two red wires.

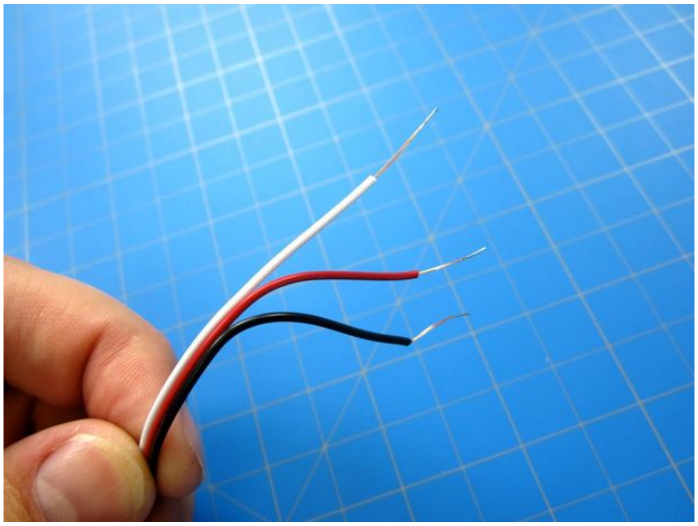
Third, find the short wire. It's solid core wire and should be much stiffer than the other wires. Cut it in half. Do not strip the wire.

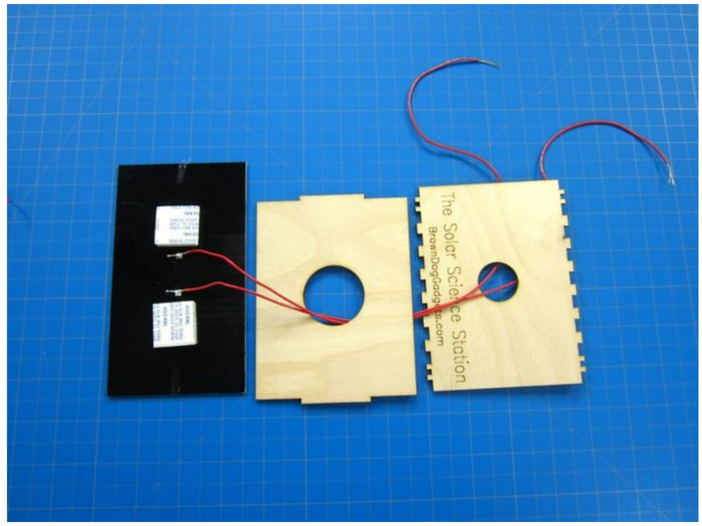
Lastly, strip the wires coming off the LED. There are three wires. The red wire and white wire are both **Positive**, and you may wish to keep them connected together. The black wire is **Negative**.

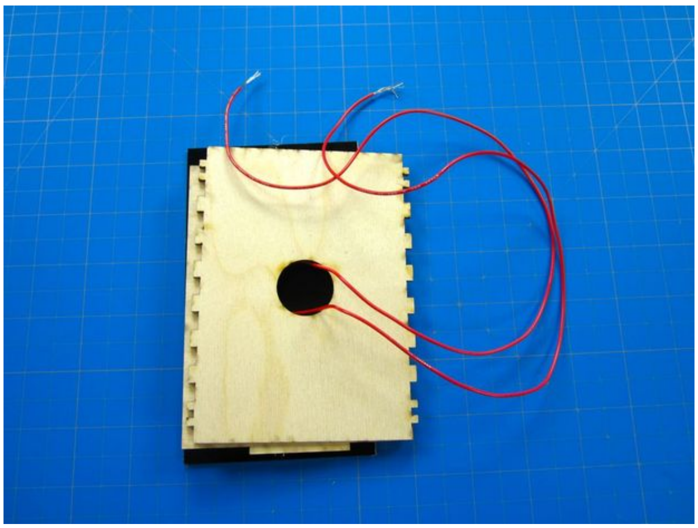
Remember, you can always strip off more wire later. Do no more than half an inch on any wire.











Step 4: Adding Wires to Parts

Before we attach everything together lets add wires to the parts that don't have wires.

Grab one of the stripped red wires and one of the stripped black wires.

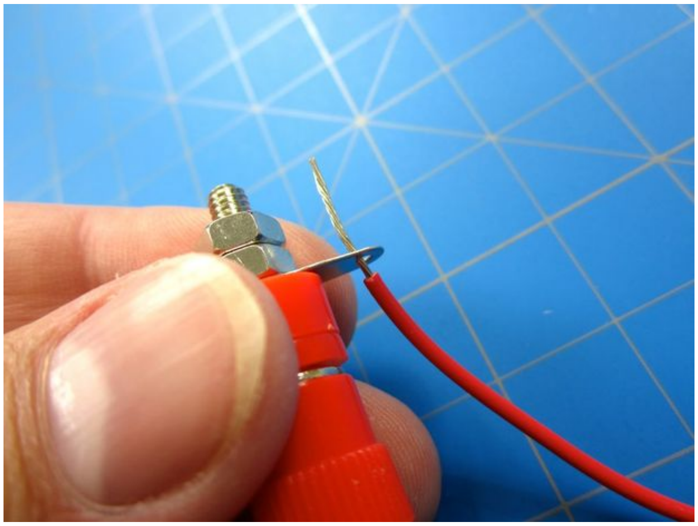
Pick up the USB Circuit and find the + and - markings on the back of the circuit board. There will be two large holes for you to thread the wires through.

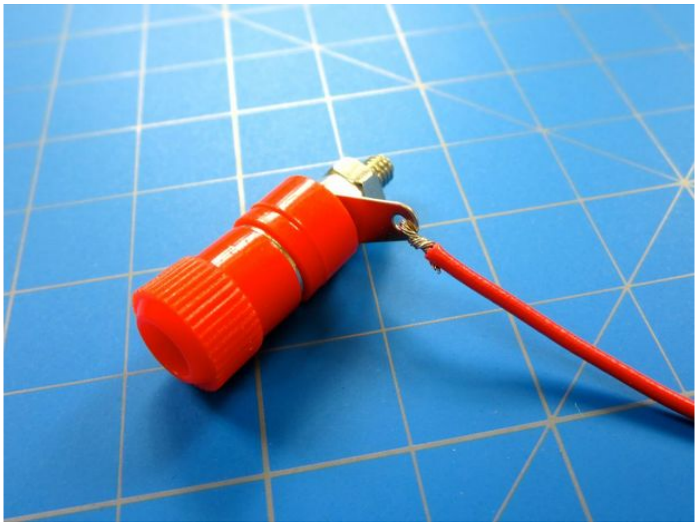
Make sure the wires have been stripped enough so that the exposed wire wraps around the board completely and can twist together securely. Do this for both sides.

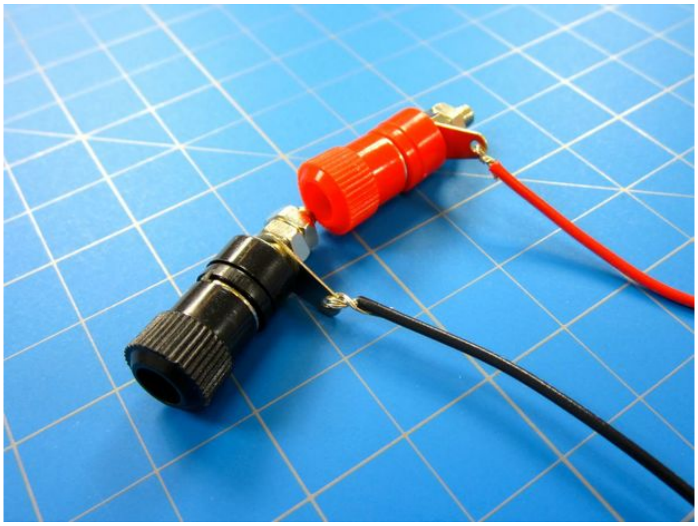
Grab the red and black screw terminal ports as well as your remaining stripped black and red wires.

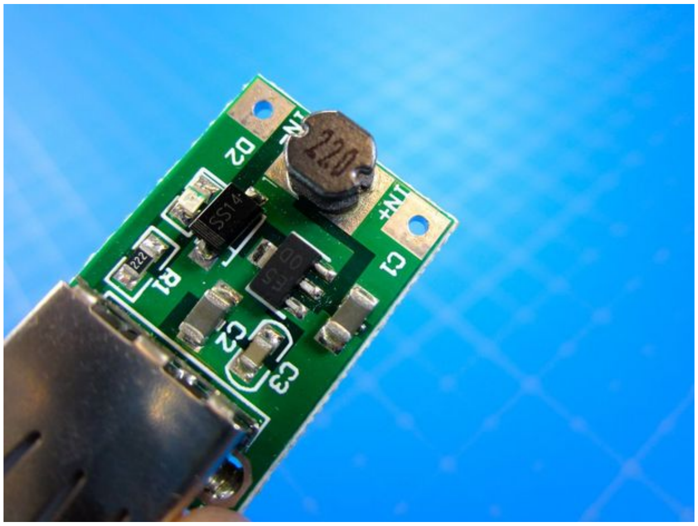
On the terminal ports you'll see a piece of metal with a hole in it. You can either thread your wire through that hole or just screw the wire into place, wrapping the wire around the shaft of the screw.

Do this for both terminal ports using the red wire for the red port and the black wire for the black port. If you need to strip your wires a bit more, do so.





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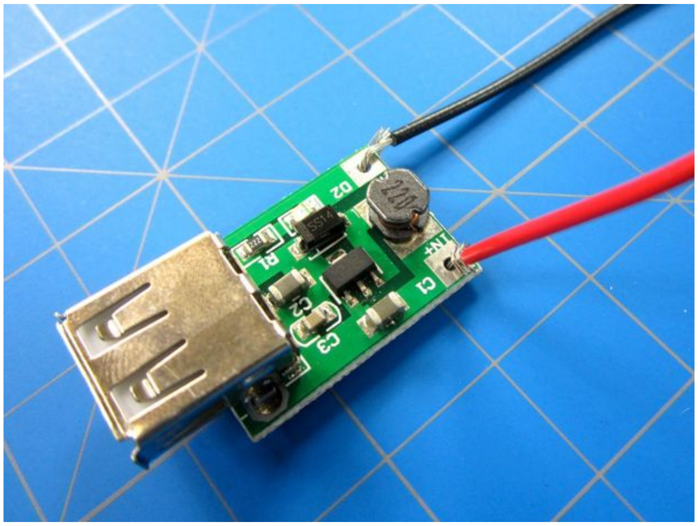
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C2
C3

Step 5: Hooking Up Everything

At this point we're just connecting all the red (**Positive**), wires together and then all the black (**Negative**) wires together.

Before we do that we need to thread the solar cell's wires through its mount and the top of the box. Grab the laser cut solar cell mount and just thread the wires through. Do the same with the top of the box. (The box top has writing on it, the mount doesn't. They're the ones with the big circles cut out.)

You DO NOT need to mess with the foam tape at this point.

Grab your terminal block. Find a screw driver that works with it. Loosen up all the screws on top.

Our main method of getting things to hook together is to just twist wires. We can't get all the positives to twist together and into the block, so we're going to split things up.

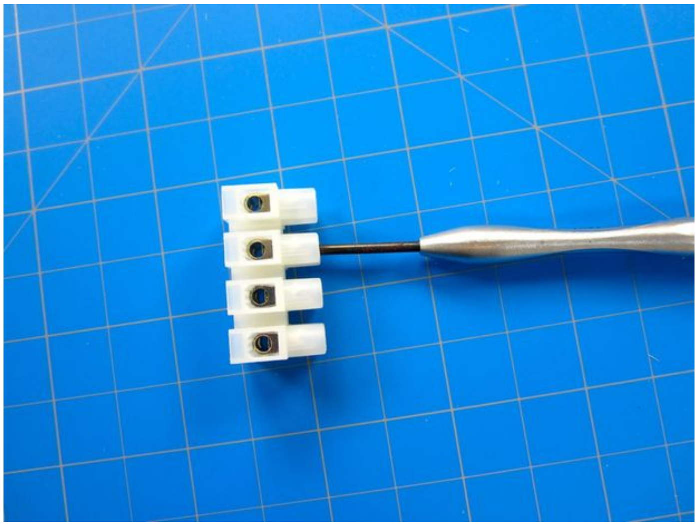
Grab the positive wire from the solar cell and the positive wires (being both the red and white) from the LED. Twist them together. Put them into one of the terminal slot. Screw to clamp down.

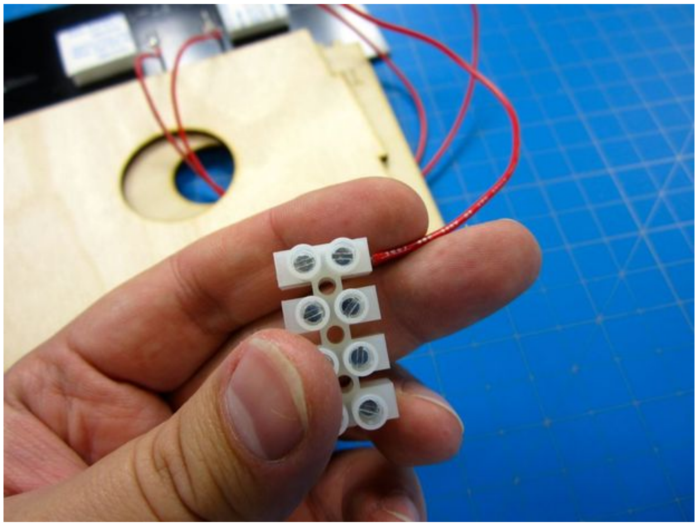
Grab the Positive wire from the USB Board and the red terminal port. Twist them together. Insert them so they are directly opposite from the other red positive wires. Screw to clamp down.

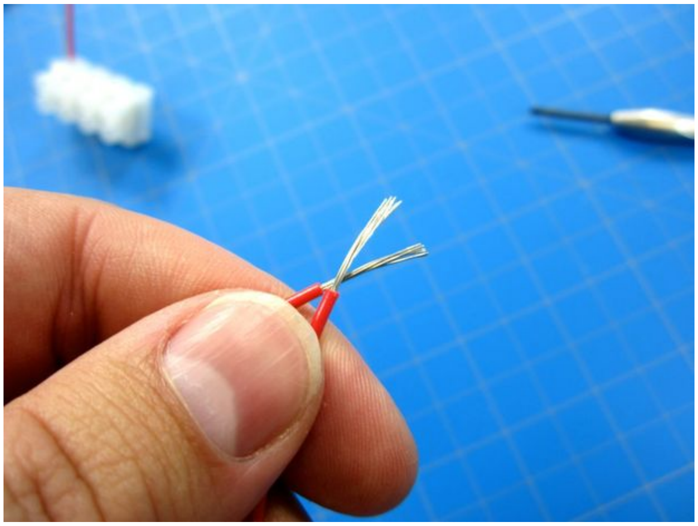
Do the exact same thing with the black negative wires.

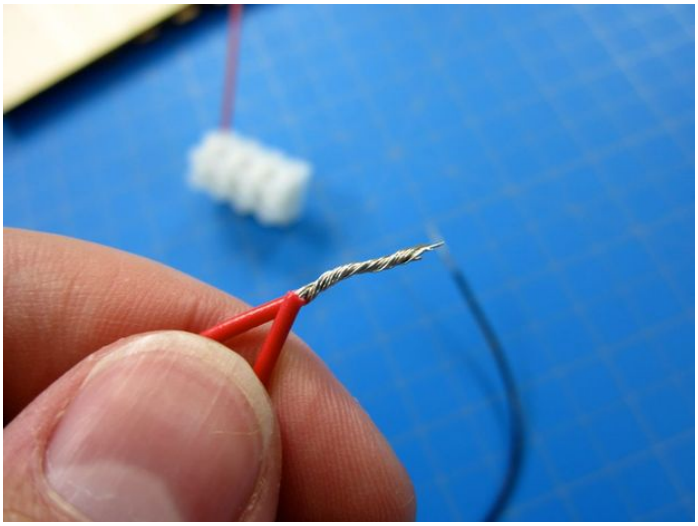
There will be unused terminal block ports. Make sure the wires are clamped down snug. Give them a small tug to be sure.

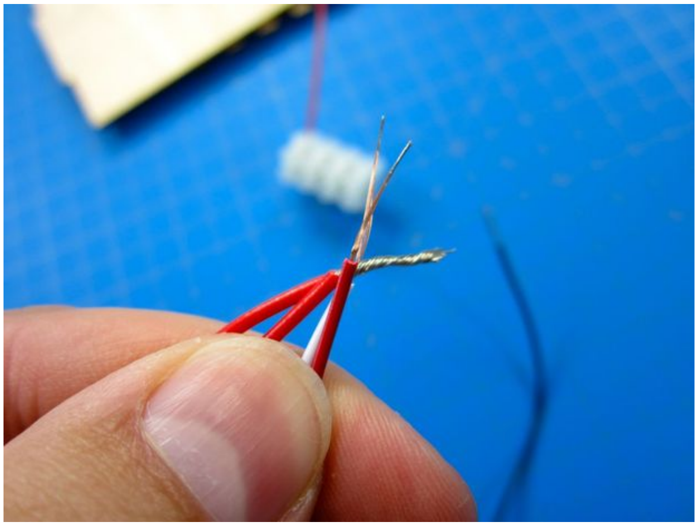
Take your bundle of to a source of sunlight and make sure everything is working. The LED will turn on and an LED on the USB Board will light up.

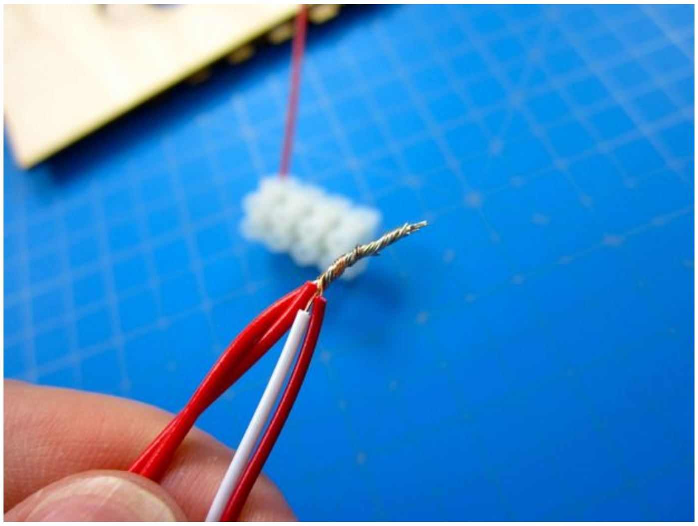


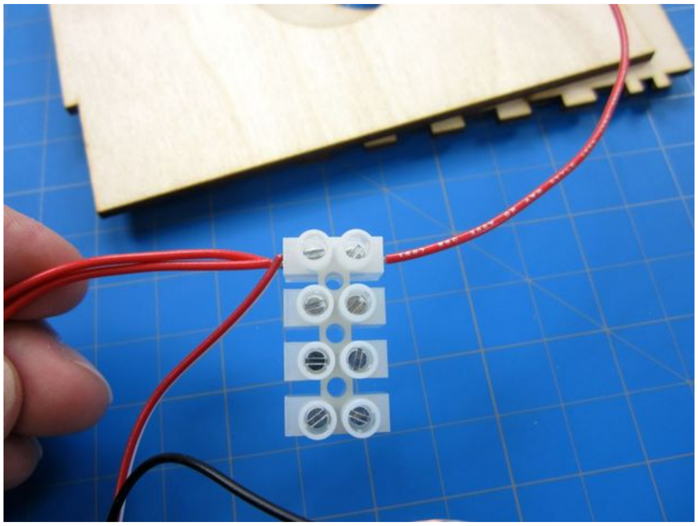


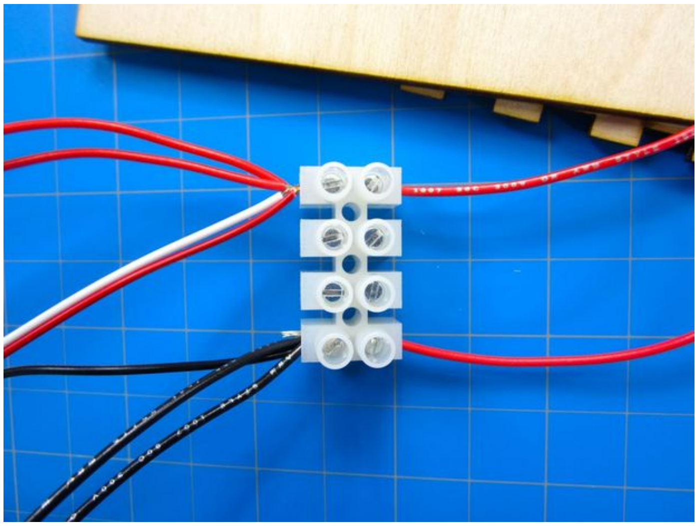












Step 6: Making the Box

There are 22 screws and nuts in this project. That's a lot. It helps to put the nuts on the screws before assembling the kit.

Also, we're adding the foam tape on last. We recommend you do so as well.

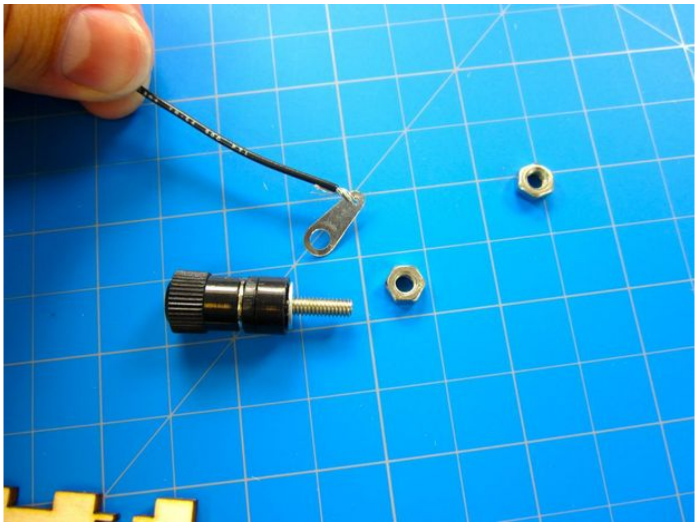
Add all the electrical parts to the front face plate. The terminal ports screw into place. The USB port will be fixed to the bottom of the box using foam tape (which you may wish to hold off on). The LED is held in place by the two short wires. Thread them through the holes and twist to hold them into place.

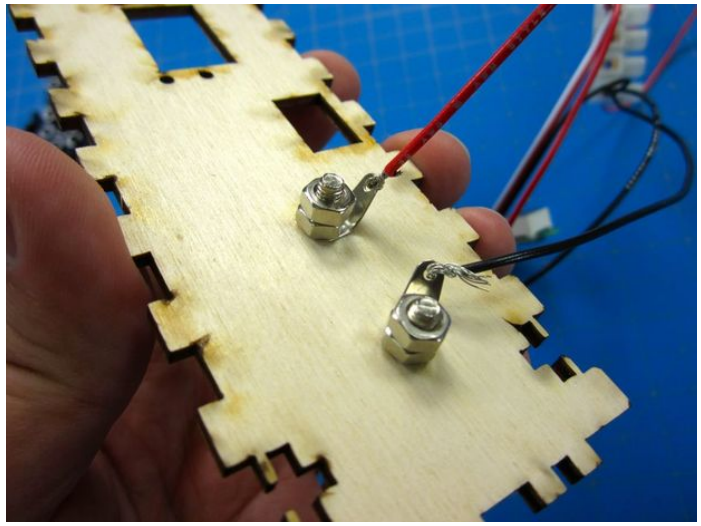
Start with the bottom of the box and the four sides. Using just your hands, pop the screw/nut combo into place. Use your fingers to lightly secure them. DO NOT tightly screw things into place. If you must screw them into place, do so lightly to allow some movement.

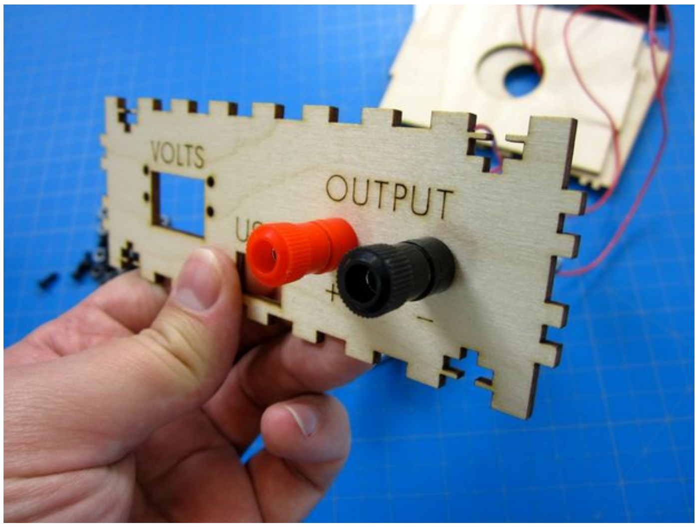
Once the four sides are in place, attach the two curved wings (they have the arrows on them). It may or may not be helpful to also have the solar mount between them. The two wings should be "inside" compared to the two sides (they have the numbers on them).

Once you have the box (mostly) hooked together you can use your foam tape to attach the USB port to the bottom of the box. The same goes for the foam tape on the back of the solar cell.

At this point you can put the top on the box, then tighten all the screws.



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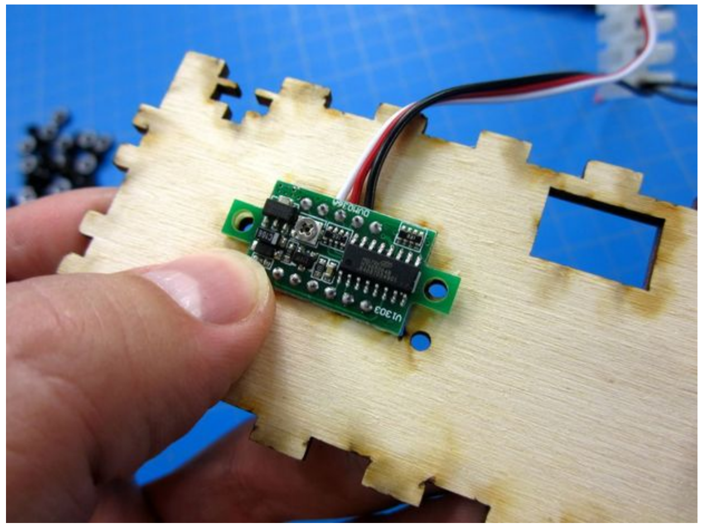

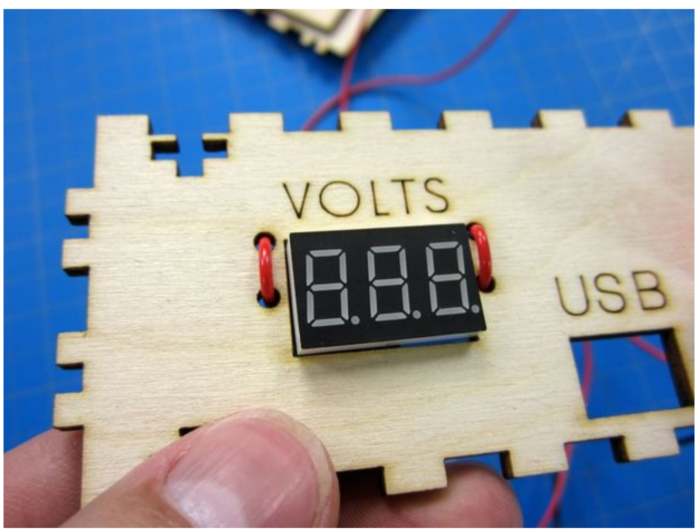
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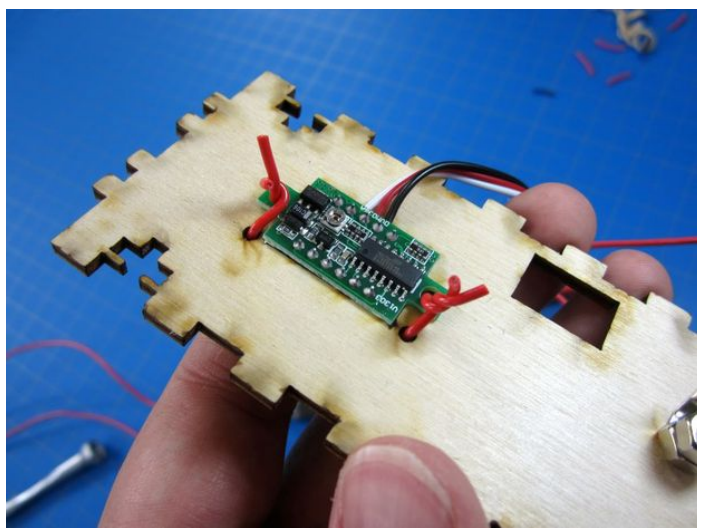



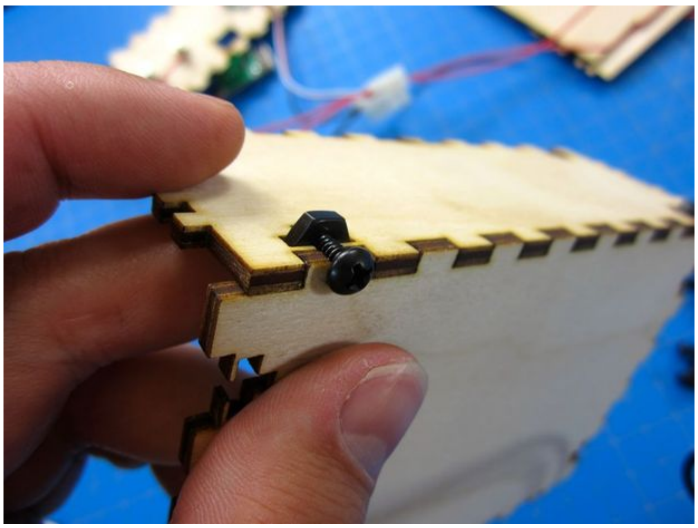
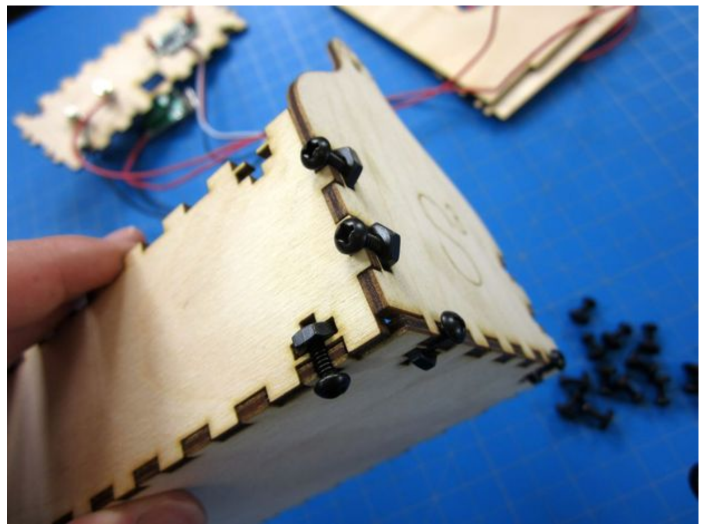
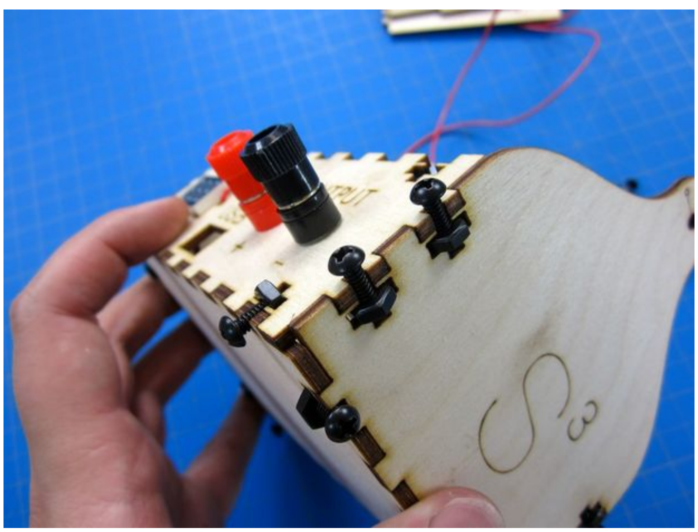
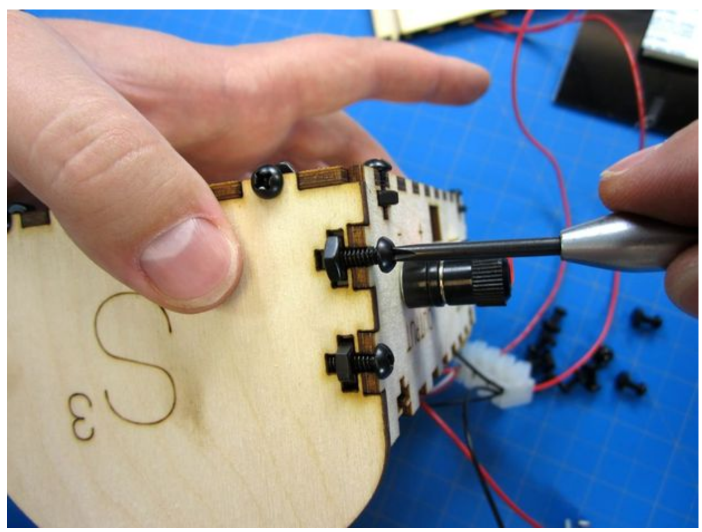

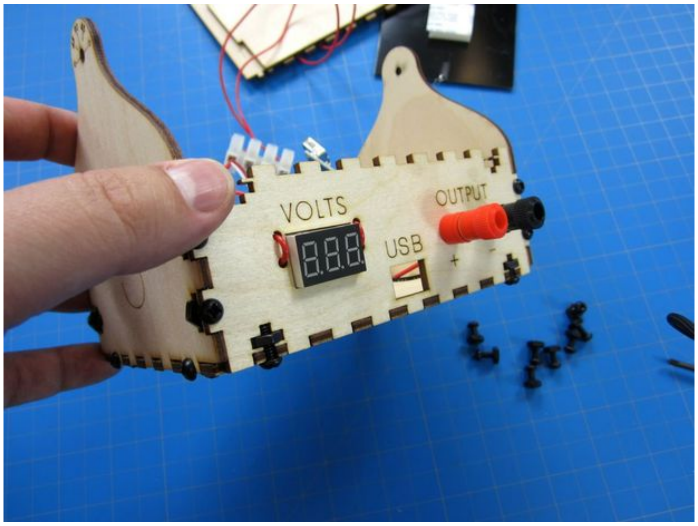
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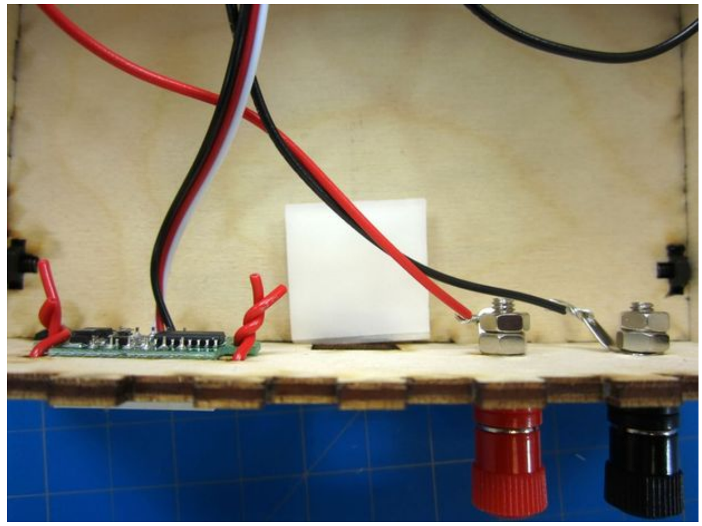

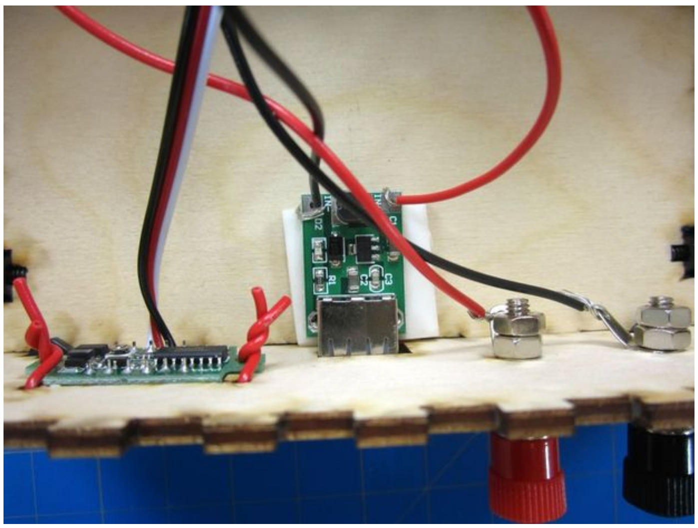

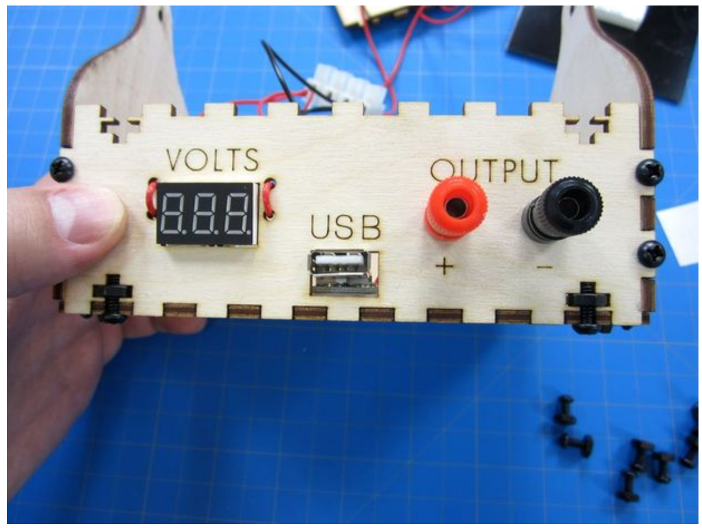
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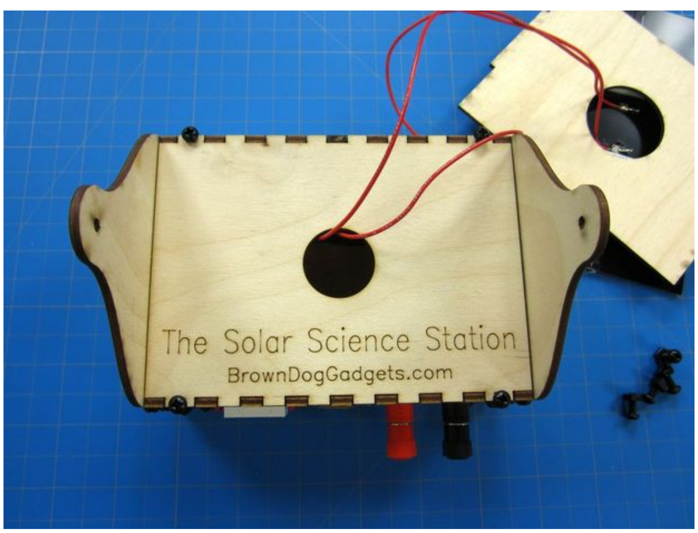
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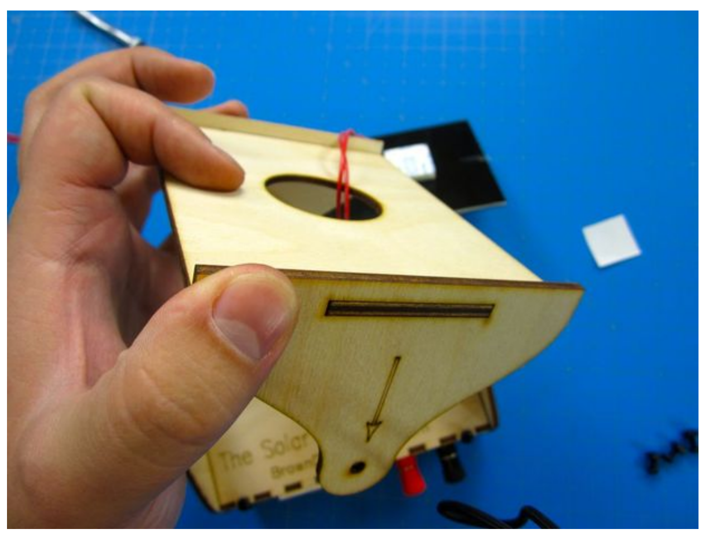
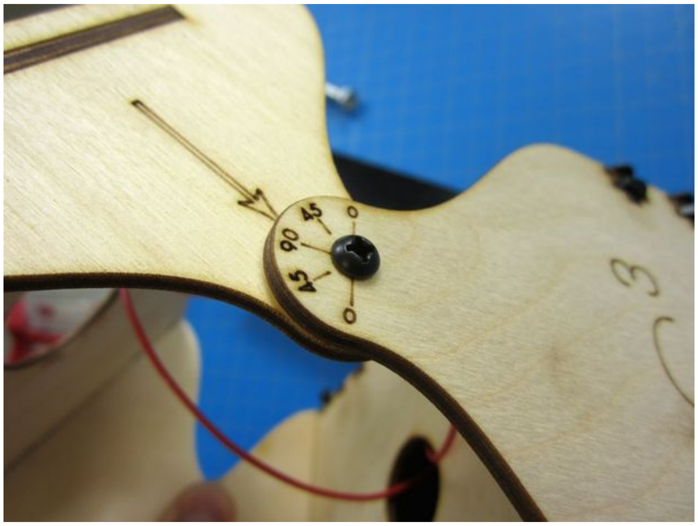
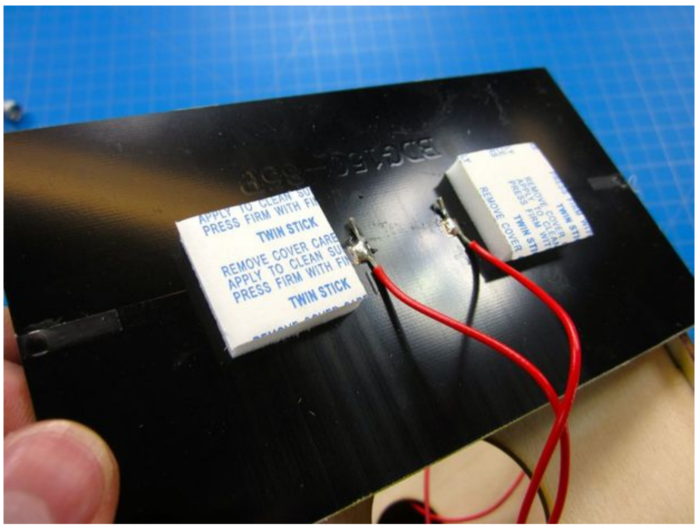
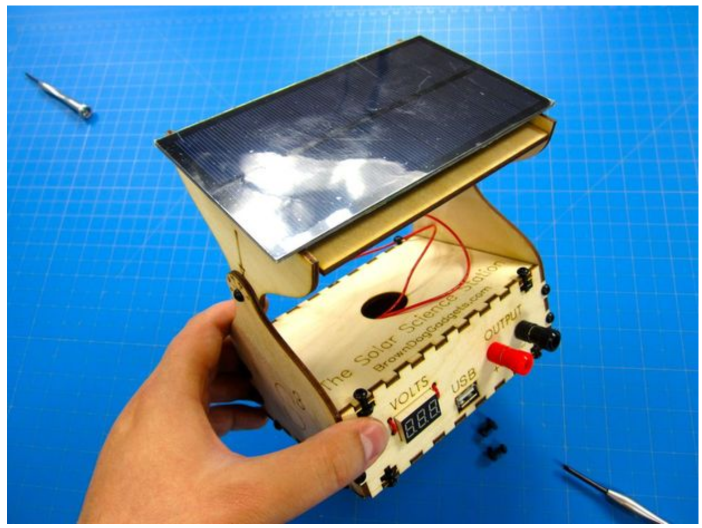




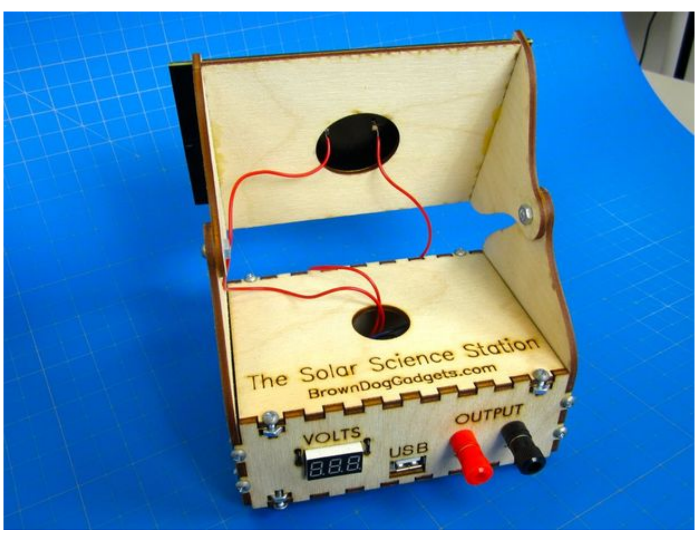




Step 7: Finished

Success! You've made the Solar Science Station.

Now for the fun part. In the next few steps we're going to show you how to add batteries, for both power and solar charging, as well as how to use it at home or in the classroom.



Step 8: Adding A Battery

Adding a battery pack into the mix is simple and adds functionality to the kit. It's not necessary, but it's very helpful. More or less you're making an overpowered version of our USB 2.0 Kit.

Here is what you need:

2 or 3 AA Holder with a built-in switch

2 or 3 Rechargeable AAs

1N914 Diode.

Why?

The Diode is necessary to prevent the solar cell from draining the batteries, which also destroys the solar cell.

Rechargeable (NiMh) AAs are great for solar charging situations. They don't require any special electronics to work and are very safe. They're also easily available and inexpensive.

We highly recommend using a battery holder with a switch, as it makes using the LED Voltmeter difficult. For best LED readings, you want the battery holder to be "off". For battery charging, better USB charging, or to power the terminal ports from the battery, switch the holder into the "on" position.

How?

Wiring everything together is easy. There is only one tricky part- the diode. Take a peak at it. You'll notice that one side has a black bar on it. That's the negative side.

Unscrew all the positive wires from your terminal block. In one block, screw the positive wire from the solar cell and the positive end of the diode together.

Then, screw all the remaining positive wires (LED, USB, Terminal Port, and battery pack) along with the negative end of the diode into one of the unused terminal block slots.

Screw the negative wire from the battery pack in with all the other negative wires.

Take a look at the picture to see if yours is similar.

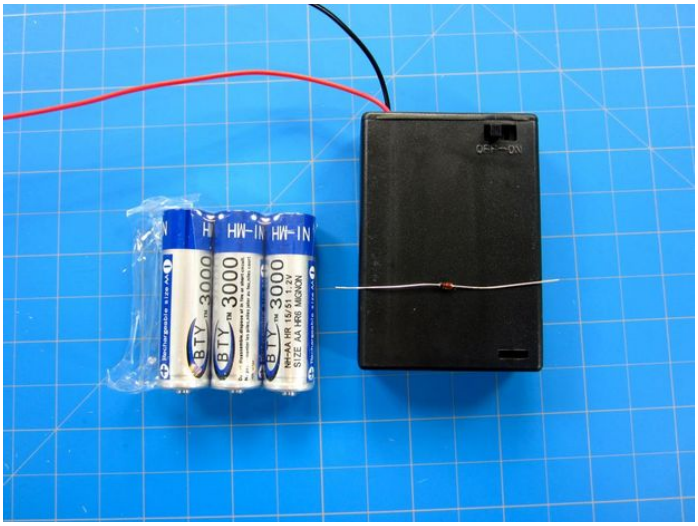
We like mounting the battery pack on the outside of the case for easy switch access.

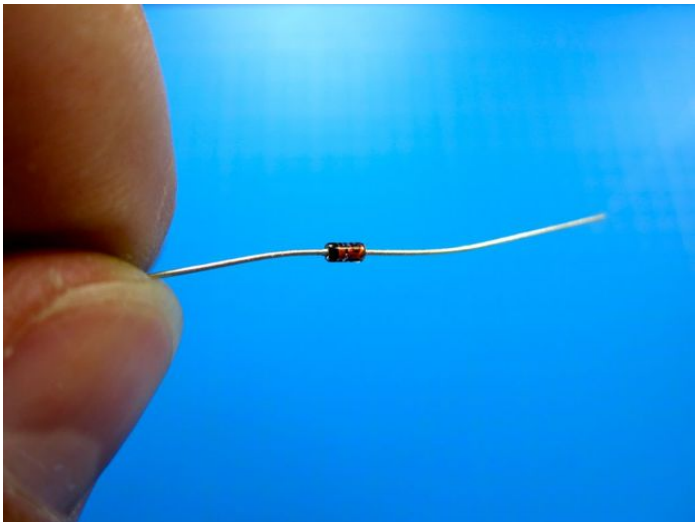
Using:

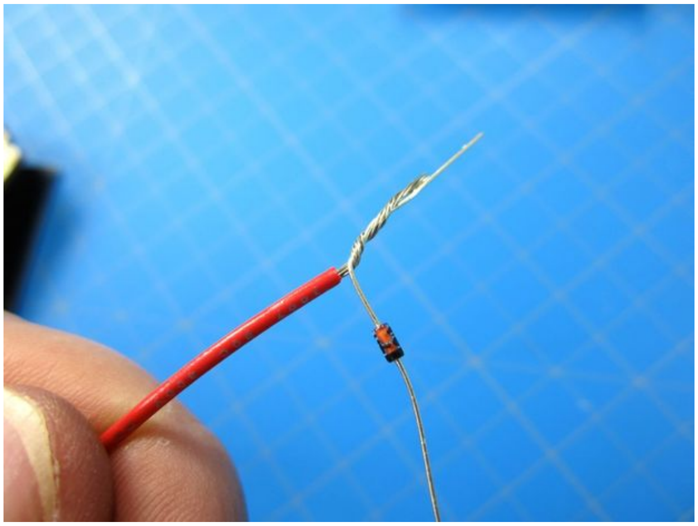
To charge batteries just put in rechargeable AAs (not AAAs, as you may overload them) into the battery holder, place the Science Station in the sun and wait. Typically AAs take between 8 -12 hours to charge up. As a general rule, we say 3 days of decent sunlight is best. Make sure your holder is in the "on" position, otherwise energy will not reach the batteries.

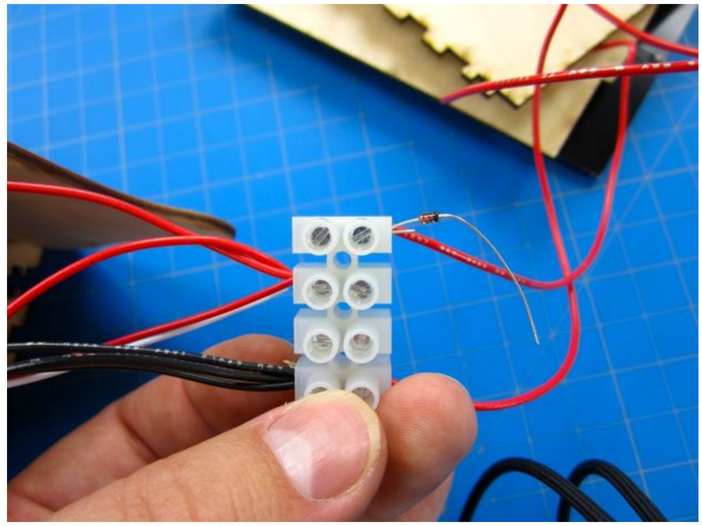
Once the batteries are charged up a bit you can use them with your USB port and terminal ports. Just switch the holder to the "On" position and plug in a USB gadget or other device.

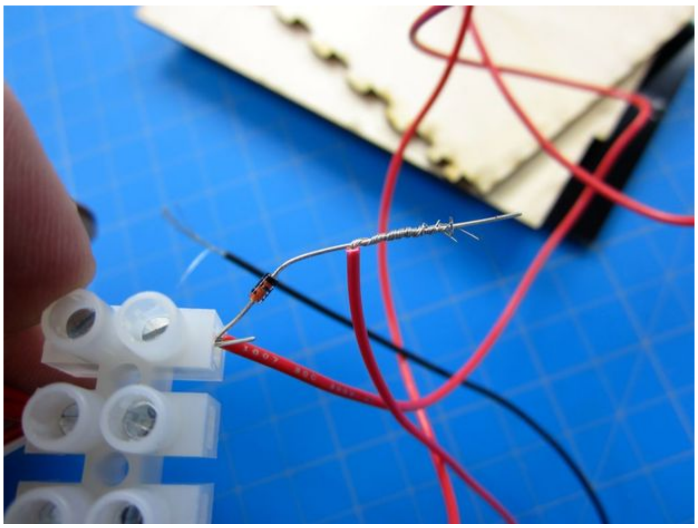
You can use the LED voltmeter to tell if the batteries are fully charged. Take your Science Station out of the Sun (or put your hand over it) so that the LED Volt Meter isn't displaying any information. Then, put the battery holder in the "on" position". A fully charged rechargeable AA will have a voltage of 1.2 - 1.25V of power. Since we're using 3 we'd have a total voltage of 3.6 to 3.75V of power.

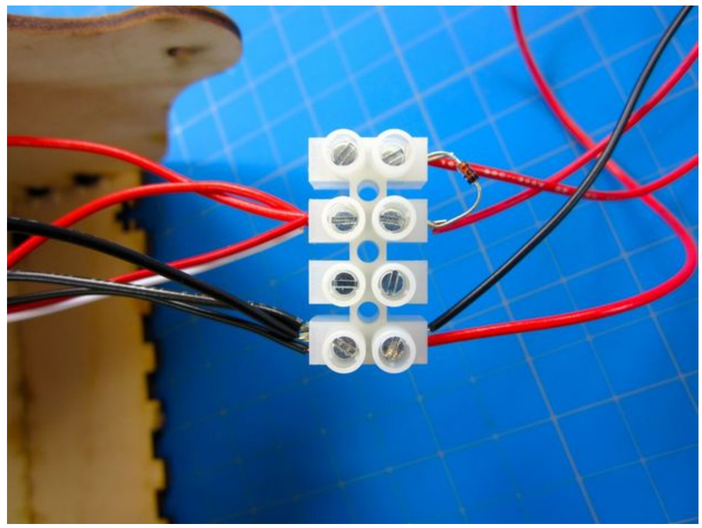


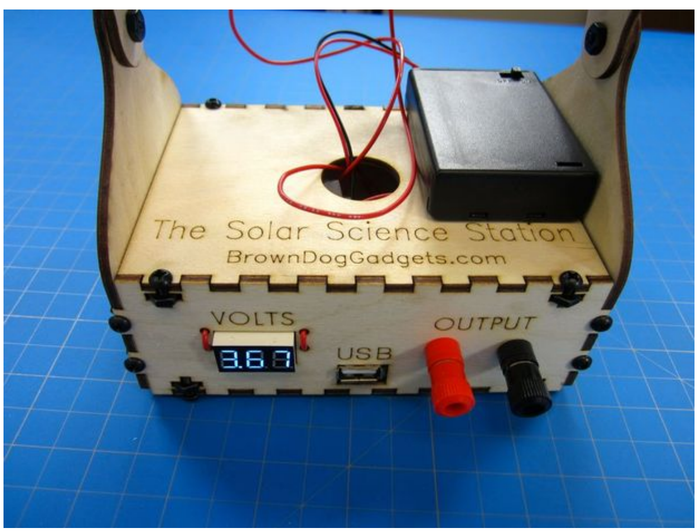


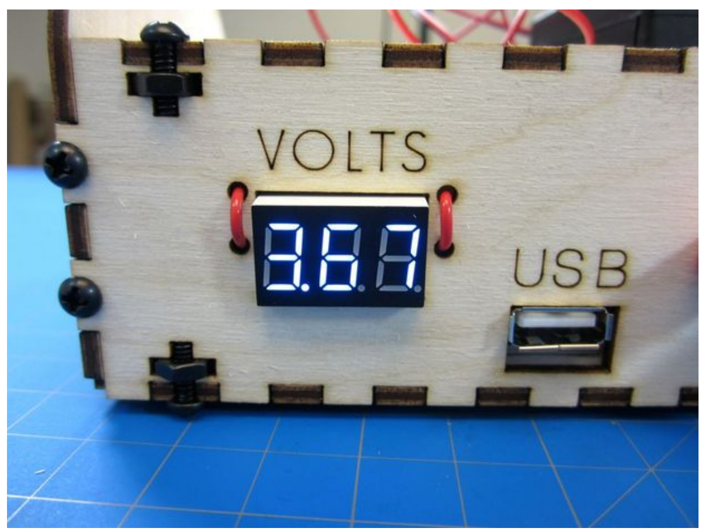









The Solar Science Station
BrownDogGadgets.com
VOLTS
USB
OUTPUT


VOLTS
USB

Step 9: Activities

While designed for classroom use, the Solar Science Station is just as much fun at home.

Here are some simple activities for students. They can be done individually or in groups. If you have more than one classroom, do this activity throughout the day and have the different classes compare notes.

Measuring the changes in solar energy

Questions: How does solar energy change over time? Does the angle of a solar panel affect it's output? Does the direction a solar panel is facing affect it's output? What is the uptime position for a solar panel to be in for our school/home/city?

What you'll need: Paper, Pencil, Watch, Compass.

Procedure:

Choose a time period for this project. It can be days, weeks, or even months. To get the best results you need to take measurements at the same time every day.

Take your Science Station into an area with direct sunlight. Places like a playground, parking lot, or open park work best.

(If you have a battery pack attached make sure that it's in the "off" position or the batteries have been removed).

Using your compass, position the Science Station facing South.

Take voltmeter measurements at various angles. The bare minimum should be 90 degrees, 45 degrees, and 0 degrees. Write down the time and the Voltage output.

Do this again with the station facing West, North, and East. For for detailed readings have students take readings in more directions, such as North West, South West, North East, South East.

Repeat for days, or once a week for a couple of months. (For interesting results, break out the Science Station again during Winter and see what the results are.)

Reporting:

The simplest way of turning data into an interesting report is by graphing it.

For example, we took measurements at 3 pm every day for a week using the angles of 90 degrees, 45 degrees, and 0 degrees. We took measurements North, South, East, and West.

For our graphs we decided to use the X axis for "Days", Y axis for "Voltage", and then use three colors of pencils to differentiate the three angles.

We made one graph for each direction.

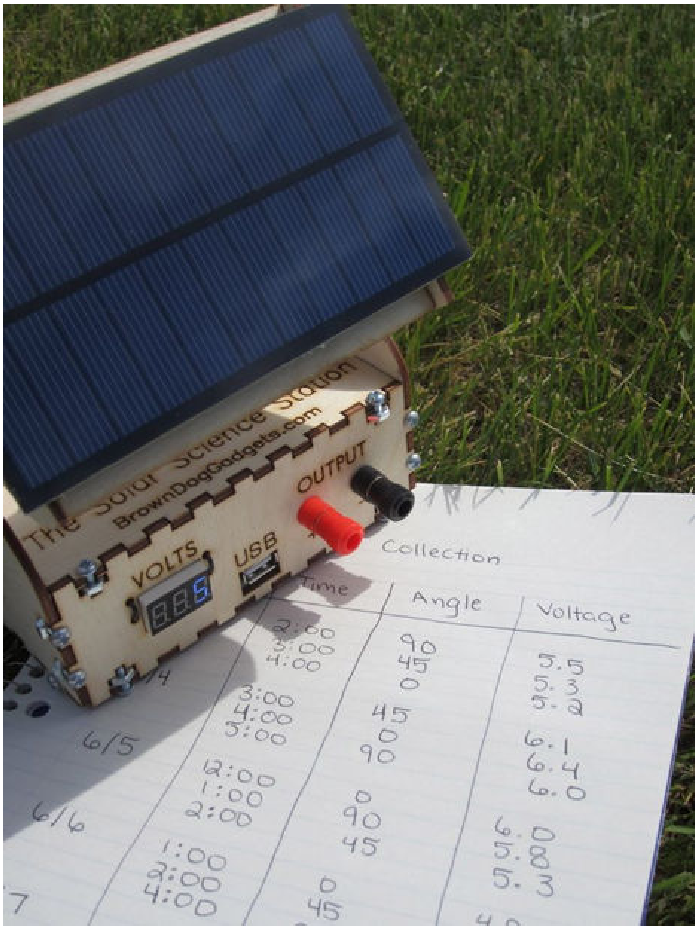
The only problem with graphs is that you can do them may different ways. Help your student or child find a solution that works best for them. Younger students can take less data points, older students more.

Real World Applications:

Situation: Our school has been given a bunch of solar cells. Sadly, your teacher, Mr/Ms X, has lost the directions. As a class we need to figure out where to put the solar cells so they create the most energy. Can you provide evidence that can help your school place the solar panels in the right direction and angle?

Situation: You're out camping and somehow have found yourself with a busy schedule shooting video of wildlife. Your camera has a limited battery life and has to be recharged daily for one hour. According to your scientific data, what one hour time period will charge up your camera the most?

Situation: Your sister's iPod has gone dead. To charge it up she lays a solar panel flat against the top of her car. She says that her iPod will charge just fine if it's facing upward (90 degree angle). You, being an awesome scientist, tell her that she'd get more power having it at a 45 degree angle. Who is correct? How can you prove it one way or another?



Step 10: Building from Scratch + Science Faire Advice

To build a simple version of this project from scratch, you'll need the following:

Super Simple Design: Parts List

1) Multimeter

2) Protractor

3) 5V to 9V solar cell with wires (alligator clips help out a lot)

Super Simple Design: Body and/or Box

1) Cardboard Box + Dowel Rod

In this situation, you'll cut down a box and fix a dowel rod across the center. Then, glue the solar cell to the rod. You can also mark out angle measures along the side of the box (provided you also attach an arrow to the dowel rod).

2) Coffee Tin

This option is comparable to a cardboard box, only more stable and durable. Metal cutting tools will be required, though.

3) Soda Bottle

Same idea, although this option will be easier to cut apart.

4) The Simple Approach

You just manually hold everything and use the protractor. Works best when you have groups of middle schoolers as multiple hands are needed.

Slightly Fancy Approach

If you're making a stand alone project and want to get slightly fancy you'll need a couple of tools. You'd want to do these if you were making a science faire demo.

1) LED Voltmeter or Analogue Voltmeter

We love using old school analogue voltmeters when doing projects with kids. The motion and movement are exciting and the retro look appears more scientific to young learners.

2) Something Interactive

Solar is, by definition, dull. It doesn't move, light up, or make noise. If you've got a science fair project, you'll want some sort of interactivity or showmanship.

More Ideas:

A large knife/toggle switch adds a nice interactive touch and retro feel.

Add LEDs, a motor with a fan, a USB Device, or just a buzzer.

Get three switches and power an LED, motor, and buzzer using just your solar power.

Science Faire Advice:

An amazing project is just one aspect of a Science Faire. You'll need good data, charts, and explanations. Recording solar data is easy to do and takes very little time. Make graphs, charts, and have all your data available. Be sure to explain your charts and your findings!

One thing that we've noticed from teaching is that many projects lack a central question to be answered. Without a central question, a project is just a project. Even a question as simple as: "When is the ideal time for solar charging at school?" affords a lot of wiggle room for charts, data, and explanations. Be sure not to make a simple "yes" or "no" question, as they are very limiting in their scope.