

Ball and Beam Assembly Instructions

These assembly instructions cover how to construct the ball and beam module. See the bill of materials for the required parts.

Step 0: Generating the Laser Cutting Files

If you are using 0.205" and 0.345" acrylic skip this step. Otherwise, change the values for "Thick Acrylic" and "Thin Acrylic" listed in the equations folder in the tree of "Ball and Beam Assembly 5.0.SLDASM" to whatever acrylic thickness you want to use and regenerate the laser cutting files. The assembly should automatically update itself, as should the "Laser Cutting 5.0.SLDDRW" file.

Step 1: Cutting the Acrylic

The laser cutter settings for cutting acrylic on the 170W BOSS LS-3650 Laser Cutter are shown below, but are likely to change depending on a variety of factors. These settings should be used as a starting point only; you need to make several test cuts to find the right power and speed before cutting the whole thing.

0.345" Acrylic 170W BOSS LS-3650 Laser Cutter Settings		
Setting	Speed	Power
Cut	5	90
Shallow Engrave	200	15
Deep Engrave	200	70

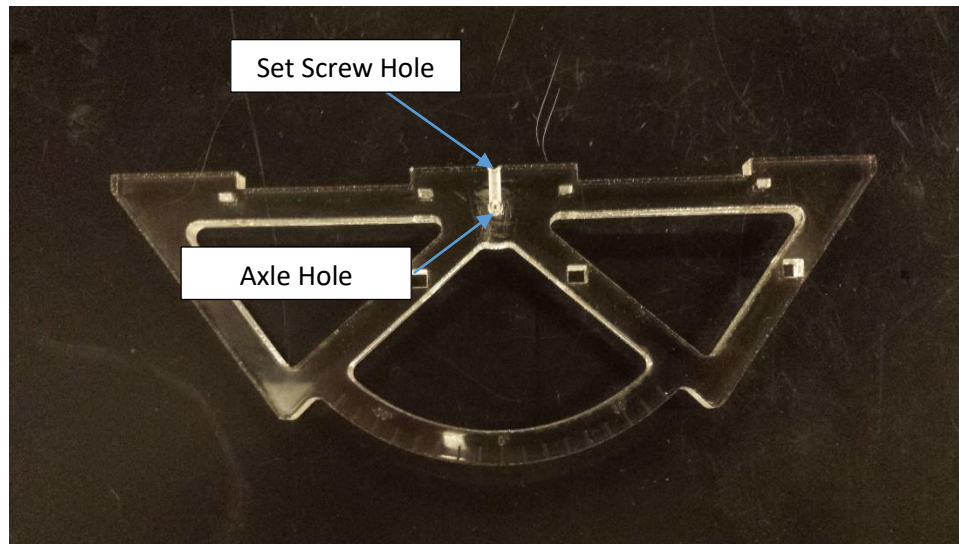
0.205" Acrylic 170W BOSS LS-3650 Laser Cutter Settings		
Setting	Speed	Power
Cut	10	70
Shallow Engrave	200	15

The Base, IR Sensor Mount, and Axle Support should be cut out of the thick acrylic and the Track and Side Supports should be cut out of the thin acrylic. The hex nut relief on the IR sensor mounts should use the "Deep Engrave" settings and all other markings (rulers, MAHI logo) should use the "Shallow Engrave" Settings.

Step 2: Drilling/Tapping Holes

Drill a hole for the set screw where the notch in the base is located. Use a starter bit to start the hole and ensure that it is centered, then a #29 drill (0.136"). Tap the hole with 8-32 threading.

Drill out the hole for the shoulder bolt using a #12 drill (0.189") on both the base and axle support. The shoulder bolt should fit tightly in the hole.



Step 3: Glue Axle Support

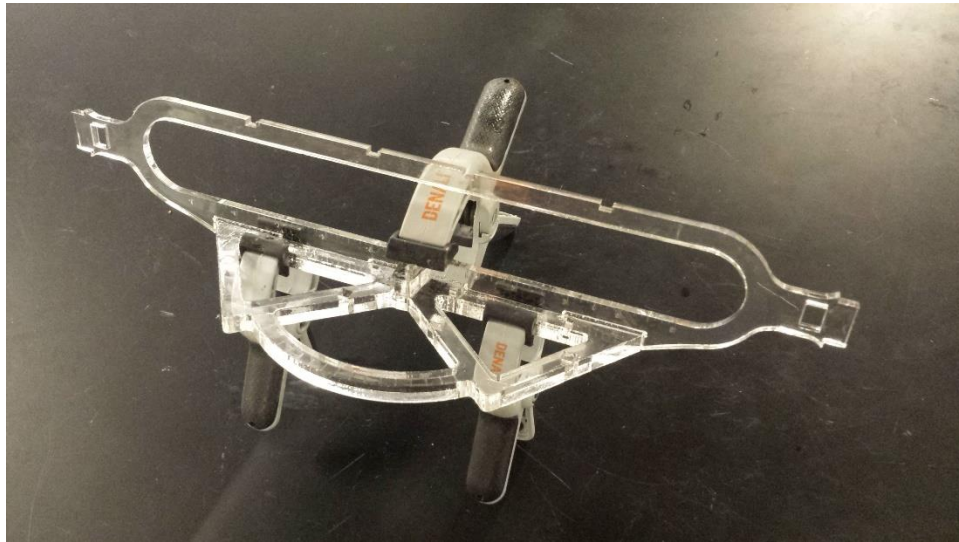
Only use acrylic glue to bond all pieces of acrylic. It should reach full strength after about 24-36 hours, but it sets fairly quickly (less than 1-2 minutes) so you have to work fast to clamp each piece together. It's helpful to have some paper towels on hand to wipe up spills and excess glue since it is very runny. You must sand and clean each surface to be bonded to get a strong bond. After you clamp the pieces together apply a small amount of glue at the edges (capillary action should draw some of the glue into the cracks). Wait about 5-10 minutes between each of the following steps to allow for the acrylic glue to set before moving on.

Use the shoulder bolt to align the holes in the base and axle support and apply acrylic glue to one or both surfaces. Clamp the parts together and remove the shoulder bolt. Because the shoulder bolt hole is so tight you may need to re-drill the hole at the end of the process, and if you do then give the bond plenty of time to set so that the drill doesn't shear the base and axle support apart.



Step 4: Glue Track and Base

Glue the track and base together; they can be clamped as shown below. **Double check that the ruler engravings are on the correct sides.** It's very easy to glue something on upside down or backwards and you will probably have to laser cut new parts if you don't notice the mistake right away. Make sure that the teeth farthest away from the center are bonded together well, as they support the cantilever parts of the track.



Step 5: Glue Side Supports

Glue the side supports one by one. Clamping isn't really necessary.



Step 6: Glue IR Sensor Mounts

Glue the IR sensor mounts and clamp as shown below. Make sure that they form a 90° angle with the track.



Step 7: Cut and Glue Rubber Friction Drive

Cut out a piece of rubber to glue to the base and bond using Loctite 406. Wear gloves unless you want to glue your fingers together. It works best to balance the beam assembly upside down on the corner of a table so that the base is vertical.

Step 8: Mount Beam to Haptic Paddle Base

Mount the beam on a shoulder bolt that has a magnet attached. Use a Belleville washer or two along with normal washers so that the Belleville washers are compressed when the nut on the end of the shoulder bolt is tightened. This axial spring force prevents the inner races of the ball bearings from wobbling, eliminating play from the system.

Step 9: Plug in and Zip-Tie Wires

Zip-tie the IR Sensor wires against the back side of the base use the 4 pre-cut holes. If you wish to unplug the JST connectors use a small pointy object (e.g. the end of a tiny flathead screwdriver) to depress the two locking nubs on either side of the connector as shown in the following picture and pry the male and female parts of the connector apart. Don't try to pull on the wire to unplug the connector.

