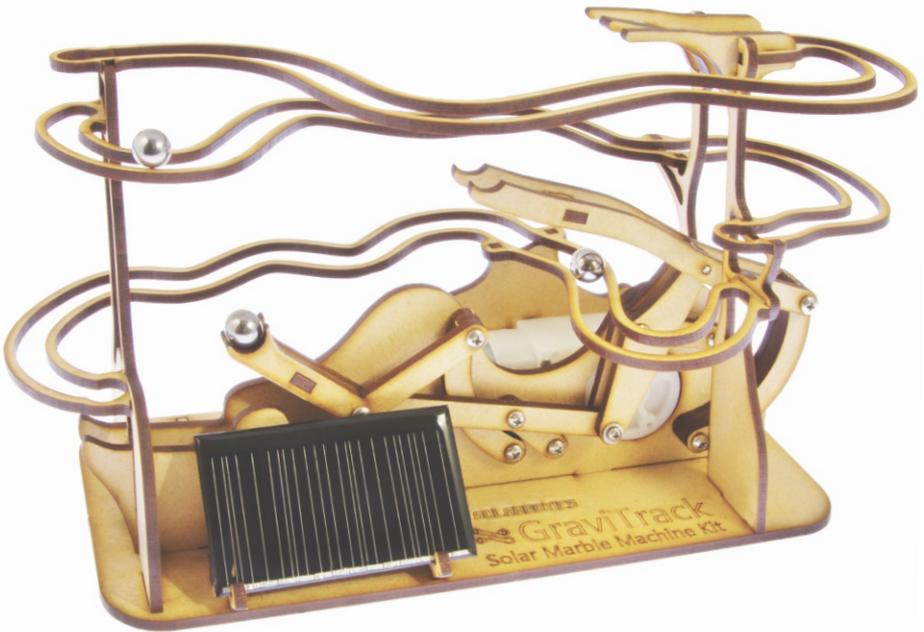




# GraviTrack Solar Marble Machine Kit

**No Soldering  
Required!**

Use *solar power* to drive the mechanism in this elegant, two-handed marble machine.



Intermediate skill level - ages 12+



No batteries included (or needed - it's solar powered!)



Basic hand tools required.



3 hours build time



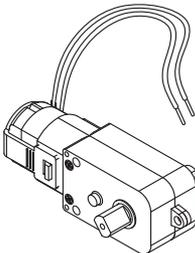
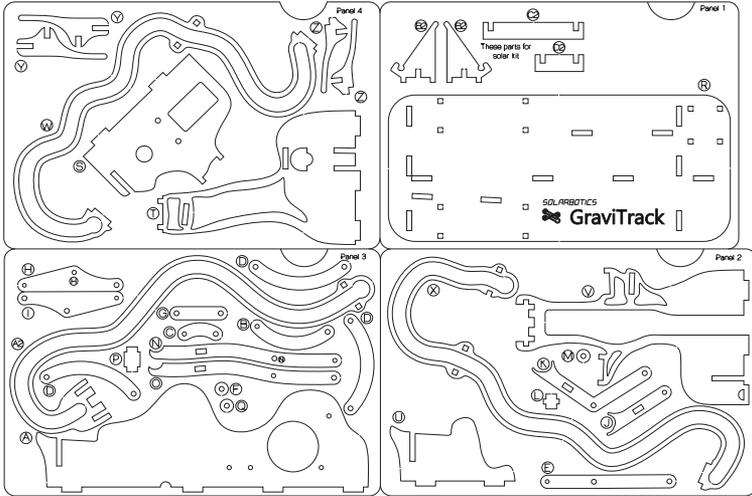
[www.solarbotics.com](http://www.solarbotics.com)

1-866-276-2687

[solarbotics.com/products/60418/](http://solarbotics.com/products/60418/)  
Document revision: May 20th 2019

## PARTS LIST

1 x Set of laser-cut wooden parts



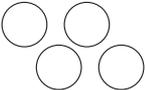
GM3 Motor

GMW  
Motor mount



37x66mm solar cell

4 x 0.375"  
steel marbles



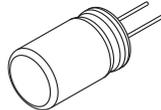
1 x #2  
washer



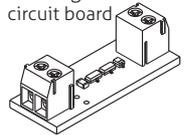
Double-sided  
sticky tape



Large storage  
capacitor



SolarEngine  
circuit board



\*parts to scale

3 x 1/4"  
4-40 screw



2 x 1/2" #4  
TF screw



1 x 1/2"  
4-40 screw



2 x 5/8"  
4-40 screw



3 x 3/8"  
4-40 screw



1 x 1/2"  
#2 TF screw



**TOOLS REQUIRED**

- Philips screwdriver
- White glue
- File/exacto knife

## ASSEMBLY

**Step 1. Assembling the Linkage**

All the laser cut parts are labeled and marked per panel. It's now the simple process of find, prepare, and assemble!

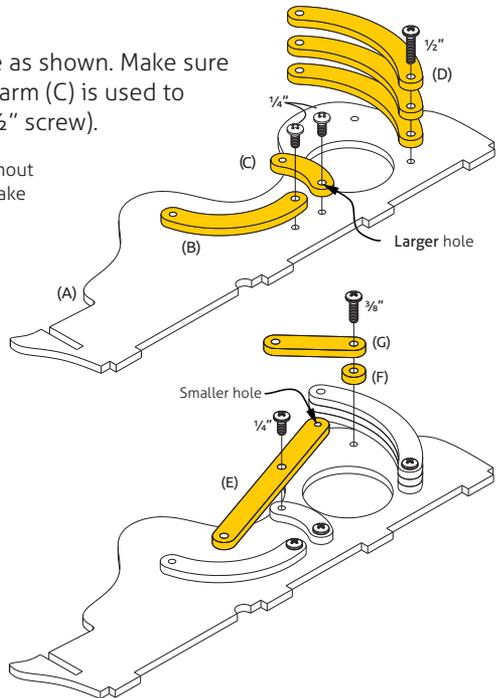
**1.1**

Get the linkage base (A) from Panel 3. Locate the small curve (B), small arm (C), and 3 x large curves (D). Use the screwdriver to push out any sticking cutouts.

**1.2**

Assemble the pieces to the linkage base as shown. Make sure the **larger** of the two holes of the small arm (C) is used to attach it to the base (2x 1/4" screw, 1x 1/2" screw).

**⚠** Tighten the screws so the pieces can move without friction but stay flat against linkage base. So make them tight but so snug they can't move freely.

**1.3**

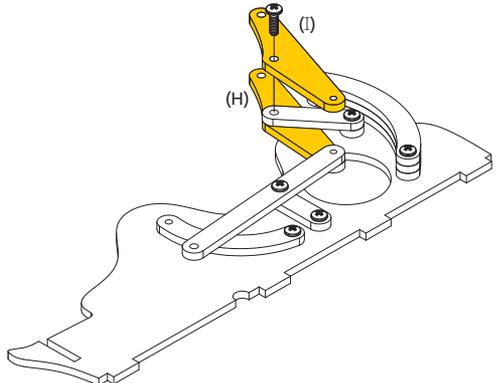
Assemble spacer #1 (F), and medium arm (G) and from Panel 3, and the large arm (E) from Panel 2.

Remove any cutouts and attach to the linkage base as shown (1x 1/4" screw, 1x 3/8" screw).

**1.4**

From panel 3, get Triangle #1 (H) and Triangle #2 (I), and attach to the linkage base as shown.

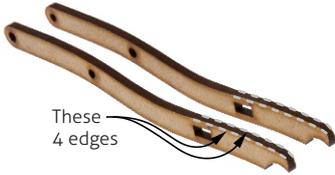
Install Triangle #1 (H) on the bottom using the 3/8" screw.



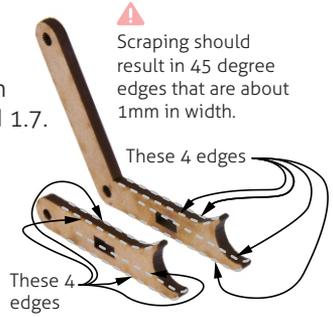
## ASSEMBLY

### 1.5

It's all about *being smooth*. To ensure graceful operation, shape the arms by scraping & smoothing the edges shown using a sharp knife or sandpaper. Do this for steps 1.6 and 1.7.



These 2 facing edges



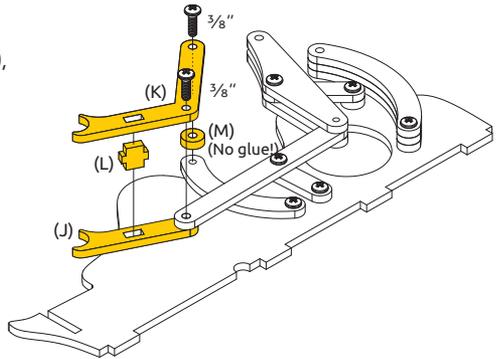
⚠ Scraping should result in 45 degree edges that are about 1mm in width.

### 1.6

From panel 2, find the small lifter #1 (J), small lifter #2 (K), lifter spacer #1 (L), and spacer #2 (M).

Assemble as shown, using a *little* white glue to keep the lifter spacer #1 (L) in place. Do *not* use white glue on the spacer #2 (M).

Attach with 2x  $\frac{3}{8}$ " screws.

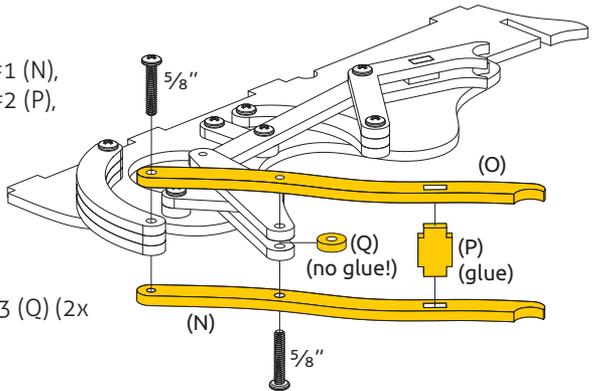


### 1.7

On Panel 3, remove large lifter #1 (N), large lifter #2 (O), lifter spacer #2 (P), and spacer #3 (Q).

Assemble as shown, using a *little* white glue to keep the lifter spacer #2 (P) in place.

Do *not* use glue on the spacer #3 (Q) (2x  $\frac{5}{8}$ ).



Because the top screw of the "large lifter assembly" enters from the back side, make sure the screw ends flush with front of large lifter (O). If it extends past, it will interfere with the moving parts.



## ASSEMBLY

### 1.8

Use the #2 screw and washer to pin the triangles and large arm to any of the 4 holes of the plastic GMW motor connector wheel.



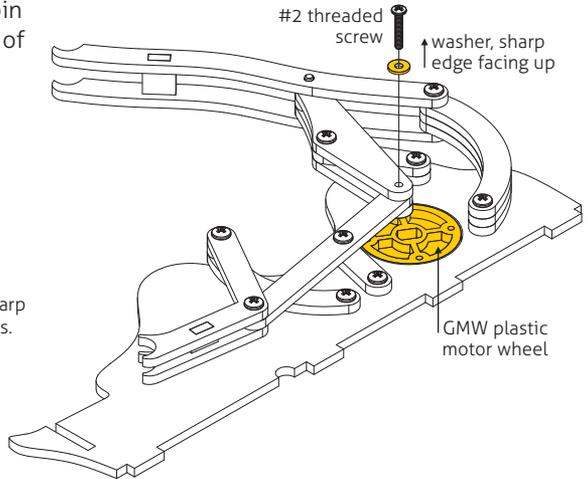
The washer has two sides, make sure the sharp edge is facing outwards **away** from the arms.



rounded edge

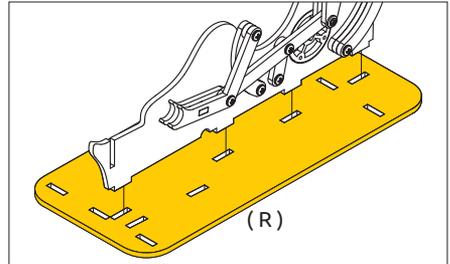


sharp edge



### 1.9

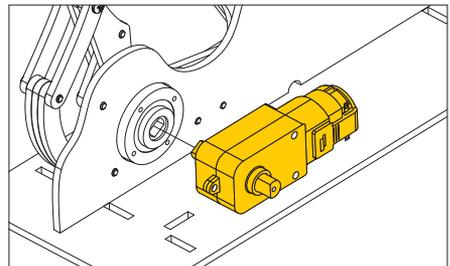
Attach the linkage base to the marble base (R) as shown, with the marble base logo-side up. Use a little white glue to keep it in place.



## Step 2. Mounting the Motor

### 2.1

Align the mechanism so the GMPW wheel can receive the shaft of the GM3 motor. Hold the assembly together until the next step.



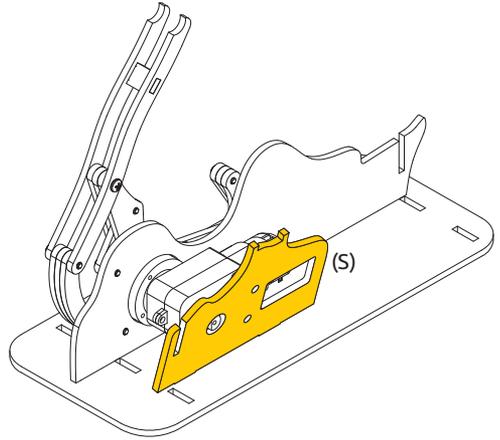
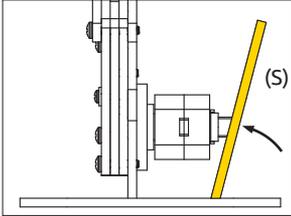
## ASSEMBLY

**2.2**

From panel 4, remove motor mount (S) and rock it into position on the other side of the GM3 motor.

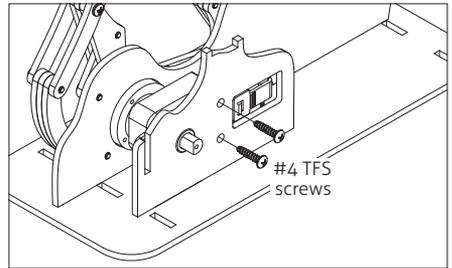
Glue the tabs into the slots.

Side view:

**2.3**

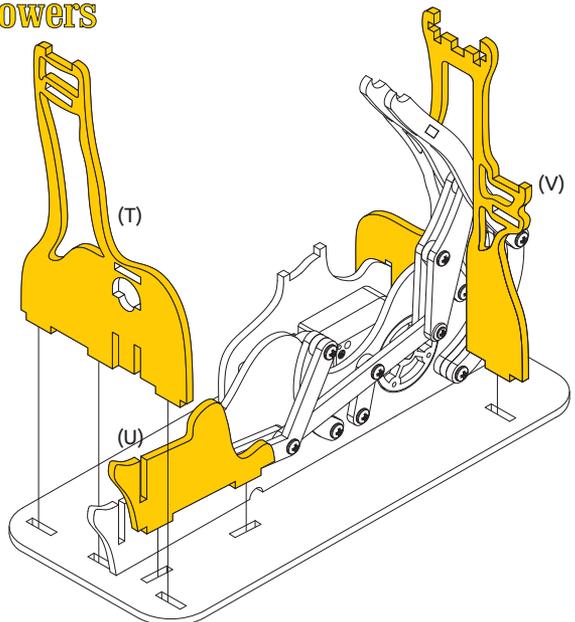
Secure the motor to the motor mount with 2 x #4 TFS (thread-forming screws).

These screws are designed to bit into plastic better than the other screws.

**Step 3. Building the Towers**

Remove the Small tower (T) from From panel 4, and from panel 2 the marble catch (U), and large tower (V).

Slot them into the marble base, gluing them into place.

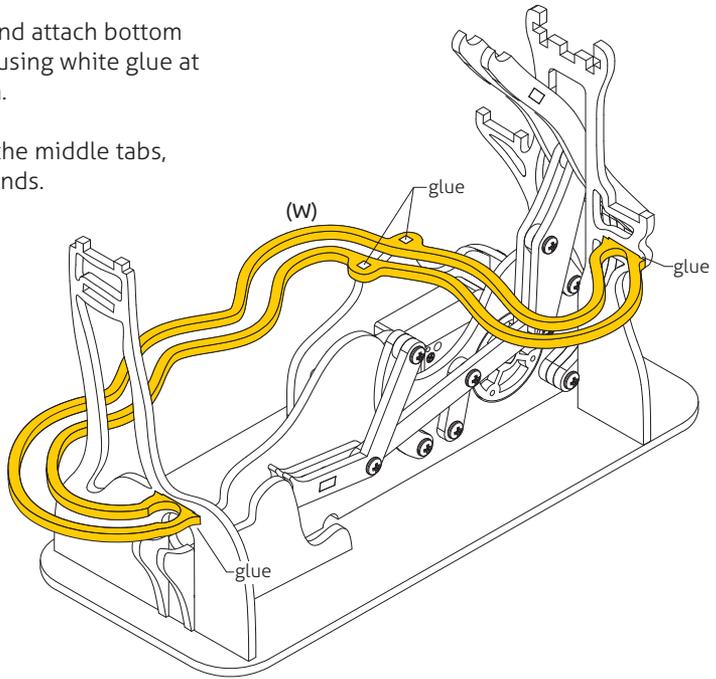


## ASSEMBLY

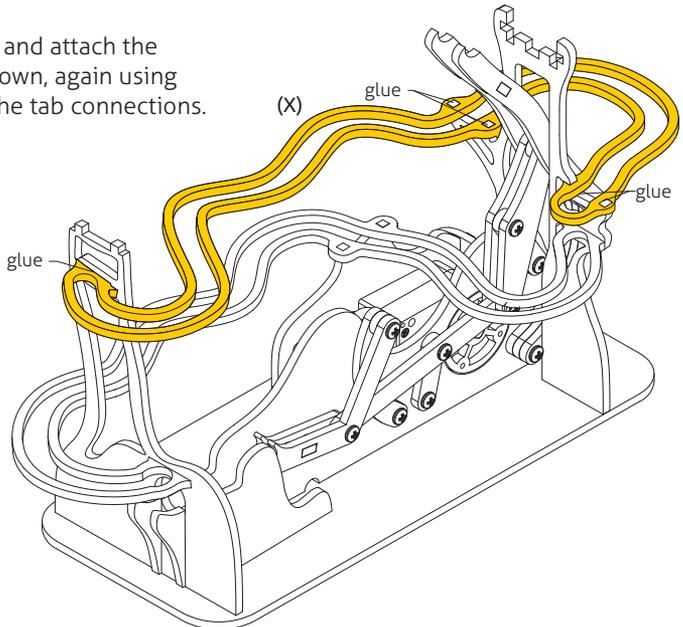
**Step 4. Attaching the Marble Tracks****4.1**

From panel 4, find and attach bottom track (W) as shown, using white glue at each tab connection.

Start installation at the middle tabs, working out to the ends.

**4.2**

From panel 2 remove and attach the middle track (X) as shown, again using glue to secure all of the tab connections.



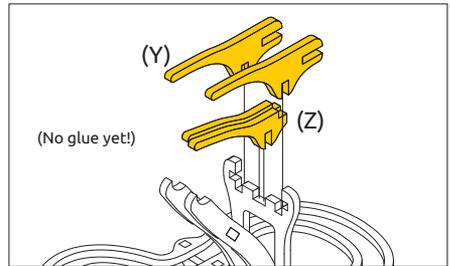
## ASSEMBLY

### 4.3

From panel 4, remove the 2 x large receivers (Y) and 2 x small receivers (Z).

Slot these all into the top of the Large tower (V) as shown.

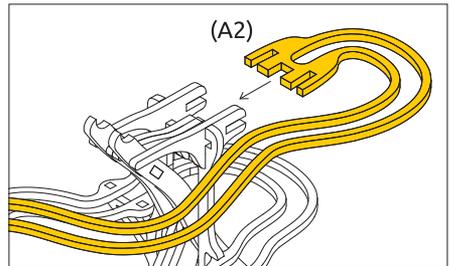
Do *not* use any glue until the end of the next step as these receivers need be wiggled to help insert the top track.



### 4.4

From panel 3, slot the top track (A2) into the receiver finger slots.

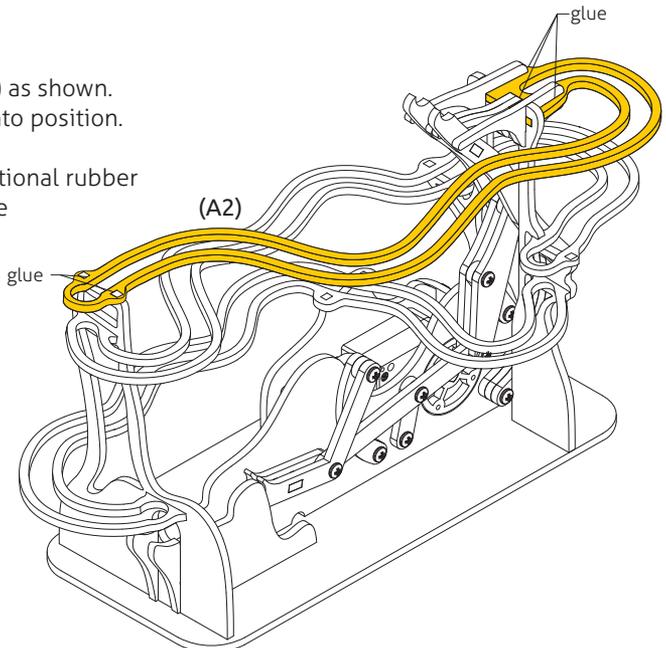
When in place, apply glue in the slots to hold everything in place.



### 4.5

Attach the top track (A2) as shown. Use glue to lock them into position.

You can also add the optional rubber feet to the bottom of the Gravitrack at this time.



## ASSEMBLY

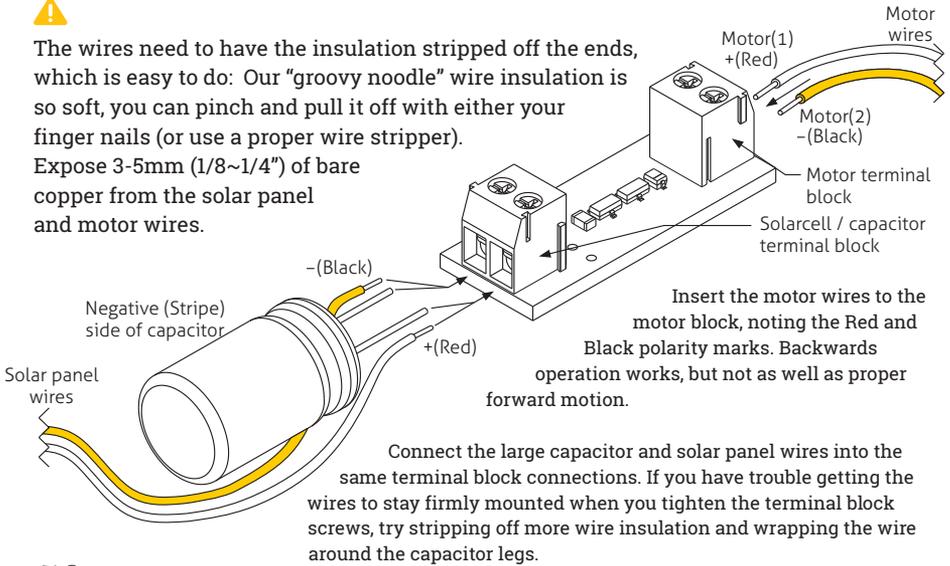
### Step 5. Installing the SolarEngine

#### 5.1

While you won't do any damage by plugging them in backwards, the SolarEngine will only work properly if the solar panel and capacitor are installed as shown. Batteries don't work when installed backwards - the same applies to these parts! **We will connect the motor now, and the solar panel later.**

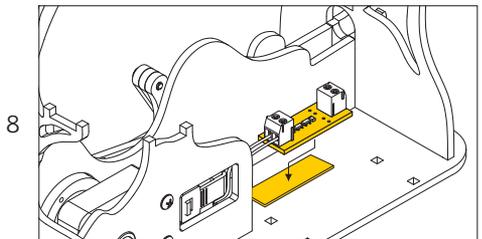


The wires need to have the insulation stripped off the ends, which is easy to do: Our "groovy noodle" wire insulation is so soft, you can pinch and pull it off with either your finger nails (or use a proper wire stripper). Expose 3-5mm (1/8~1/4") of bare copper from the solar panel and motor wires.



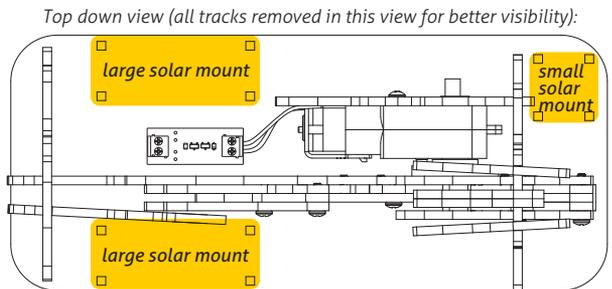
#### 5.2

Cut the double-sided sticky-tape (DSST) in half, and use one piece to install the Solar Engine just behind the motor.



#### 5.3

**Pick a solar cell mounting location:** Choose the GraviTrack solar cell location that best exposes the cell to your lighting situation, i.e.: front (if on a shelf), back (as on a window-sill), or side (on a desk).

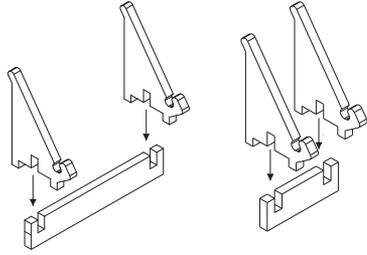


## ASSEMBLY

### 5.4

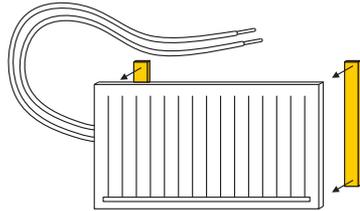
You get to pick the best place to mount your solar cell, and the mounting parts from Panel 1 are configurable to suit the need.

Assemble them as shown and then insert the mount into one of the locations in the previous step.



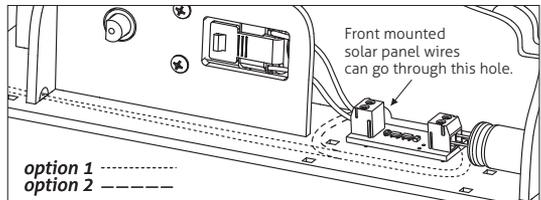
### 5.5

Depending on which location you've selected, the solar panel will need to be horizontal or vertical. Place the remainder of the double-sided tape on the back of the solar panel and adhere it to the mount. Cut it into small strips as shown.



### 5.6

There are holes located on the GraviTrack for routing the solar cell wires for best access. Run the wires through the hole of your choosing and connect the wires and large capacitor to the SolarEngine as shown in the previous step 5.1.



You are now FINISHED. As soon as you complete the motor wire attachments to the solar cell/capacitor terminals of the solarengine, your device will start operation.

Test it under a bright *incandescent* or *halogen* lamp (LEDs/fluorescents are terrible for solar cells), or in sunlight. The motor should start pulsing every few seconds, moving the arms 3~15mm (1/8" ~1/2") each time. Watch it go through a full cycle or two to make sure nothing is binding, then add your balls to the track, and watch it do it's magical mid-lift hand-off between the two arms!

Being *solar-powered* means the more light it gets, the better it runs. In bright California sunlight, the Gravitrack runs *almost* continuously. In a dark Canadian winter, you'll only see a pulse every minute or so. The solarengine will take whatever power available, and uses it as best as it can, be it low, low light, or intense sunlight.

## TROUBLESHOOTING

**Linkage jams when the arms are attempting to pass the marble:** Use a knife or other sharp edge to shave down the inside of the large lifter arms and the outside of the small lifter arms. See page 5, below step 2.5.

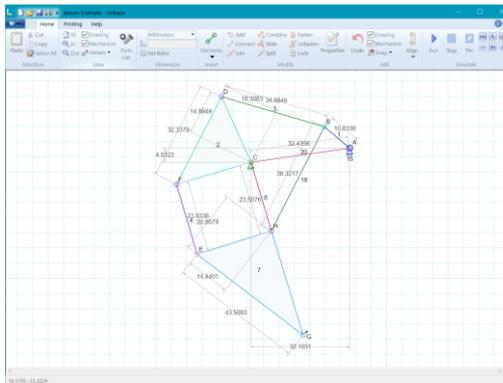
**Linkage jams during linkage movement, or scraping noise can be heard:** Adjust the screws a quarter turn at a time either tighter or looser until smooth, non-jamming movement has been obtained. Scraping noises are usually a sign that a screw is tightened too far and is poking out the back of the linkage pieces.

**Marbles are falling off the track:** The GraviTrack needs to be within  $\sim 5^\circ$  of level for consistent operation. You may have to shim the surface of the GraviTrack to level it.

**SolarEngine not working:** Confirm that your motor and solar panel are plugged into the appropriate connections, and they are not backwards. If available, use a voltmeter to monitor the main capacitor. The voltage should slowly rise to near 3V, then drop quickly as the power dumps to the motor, then restarts climbing. The more light you give it the quicker it will increase to trigger ( $\sim 5$  seconds near an outside-facing window).

## DESIGNING YOUR OWN

Hey! Do you enjoy the GraviTrack and want to design your own version of the linkage? We built ours using David Rector's free linkage mechanism designer software found here: <http://blog.rectorsquid.com/linkage-mechanism-designer-and-simulator/>



Although we have several CAD packages, we found his software to be extremely useful with a number of different options to create dynamic linkage systems with ease. One of the biggest benefits is that it allows you to export your designs in a DXF format for easy importing into your favorite vector cutting or CAD modeling software. We used a combination of Solidworks and CorelDraw to create the GraviTrack you've assembled today!



See it in action:  
[bit.ly/2y6Aqj0](http://bit.ly/2y6Aqj0)

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## Solarbotics "No Fear" Warranty

If damage occurs during construction, contact [sales@solarbotics.com](mailto:sales@solarbotics.com). We'll make sure you get the replacement parts to have a successful GraviTrack experience!

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Visit us online for more info and cool stuff:

[www.solarbotics.com](http://www.solarbotics.com)

Questions or  
comments?  
Let us know!

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3740D - 11A Street NE  
Suite 101  
Calgary, Alberta T2E 6M6  
Canada



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