Notes on our assembly: Our paddle was made from the files found on the website. We used a Universal Laser Systems X-660 Super Speed Laser Cutter to cut our pieces. To cut 3/8" acrylic, we set the speed to be .7 and the power to be 100%. Note that this will vary from machine to machine, and possibly on the same machine as it ages. Make a couple of test cuts in order to determine what will work best before trying to cut out the whole paddle.

Side Supports:
1. Drill a hole with a #29 drill bit on the bottom that is 0.375" from the back of the piece and .1875"from the side of the base. The depth of the hole should be between ¾" and 1".
2. Tap the hole to be 8-32.
3. Drill holes with the #29 drill bit 2.2", 3.5", and 4.4" from the bottom on the front face and 0.1875" from the side edge. [1] The depth of the holes should be between ¾" and 1".
4. Tap the holes to be 8-32.

Front Plate:
1. Drill #18 holes 2.2" and 3.5" from the bottom that are both 0.1875" from the side of the plate. Do this on each side.
2. Countersink the holes from the front of the plate until the screw will be flush with the face.
3. Drill a #36 hole in the center of one square extrusion. This hole will be 0.2" from the top of the square and 0.2" from the side of the square. Repeat this step for the other square extrusion.
4. Countersink the holes from back of the plate.
5. Tap the holes to be 6-32.
6. Drill a #29 hole on the bottom of the front plate piece that is 0.9" from the center of the bottom and 0.1875" from the side of the bottom. The depth of the hole should be between ¾" and 1". Do this on each side of the bottom of the front plate.
7. Tap the holes to be 8-32.

Paddle Base:
1. Laser cut part.
2. Decide whether to glue or bolt the base to the vertical supports. We choose to bolt because it allows disassembly. However, choosing to glue the side supports will be easier. For gluing instructions see footnote two. [2] If gluing, skip the remainder of this section.
3. Drill a #29 hole 0.375" from the back of the piece and 0.1875" from the side of the base. Do this on each side.
4. Countersink the hole from the bottom so that the screw will be beyond flush with the base.
5. Tap the hole to be 8-32.
6. Drill a #29 hole 0.9" from the centerline of the piece and 2.6875" from the bottom of the base. Do this on each side.

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[1] 0.1875" is exactly in the middle of 0.375" acrylic. However, sheets are not perfectly to size and have a tolerance issue. For best results measure the exact width of the piece of acrylic you are using and divide it by two. Replace 0.1875" everywhere you see it with your own value.

[2] Any sort of acrylic glue will work for this application. When testing this we used Plexiglass Acrylic Glue IPS 3. In order to glue get two vertical supports that can be aligned to make a right angle at the back of the base. Place the side support against the supports in the desired position and place a thin line of the glue along the inside of the side support along the base. Wait five minutes to give the glue some time to dry before removing the side supports. Once the side supports are removed place another line of glue along the inside and outside of the side supports. Repeat this for the other side. Then allow the glue to dry overnight.

7. Countersink the hole from the bottom so that the screw will be beyond flush with the base.
8. Tap the hole to be 8-32.

Motor Support
1. Countersink beyond flush the 4 holes on the motor support for the 6-32 screws.
The remainder of this section is non-essential, but the piece does help prevent some vibration to give better results during motor spin-down tests.
2. Choose to either bolt or glue the support together. (If gluing, use the basic method outlined in footnote 2 in order to ensure a 90 degree orientation of the piece.
3. If bolting, dimension and spacing is non critical. Choose a size screw that is convenient. Drill a hole that is the proper close fit hole in the front motor support piece. Countersink this hole. Then drill a matching hole that is the tap size for the screw being used in the smallest faces of the two rectangular pieces to align with the counter sunk holes. Drill identical holes opposite these of the same size. Tap all four holes. Then drill holes that are the close fit size in the back piece that will align with the holes in the rectangle and assemble the U shaped piece.
4. Drill a #29 hole in the other side of the rectangular piece that is 0.5" from the bottom and 0.1875" from the side. Tap the hole to be an 8-32 screw size.

Motor Attachment[3]
1. Drill a 4mm hole in the center of one end of a 0.25" OD, 1.75" long brass[4] shaft that extends the distance of the shaft extending from the motor.
2. Drill a 1/16" – diameter hole through the brass shaft 5/32" from the base of the shaft. Put the 0.25" cover all the way over the shaft as far as it can be put on.
3. Fasten the two pieces together using a pin.
4. Place the 0.25" inner diameter trantorque on the shaft.
5. Drill a 0.625" hole in a piece of 0.6875" diameter aluminum. Place this on the trantorque and tighten it for use as a friction drive. Repeat this process for a 1.25" diameter aluminum to be used in motor spindown weight attachment.

Magnet Cap:
1. The cap is laser cut in two parts (**see note on drawing). Assemble the parts by pushing the 2 part into the 1 part on the side opposite the etched ring.
2. The purpose of the 0.040" inch fillets on the A part are for easier insertion (thickness of tab on B is actually less than slot in A due to tolerance of laser cutter).
3. The included files are designed for this cap to press fit onto the shoulder sleeve shaft, but we have found gluing the caps on prevents undesirable slip/rotation of the magnet with respect to the paddle/shaft.

Hall Mount:
1. The Hall Mount consists of Vector Board ("Punchboard") made of epoxy glass and a Single Inline Package (SIP). Using the laser cut template, mark off 4.5" x 0.625" sections of the Vector

[3] We decided to use the trantorque as we wish to be able to change out the size weight in order to do a spin down test. If one is not planning on doing so, bolting or gluing the 1.25 in aluminum piece to the shaft that gomes with the motor will be fine. This could be done by either drilling the 1-72 hole through both the motor shaft and the aluminum piece or using a glue like Loctite 620.
[4] Steel is also acceptable.

Board. Also mark off the three holes for the SIP and the two holes for the banana connectors using the template. The two holes for the banana connectors should be centered between a region of four holes on the Vector Board.
2. Using a sheet metal shearer, cut the Vector Board into the 4.5" x 0.625" sections.
3. Using a punchboard vise and a 1/16" drill bit, drill the three holes for the pins of the SIP. These three holes should already line up with the existing three holes of the Vector Board.
4. Use a 1/16" drill bit to drill starter holes for the two banana connector holes. Then work your way up using a 1/8" bit and then finally a 3/16" bit.
5. Using a razor blade, cut off a 3-pin SIP.
6. Glue the SIP into the three pin holes on backside of the Vector Board.

Paddle Handle:
1. Laser cut part. The laser cut part has lines cut into it to assist in lining up the holes to be drilled, as shown in the drawing.
2. Drill a 11/64" hole perpendicular to one of the two legs at 30 degrees that goes into the hole in the center where the shaft is placed.[6]
3. Tap the hole for an 8-32 insert.
4. Put a helical insert with an 8-32 internal thread into the hole.
5. Put a ¼", 8-32 set screw into the helical insert.
6. We used glue on the ends of the paddle handle when we attached the neoprene in order to keep the neoprene from losing contact with the bottom of the paddle handle.

Assembly:
1. Use 8-32 screws to screw the two side supports to the base piece.
2. Use 8-32 screws to screw the front plate to the side supports.
3. Put a 6-32 screw into the hole at the top of the front plate in order to act as a stop.
4. Use 6-32 screws to attach the motor to the front motor support plate.
5. Use 8-32 screws to attach the U bracket to the front motor support plate. (Skip this step if choosing not to build this piece)
6. Insert bearings into either side of the central hole at the top of the front plate. [7]
7. Attach the magnet cap to the rod sized to fit through the bearing.
8. Put the rod through the bearing.
9. Put washers to act as spacers on the front side of the paddle. We find that 2-4 usually works.
10. Place the pendulum onto the rod.
11. Put washers to cover the remainder of the non-threaded length of the rod.
12. Put a lock washer and an appropriately sized nut at the front.
13. Adjust the set screw to tightly fasten the pendulum to the rod.
14. Put a ¼ -20 bolt through both the front motor support and the front plate.
15. Use a wing nut to secure the pieces together.
16. Enjoy the paddle!

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[6] The combination of metal and acrylic threads will lead to the breaking down of the acrylic threads with repeated use. To combat this issue, we used an 8-32 heli-coil. To do this, one will need to purchase an 8-32 heli-coil kit which includes a drill bit, tap and tool to put in the heli-coil, McMaster Part #93060A005.

[7] Due to laser cutter properties and the thickness of acrylic being used, the bearings might not fit perfectly. Because the bearings will be bolted on either side, as long as it fits inside the hole with reasonable surface area of contact to the front plate, it will function properly. If the hole is too small on one side, which we often found it was, line it up and then tap it lightly with a hammer. This will push the bearing down into place.