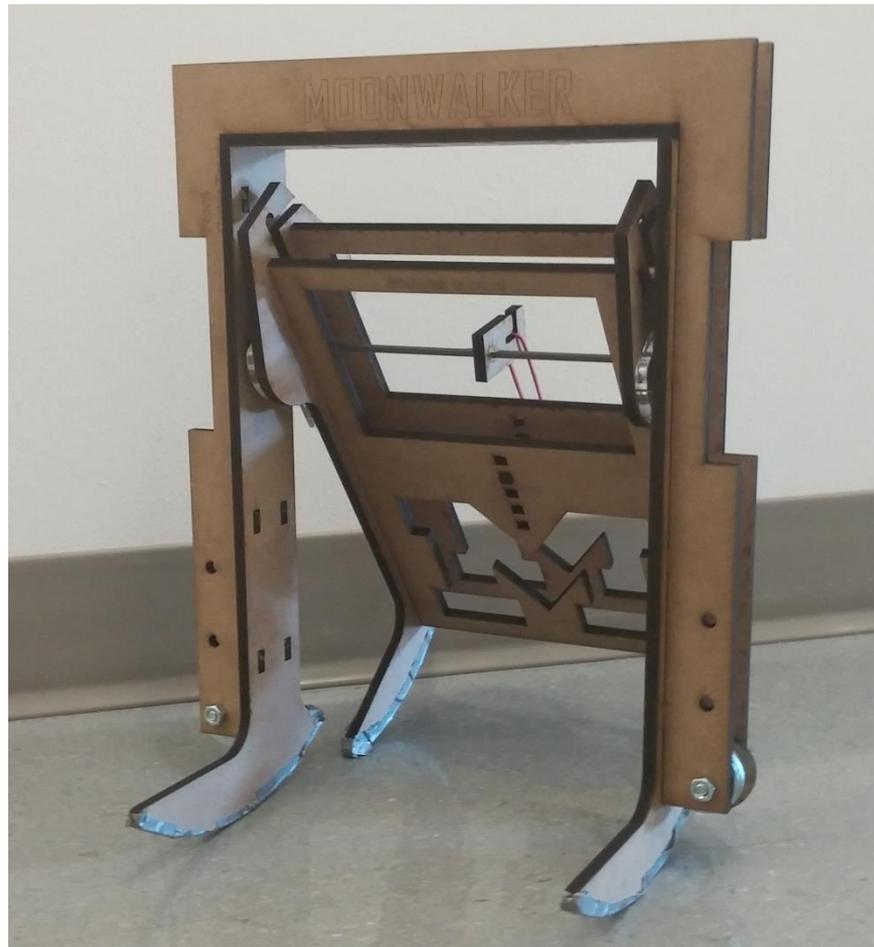




# MOONWALKER



# Purchasing Materials

*If you have a kit, skip ahead to Assembling the Walker.*

Purchase the following from a local hardware store (we recommend Home Depot).

<b>Part</b>	<b>Qty</b>	<b>Estimated Cost</b>
Rubber Bands	1	\$0.98 (2oz bag)
1/4" 2'x4' Medium Density Fiberboard	1	\$6.42
1/4" Hex Nut	2	\$0.06 each
1/4"x1-1/2" Hex Bolt	2	\$0.17 each
1/2" AGB Washers	10	\$0.35 each

You will also need a hot glue gun and duct tape. Wire cutters and gloves would be helpful, but are not necessary.

# Purchasing Materials

*If you have a kit, skip ahead to Assembling the Walker.*

Order the following from [mcmastercarr.com](http://mcmastercarr.com)

<b>Part</b>	<b>Qty</b>	<b>Estimated Cost</b>	<b>Item Number</b>
SAE 863 Bronze Sleeve Bearing, for 1/8" Shaft Diameter, 1/4" OD, 1/4" Length	2	\$0.47 each	#2868T32
Wood, Oak Dowel Rod, 1/4" Diameter, 36" Length	1	\$0.98	#96825K73
Highly Corrosion-Resistant 6063 Aluminum, Architectural Rod, 1/8" Diameter, 2 ft Long	1	\$1.13	#1640T11
Steel Oversized Key Stock, 1/8"x1/8", 12" Length	1	\$0.66	#98830A100
Optically Clear Cast Acrylic Sheet, 1/4" Thick, 6" x 6"	1	\$5.49	#8560K358

# Preparing Materials

*If you have a kit, skip ahead to Assembling the Walker.*

1. Depending on your laser cutter, download the laser cut files (available in .DXF and .SLDDRW).
2. Rearrange laser cutting files to fit your table size and cut MDF sheet with a band or hand saw. Home Depot may cut it for you upon request. Our files are formatted for either four 14"x12" sheets or two 24"x12" sheets, but you can rearrange the files to fit a different sheet that better fits your laser cutter.
3. Cut the pieces out using your laser cutter. Use the settings recommended to cut acrylic. The files use red and blue lines, red for cutting and blue for engraving. Use the material mentioned in each sheet's filename.
4. Cut two 2" segments from the 1/8" aluminum rod. Mark the rods at the 0.6" mark. Using pliers, bend the rods to be perpendicular at the marks. If you do not have wire cutters, make sure the shorter end extrudes just over 0.5", without going lower.
5. Cut the oak dowel to about 10" length.
6. Cut the key stock to 8.375" length.

# Assembling the Walker

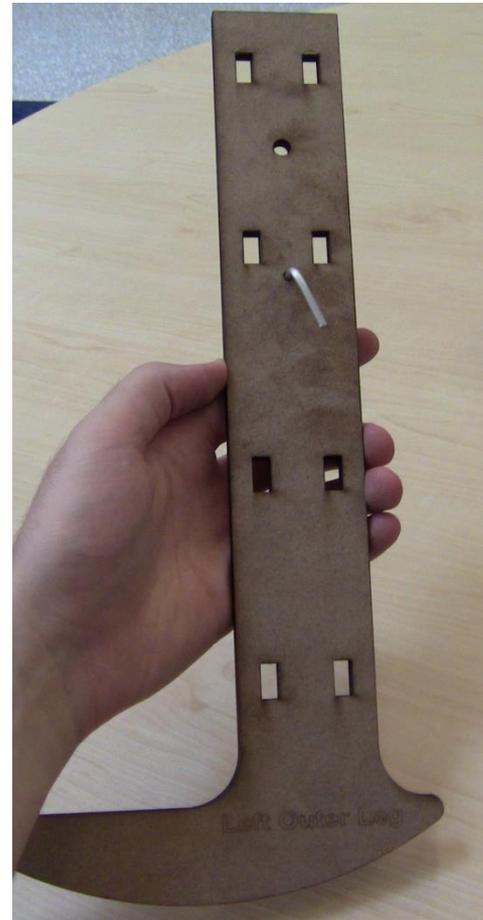
Punch out all of the pieces, until you are left with the parts pictured below.



*Tip: Put gloves on before taking the wood out of the box. Remember that the black ash will easily clean off of your skin and clothes.*

# Outer Legs

1. Insert the bent bearing axle into the lower hole of the **Left Outer Leg**. Generously glue it down. Repeat for the **Right Outer Leg**.



*Tip: The long end of the bent bearing axle should be on the outside, with the text, and the axle will stick in.*

# Outer Legs

2. Insert the **Outer Leg Top** into the **Front Outer Frame** and the **Back Outer Frame**. Glue all eight tabs by filling in the holes created by the angles.



# Outer Legs

3. Insert the **Left Outer Leg** into the left side of the **Outer Frames**, then glue the eight tabs. Repeat for the **Right Outer Leg**.



*Tip: The feet of the walker should be pointing towards the **Front Outer Frame**, and the bent bearing axles should be pointing inward.*

# Outer Legs

4. Insert the dowel rod through the upper hole of the **Outer Legs** so that it sticks out slightly on each side. Use the hot glue gun to make a “cap” of glue so that it can’t slide out of the holes.



# Outer Legs

5. Slide the bearings onto the bent bearing axles. Do not apply glue – they will need to spin freely. The axle should stick out past the bearing slightly, as pictured.



*Tip: If the bent bearing axle sticks out significantly past the bearing, you may want to use wire cutters to trim it down. Do this with the bearing on the bent bearing axle; cutting it will create a burr that will help keep the bearing from falling off.*

*If the bent bearing axle doesn't stick out at all, you will want to get up and cut a new axle. The extra length helps keep the walker in place; if it is too short, the legs won't walk smoothly and will trip in a step or two.*

# Outer Legs

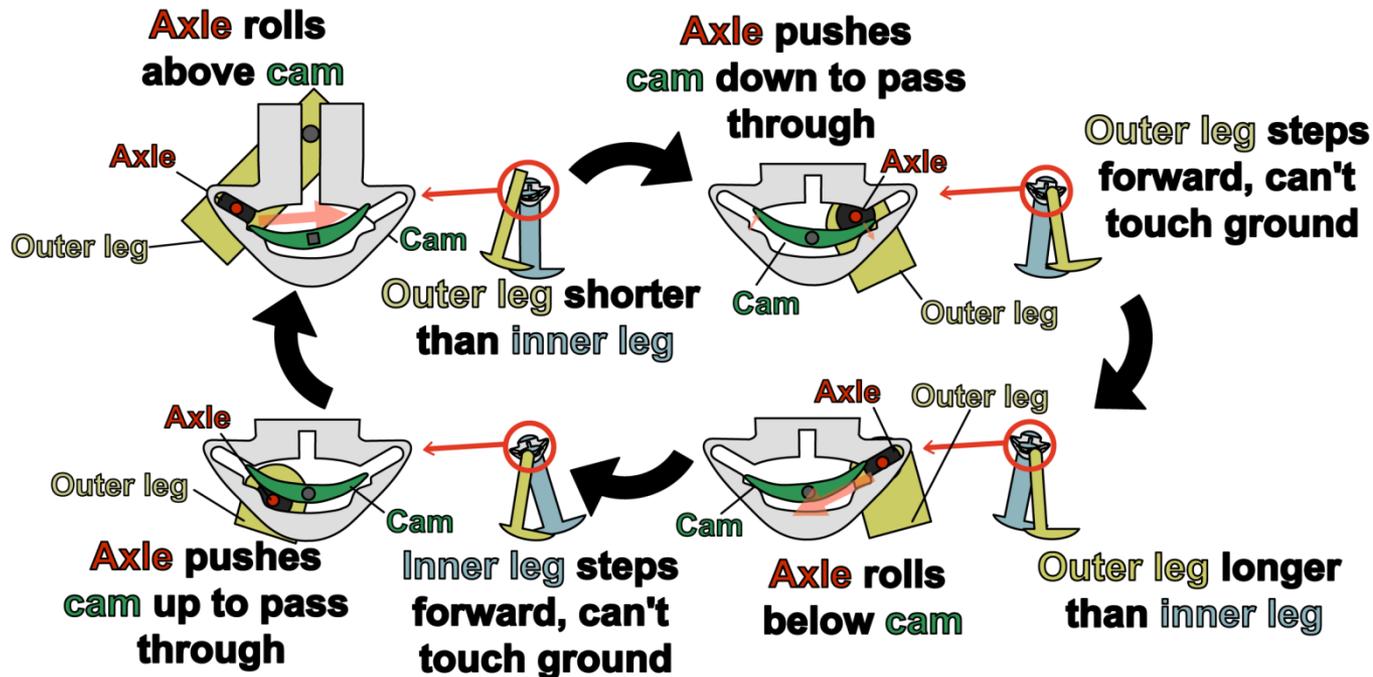
You have finished the **Outer Legs**!



*Tip: Be careful about the bearings – they may fall off of the walker, and it won't work without them!*

# Cam Mechanism

The Cam Mechanism, which we'll be assembling next, is used to change the length of the legs. A bearing will roll over and under the cam so that the shorter leg always steps forward.



If the legs were always the same length, or if the longer leg stepped forward, the foot would hit the ground and the walker would fall. We change the length of our legs by bending at the knees, but the Moonwalker raises its legs up higher instead.

# Inner Legs

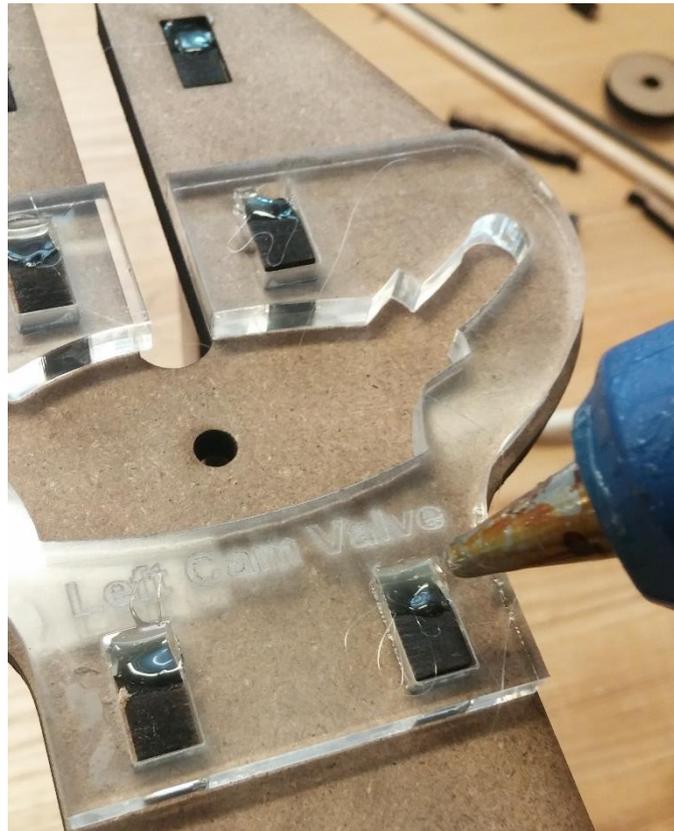
1. Insert the two **Weight Boards** into the **Left Inner Leg** and the **Right Inner Leg**, as pictured.



*Tip: Keep all the text on the outside of the walker, as shown in the pictures.*

# Inner Legs

2. Attach the **Left Cam Valve** to the **Left Inner Leg**, as pictured. Glue all eight tabs by filling in the holes created by the angles. Then do the same for the **Right Inner Leg** and **Right Cam Valve**.



*Tip: Use enough glue to fill the tabs, but try not to let them overflow. Too much glue could make the legs scrape together and stop the Moonwalker from walking!*

# Inner Legs

3. Insert the square key stock to the **Left Cam** and glue them together so that the key stock is barely through the cam.



*Tip: Let the key stock stick out slightly, and hold it in place as the glue dries. If the key stock falls out, you may need to reglue it.*

# Inner Legs

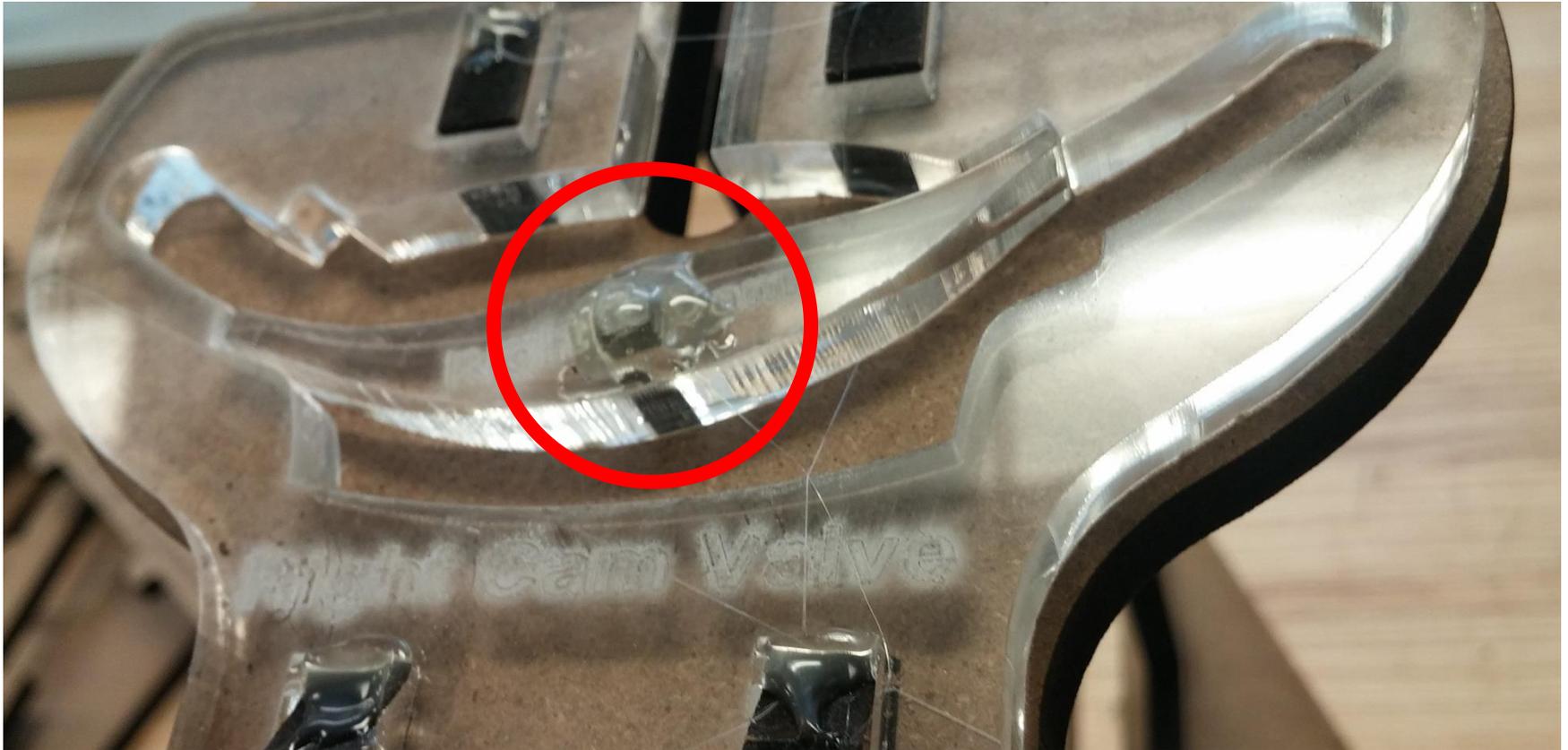
4. Push the key stock halfway through the walker from the hole on the **Left Inner Leg**, then put the **Rubber Band Holder** on the key stock as pictured.



*Tip: It's very important that the **Rubber Band Holder** is horizontal, as shown. You will also want to make sure the **Left Cam** is horizontal so that you can fully insert the key stock.*

# Inner Legs

5. Push the key stock the rest of the way through, then glue the **Right Cam** to the other end of the key stock.



*Tip: Make sure that the **Right Cam** is not glued to the side of the **Right Inner Leg** – it needs to rotate!*

# Inner Legs

6. Slide the **Rubber Band Holder** to the middle of the key stock, then glue it at both sides to keep it in place.



*Tip: This doesn't need to be perfectly aligned! Use extra glue to make sure it stays in place, however.*

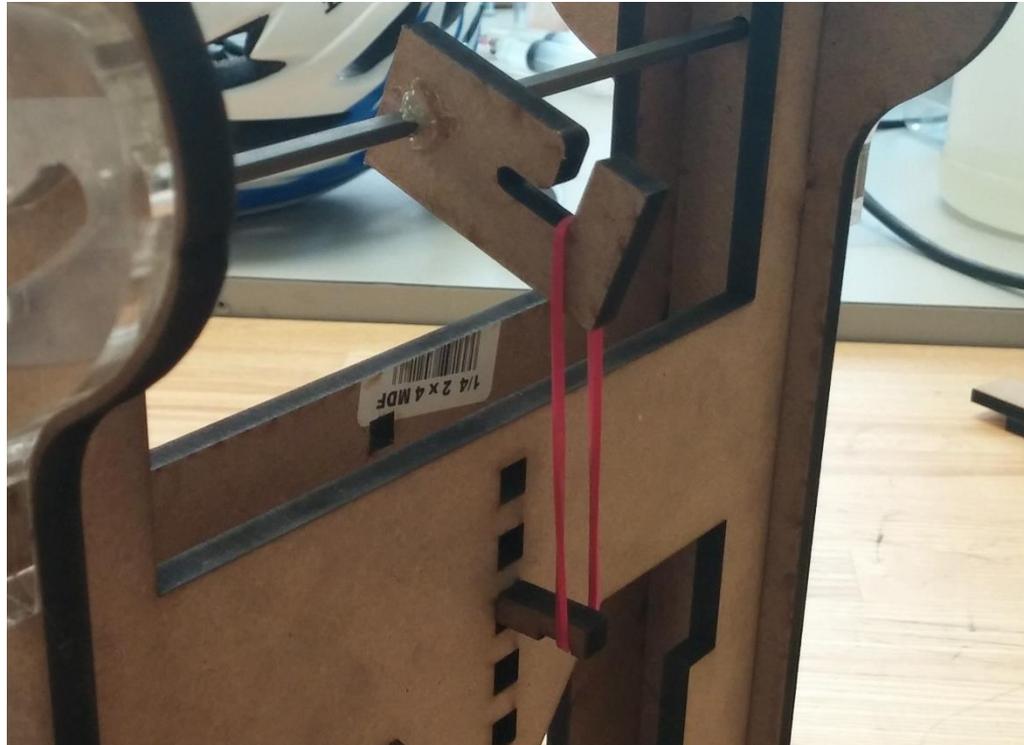
# Inner Legs

7. Insert the rubber band pegs into one of the square holes. Align the grooves, then push it up so that it stays in place.



# Inner Legs

8. Stretch the rubber band from the **Rubber Band Holder** to the peg. It should be stretched tight enough not to fall off, but it should still be easy to turn the cams. You may need to move the peg to a different hole to adjust the tightness.



*Tip: You can stretch the rubber band from between the **Weight Boards** rather than from the end, if you like. This will take more effort, but will be more secure.*

# Inner Legs

You have finished the **Inner Legs**!



*Tip: If you ever need to remove any of the parts, use the hot glue gun to heat up the glue so that it becomes liquid. Then quickly remove the part before it dries. It's okay if any parts break – most can be glued together and still work fine.*

# Final Assembly

Before we start, you will need to pick up the following parts:



Bolts (2)



Nuts (2)



Washers (20)

# Final Assembly

1. Add duct tape to all four feet for traction. Use several short pieces – it should be applied sparingly. Avoid bumps on the feet and keep it as thin as possible by not overlapping the tape too much!



*Tip: If the bumps are too large, the feet might bump into each other.*

# Final Assembly

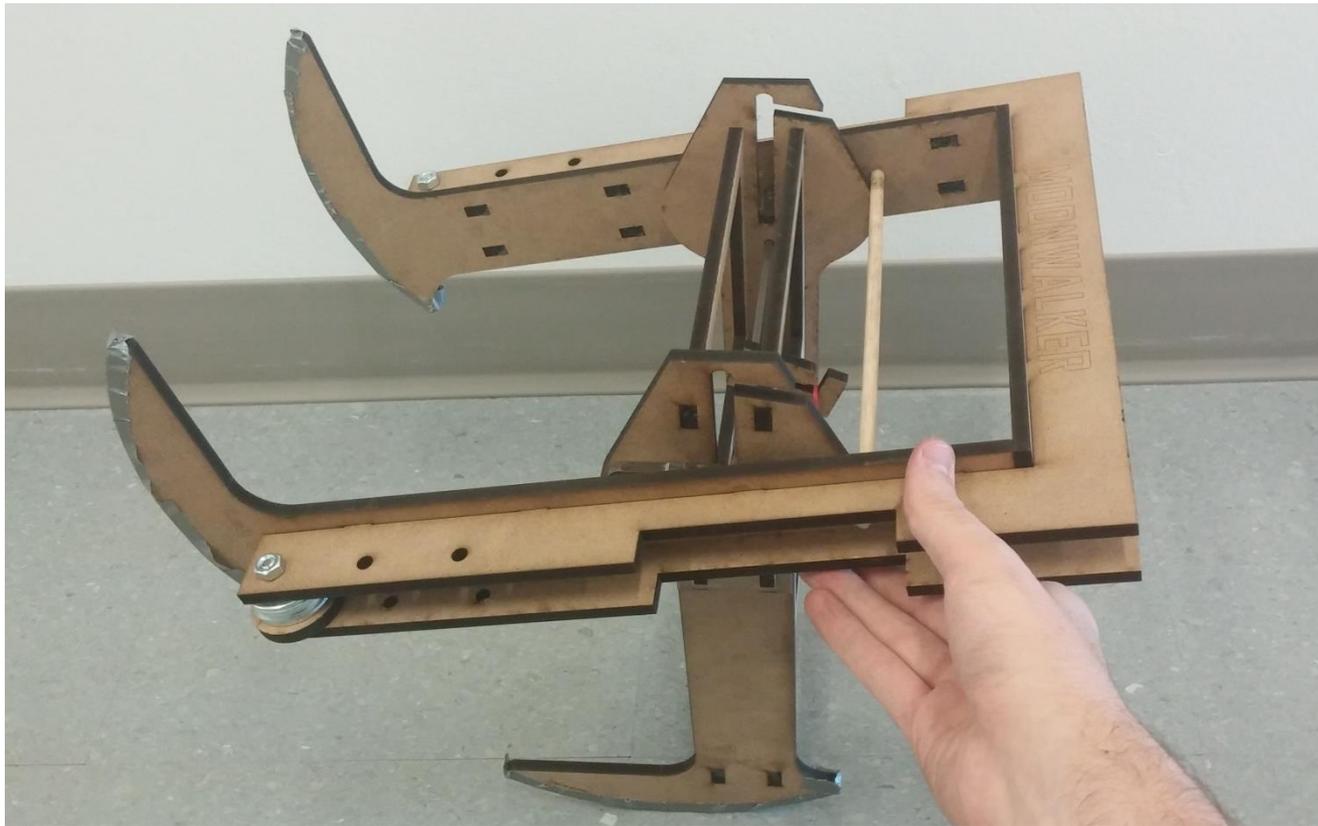
2. Use nuts and bolts to put washers between the **Outer Frames**. Pick which holes you want to use and how many washers to put between them – you'll experiment with this later. You will want to use MDF spacers so that the washers don't slide back and forth.



*Tip: There are extra holes so that you can experiment with the number and placement of washers yourself!*

# Final Assembly

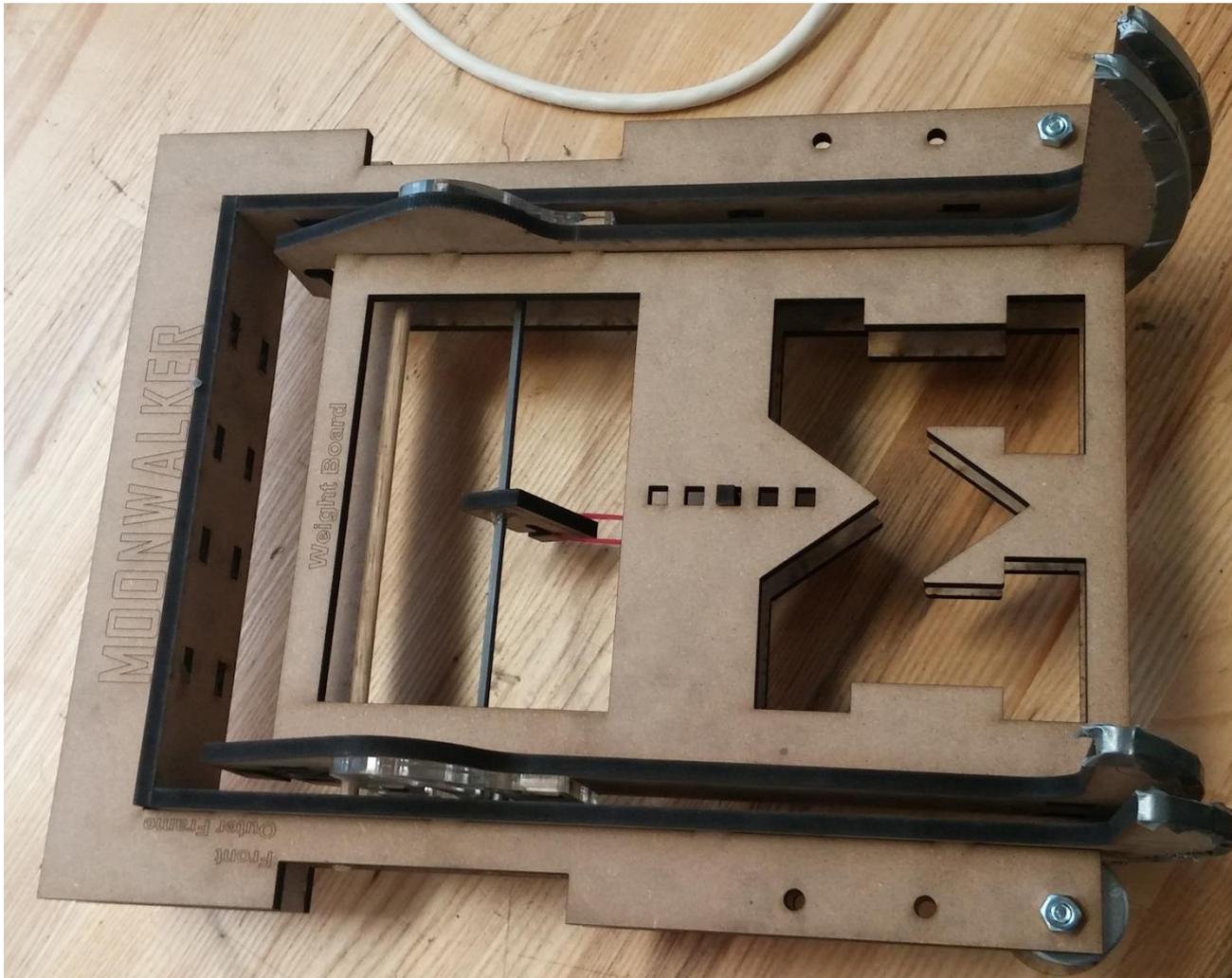
3. Hold the outer legs horizontally, align the bearings into the top of the two **Cam Valves** and slide it down. Then rotate the outer legs until the dowel rod slides into the valve of the **Inner Legs**.



*Tip: Once the legs are all the way in, you should be able to guide the legs around the cam, as if it were taking steps.*

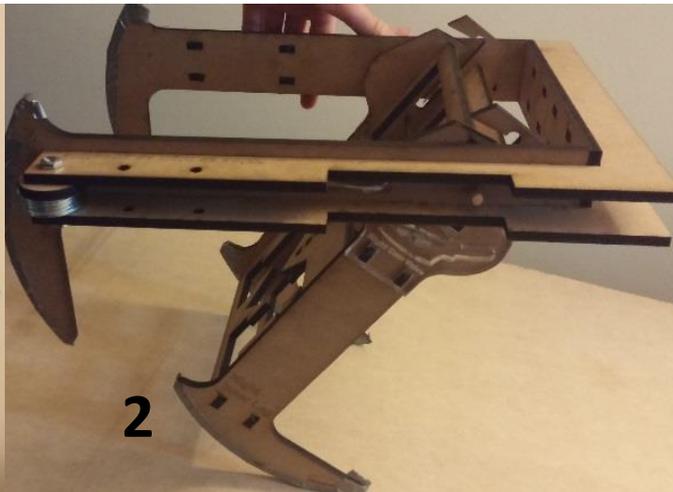
# Final Assembly

You have finished the **Moonwalker**!



# Walking the Moonwalker

1. Push the **Inner Legs** forward until you hear the **Cams** click.
2. Place the feet of the **Inner Legs** on the ground and raise the **Outer Legs** as high as possible.
3. Find the mark on the feet of the **Inner Legs** and make it flat with the ground.
4. Release the outer legs and watch it go!



*Tip: You will want to try using different numbers of washers to see if it walks better, or moving them to a different hole. You may even want to get extra nuts and bolts!*

*The most common problem is not leaning it far enough forward.*

# Troubleshooting

There are a lot of reasons the walker might not walk. If you have trouble, don't be discouraged! Check this list and try again.

1. Incorrect launch. It sometimes takes a couple tries to get the hang of it at first. Make sure the mark on the **Inner Legs** is flat with the ground and the **Outer Legs** are as high as possible so that they swing all the way.
2. Bad angle. If you're trying to walk it somewhere it hasn't walked before, the angle may be too steep or shallow for it to walk. If you're using a ramp, adjust the angle. If you're outside, natural slopes often change angle, so try again from another spot.
3. Broken pieces. If something broke during assembly, you may need to cut it again. If you used hot glue, reheat the glue to remove the broken part.
4. The bearing axles may be too long. You can cut, file, or sand them down if they are scraping against the **Inner Legs**.
5. Tilted **Outer Legs**. Sometimes one of the bearings ends up above the cam while the other is under it. An easy way to spot this is if the dowel rod is tilted. You can fix this by gently pulling the **Outer Legs** back until the bearings both touch the back of the cam valve.
6. If you're still having trouble, email [dussault@umich.edu](mailto:dussault@umich.edu) or visit our website.

To learn more about Passive Dynamic Walkers, visit our website!



<http://ram-lab.engin.umich.edu/moonwalker.html>