3D-Printed Part Assembly Guide

As specified in the ruleset, the Crater, all 4 Antennas, and Earth are completely 3D-Printed. This document serves as an instruction manual detailing how each 3D-Printed part is assembled together. The quantity of each part and the type of screw required for assembly are shown in *Table 1*. The specified nuts are required for all screws used. Follow the *3D-Printing Guide* provided with the competition ruleset to print all required parts.

Screw Table		
Screw Type (Type-Length)	Quantity	Referred To By
2-56 - ¾”	42	*Screw #1*
2-56 - ½”	2	*Screw #2*
4-40 - 1¼”	4	*Screw #3*
8-32 - 1”	16	*Screw #4*
2-56 Hex Nut	44	*Screw #1, Screw #2*
4-40 Hex Nut	4	*Screw #3*
8-32 Hex Nut	16	*Screw #4*

Table #1 – Screw Type and Designation

Crater Assembly

The Crater has 4 Individual parts of which 36 total parts will be required to complete assembly of the crater. *Table 2* gives details on the quantity of description of each required part.

Crater Required Parts		
Part Name	Quantity	Example Figure
Upper Rim	16	*Figure #1*
Lower Rim	16	*Figure #2*
Flat Area V1	2	*Figure #3*
Flat Area V2	2	*Figure #4*
Antenna Box	1	*Figure #5*
Crater Assembly Animation		*Figure #6*

Table #2 – Crater Parts List

Assembly of the Crater requires 32 of *Screw #1*. See *Figure #6* for an assembly animation displaying the appropriate orientation of each part. Once all parts listed in *Table 2* and all hardware is gathered follow the instructions listed as follows:

1. Align part *Lower Rim* and *Upper Rim* by matching the hole labeled “B” in *Figure #1,2*. Insert 1 of *Screw #1* through hole “B” and fasten. Ensure the screw head is on the interior surface of the crater.
2. Repeat Step 1 until 16 copies of the part assembled in #1 are acquired.
3. Align part *Lower Rim* and *Flat Area V1* by matching the hole labeled “A” in *Figure #2,3*. Insert 1 of *Screw #1* through hole “A” and fasten. Ensure the screw head is on the interior surface of the crater.
4. Repeat step 3 until part *Flat Area V1* has 4 of part *Lower Rim* fastened to it.
5. Repeat steps 3 and 4 for both copies of part *Flat Area V1*.
6. Repeat steps 3,4,5 substituting part *Flat Area V2* for *Flat Area V1* and *Figure #4* for *Figure #3*.
7. Attach the antenna pressure box to the flat area of the crater by matching hole “E” on *Flat Area V1* shown in *Figure #3 and hole E on the antenna box shown in Figure #5*. Insert Screw #4 through both hole “E” and fasten. Ensure that the *Antenna Box* is located inside the crater.

8. Repeat #7 substituting *Flat Area V2* with *Flat Area V1, hole "D" for hole "E"* and F*igure #3* with *Figure #4*.

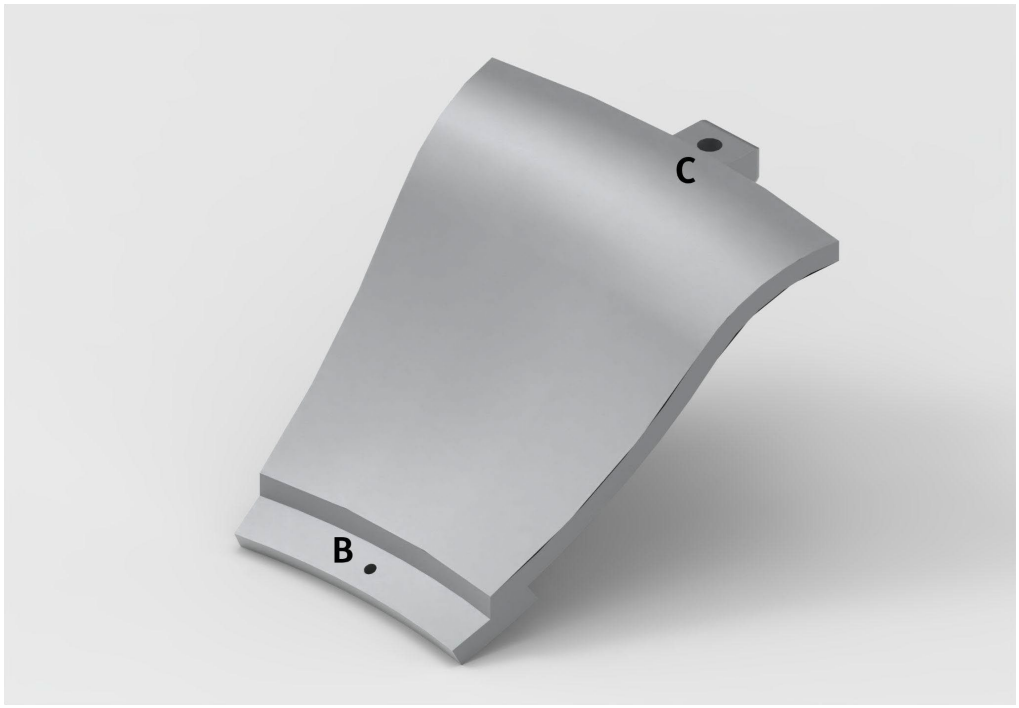

Figure #1 – Crater Upper Rim Piece (16 required)

Figure #2 – Crater Lower Rim Piece (16 required)

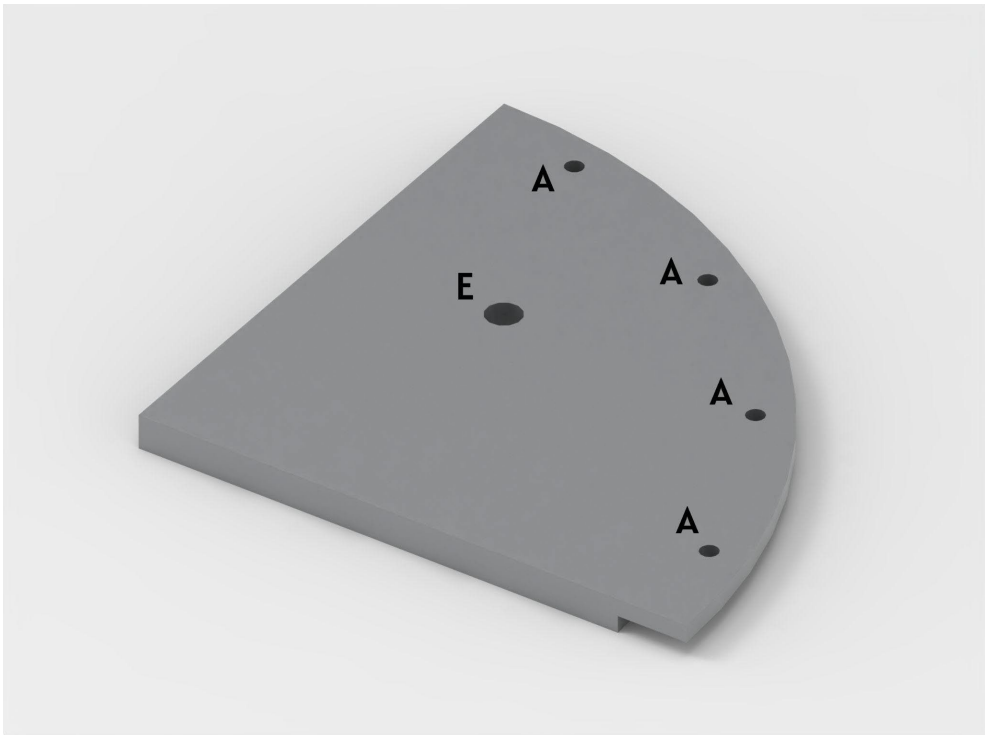

Figure #3 – Crater Base Part V1 (2 required)

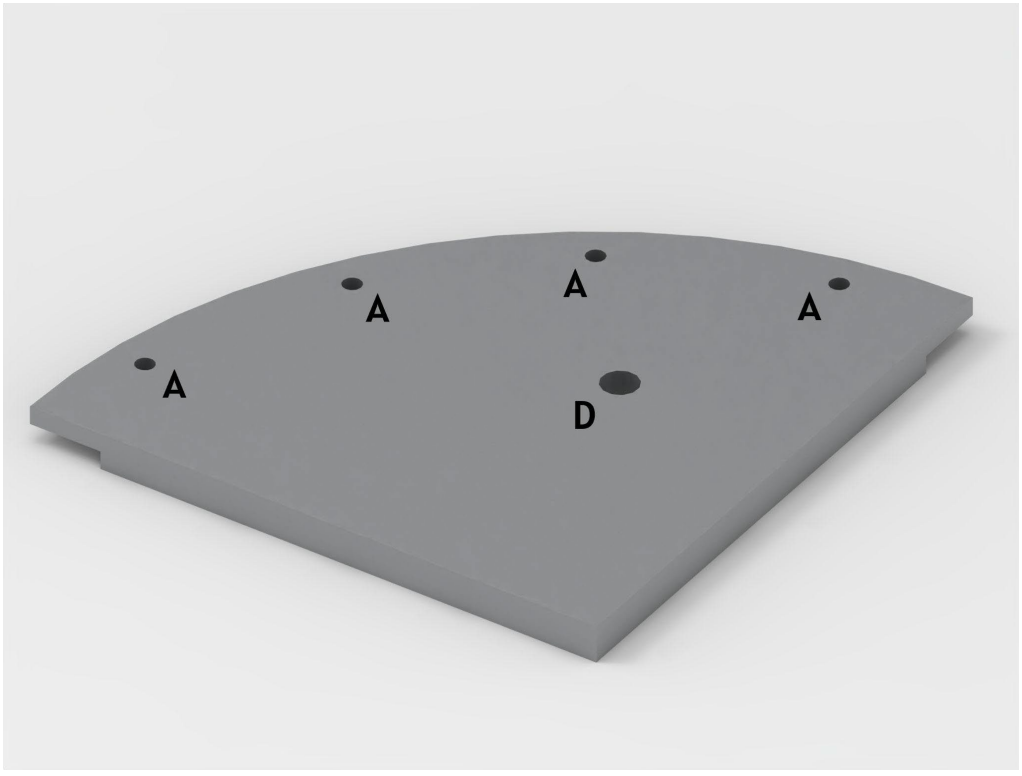

Figure #4 – Crater Base Part V2 (2 required)

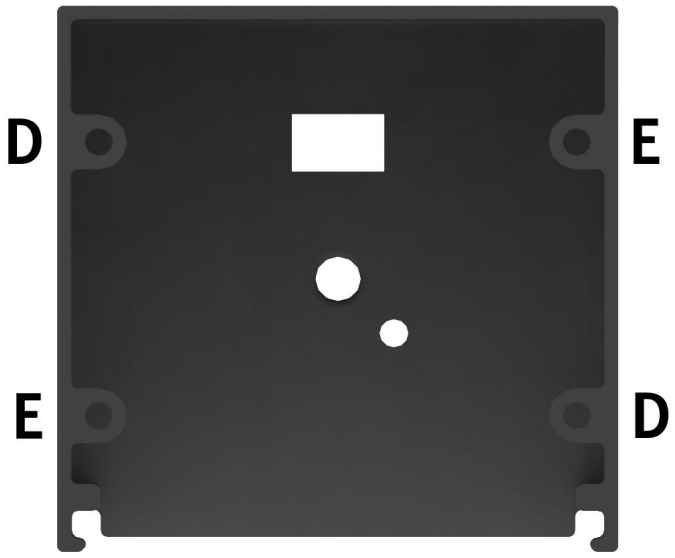

Figure #5 – Bottom View of Crater Antenna Pressure Pad Box

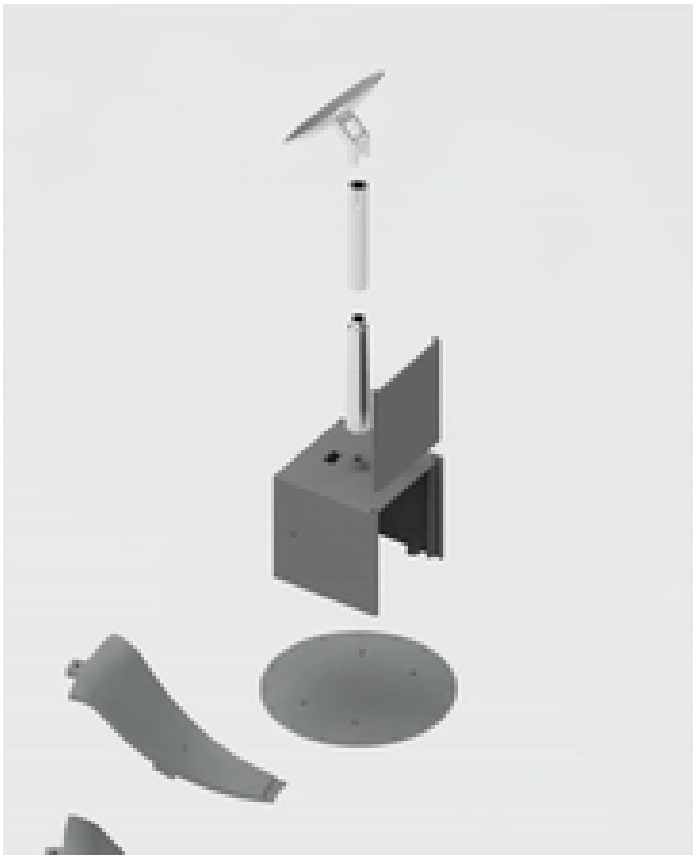

Figure #6 – Crater Assembly Animation

Antenna Assembly Instructions

Each of the 4 Antennas are split into 5 main components: the sliding hatch, lower antenna shaft, upper antenna shaft, antenna dish, and the antenna box. Each antenna differs only in the design of the antenna box. Hence, the assembly of each antenna is the same with additional instructions for the antenna boxes. To assemble the antennas, refer to the “General Antenna Assembly" section of this document. Then follow the instructions for the specific antenna box used in the assembly of that antenna. The quantity and name of each part required are listed in *Table 3*. The only Antenna requiring extra assembly is the Crank Antenna. Therefore, only the General Antenna Assembly and the Crank Antenna Assembly will be covered in this document.

Antenna Components		
Part Name	Quantity	Example Figure
Antenna Dish	4	*Figure #7*
Antenna Upper Shaft	4	*Figure #8*
Antenna Lower Shaft	4	*Figure #9*
Antenna and Box Assembly Animation		*Figure #10*
Antenna Box Hatch	4	*Figure #11*
Antenna Box Pressure	1	*Figure #12*
Antenna Box Crank	1	*Figure #13*
Antenna Box Button	1	*Figure #14*
Antenna Box Keypad	1	*Figure #15*
Crank Housing	1	*Figure #16*
Crank Spacer	2	*Figure #17*
Rotary Encoder Sleeve	1	*Figure #18*
Rotary Encoder	1	*Figure #19*
Crank Housing Assembly Animation		*Figure #20*

Table #3 – Antenna Component Parts List

General Antenna Assembly

No hardware is required to complete the General Antenna Assembly. All parts are held on by friction and are pressed to fit into place. Exercise caution when assembling the antenna parts as too much force will break the mounting points. Use your own judgment to determine if a cylinder is too tight to fit into place. If you determine that it is too tight use sandpaper on the cylindrical insertion points to achieve a looser fit. To assemble a general antenna structure, attach the parts using the following instructions.

1. Press the *Antenna Upper Shaft (Figure #8)* onto the *Antenna Lower Shaft (Figure #9)*
2. Press the *Antenna Dish (Figure #7)* onto the Antenna Upper Shaft by aligning the slot and groove of the two pieces.
3. The completed antenna assembly can then be attached to any of the 4 *Antenna Boxes (Figures 12-15)*
4. Before attaching the antenna assembly to the box, be sure to run all necessary wires through the assembly. Also be sure to orient the antenna dish as shown in the figures in the Competition Document.

Figure #10 provides an animation of the antenna assembly process and attachment to an antenna box.

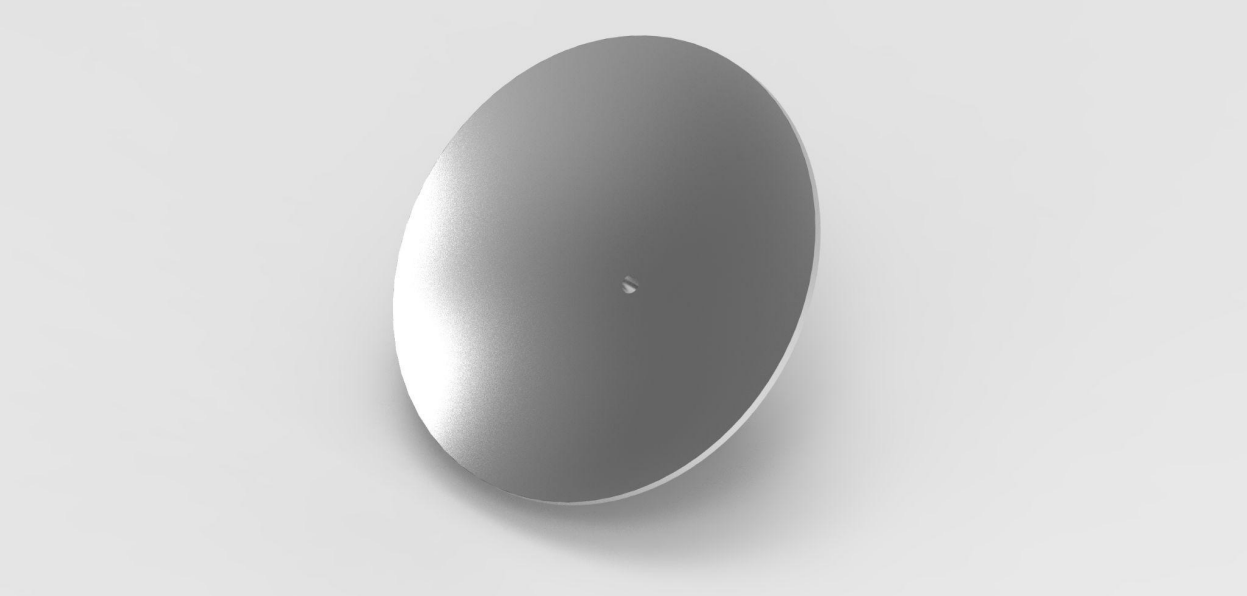

Figure #7 Antenna Dish

Figure #8 Antenna Upper Shaft

Figure #9 Antenna Lower Shaft

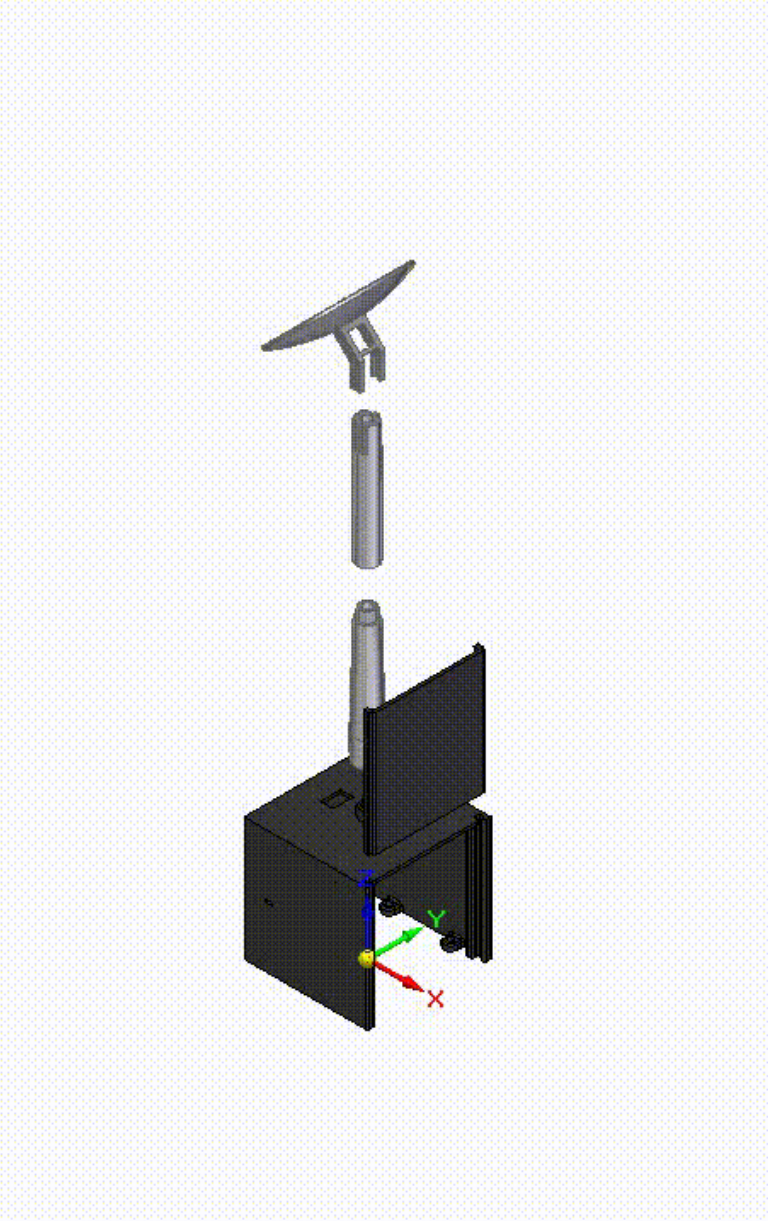

Figure #10 – Antenna and Box Assembly Animation

Antenna Box Construction

The antenna boxes consist of two pieces – the *Antenna Box Hatch (Figure #11)* and a main body (Figures #12 - #15). The Antenna Box Hatch slides into the grooves on the Antenna box to complete the assembly. *Figure #10* shows an animation of this assembly process.

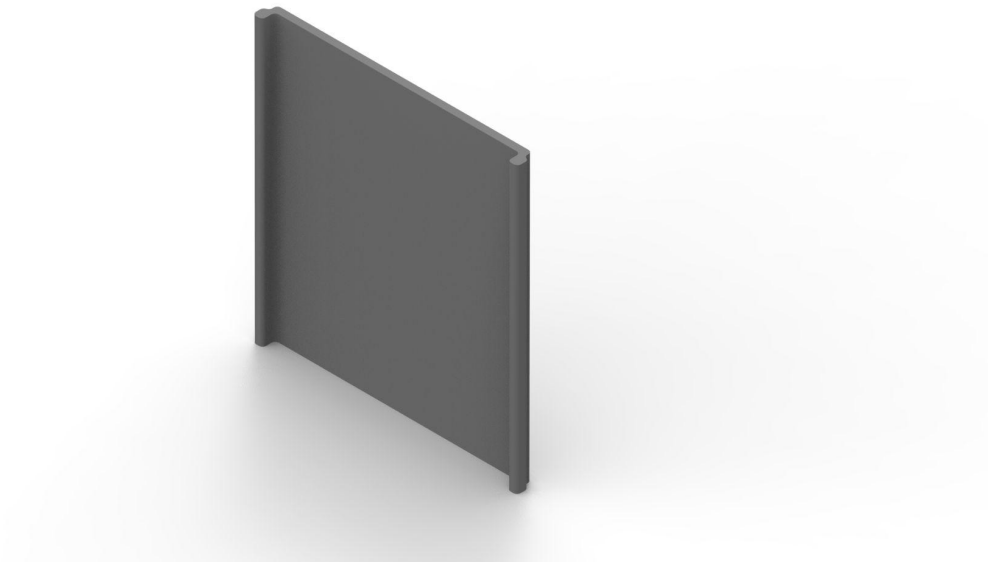

Figure #11 – Antenna Box Hatch

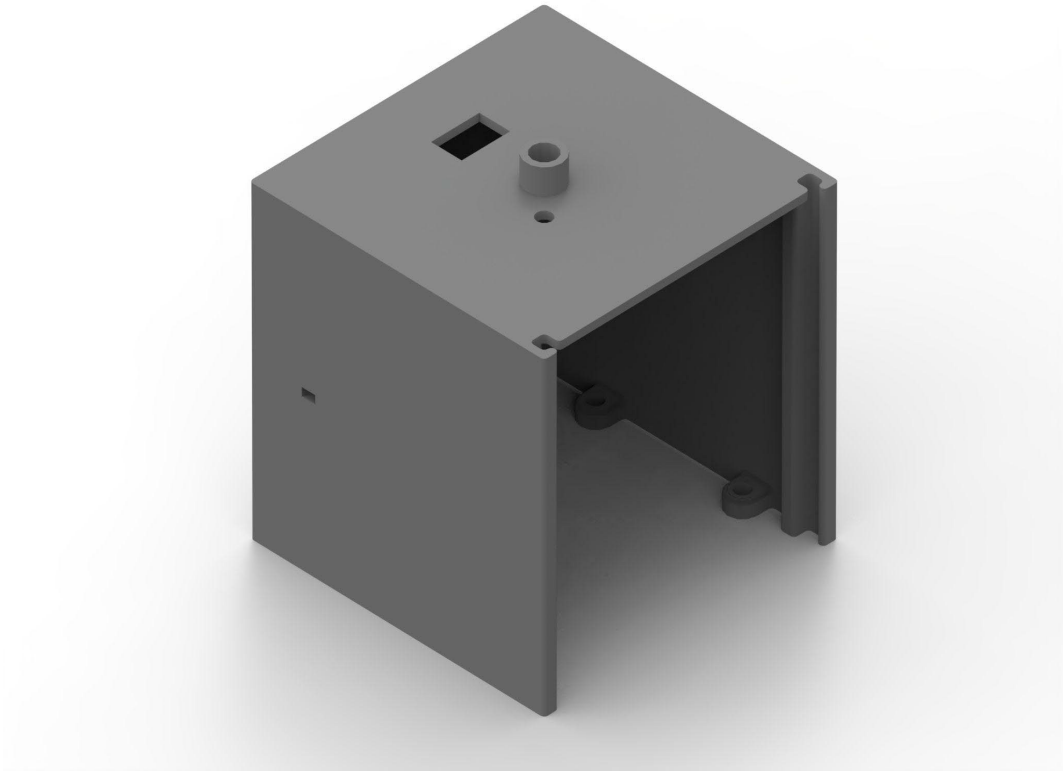

Figure #12 – Antenna Box Pressure

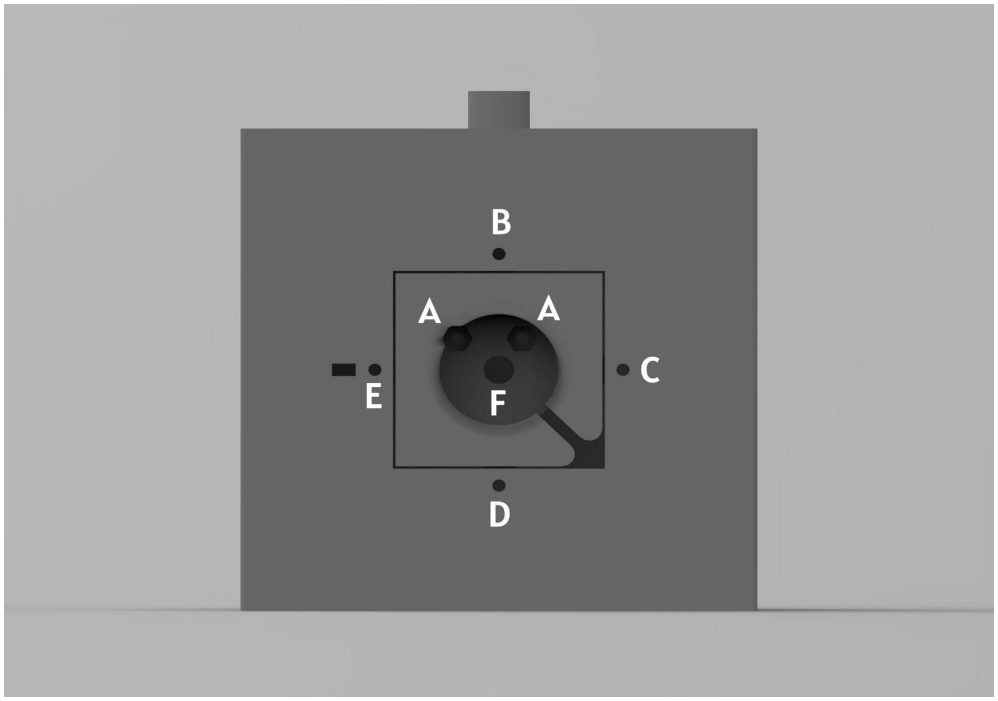

Figure #13 – Antenna Box Crank

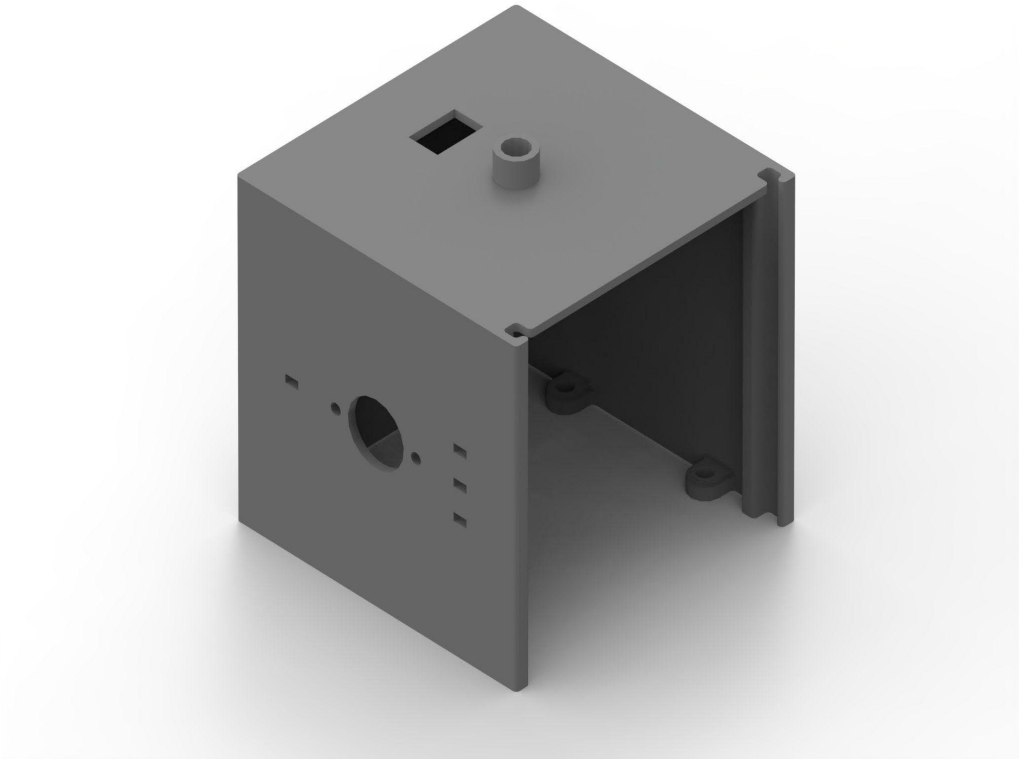

Figure #14 – Antenna Box Button

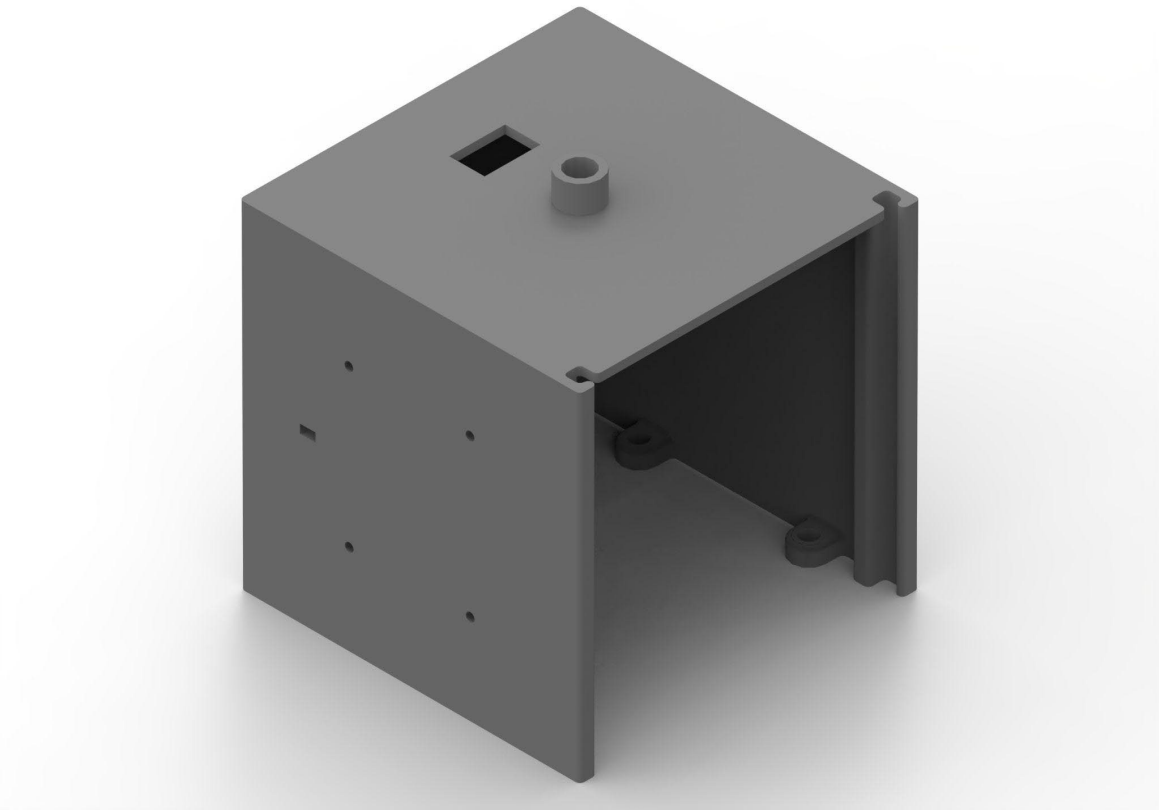

Figure #15 – Antenna Box Keypad

Crank Antenna Box Assembly

For the Crank Antenna Box, the *Crank Housing (Figure #16)*, 2 of the *Crank Spacer (Figure #17)*, the *Rotary Encoder Sleeve (Figure #18)*, and the *Rotary Encoder (Figure #19)* (detailed in the *Antenna Construction Document*) will be required for completion of the following instructions.

1. Begin by placing 2 corresponding nuts for *Screw #2* inside the hexagonal holes, marked “A”, of part *Crank Housing (Figure #16)*.
2. While holding the nuts from #1 in place, set 2 of part *Crank Spacer* onto part *Crank Housing* as shown in the *Crank Housing Assembly Animation (Figure #20).*
3. Insert the rotary encoder shaft marked “F” in *Figure #19* into the corresponding crank housing hole marked “F” in *Figure #16.* Ensure that the holes marked “A” in *Figure #19* align with the holes marked “A” in *Figures #16 and #17.*

4. Insert *Screw #2* through the hole marked “A” in *Figure #16,17,19*. Ensure the the head of *Screw #2* is flush against the PCB of the *Rotary Encoder*. Tighten the screw using the appropriate nuts.
5. Once the *Rotary Encoder* is firmly attached to the *Crank Housing*, matching holes “B”, “C”, “D”, and “E” on the *Antenna Box Crank in Figure #13* to the corresponding holes on the *Crank Housing* (*Figure #16)*. Ensure that the *Rotary Encoder* is located on the inside of the antenna box.
6. Insert 1 of *Screw #1* through each of holes “B”, “C”, “D”, and “E” and fasten with the appropriate hex nut.
7. Now, firmly push the *Rotary Encoder Sleeve (Figure #18)* onto shaft “F” of the *Rotary Encoder* (*Figure #19)*. Note, the sleeve is a very tight fit and will require a lot of force to push onto the *Rotary Encoder*.

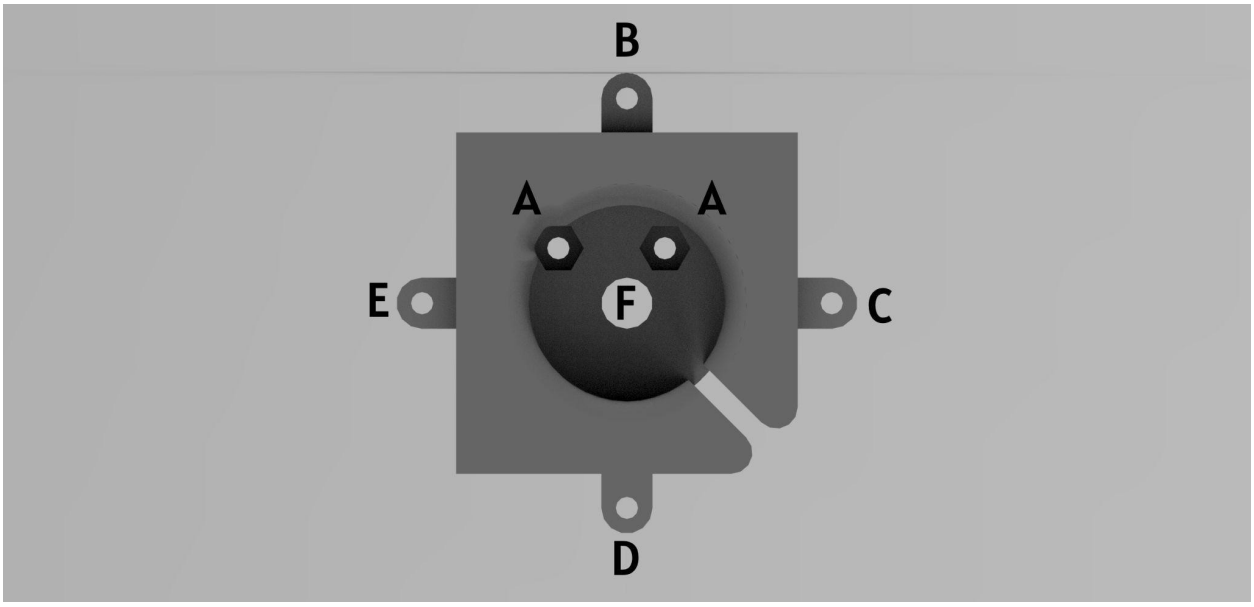

Figure #16 – Crank Housing

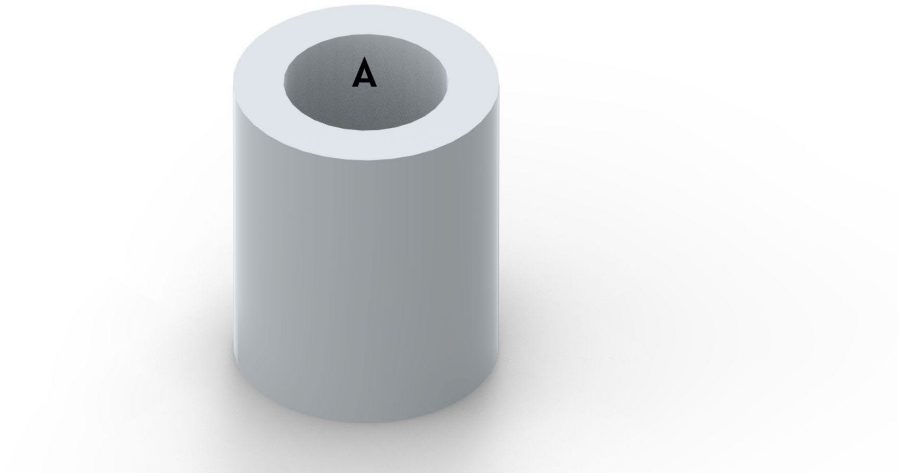

Figure #17 – Crank Spacer

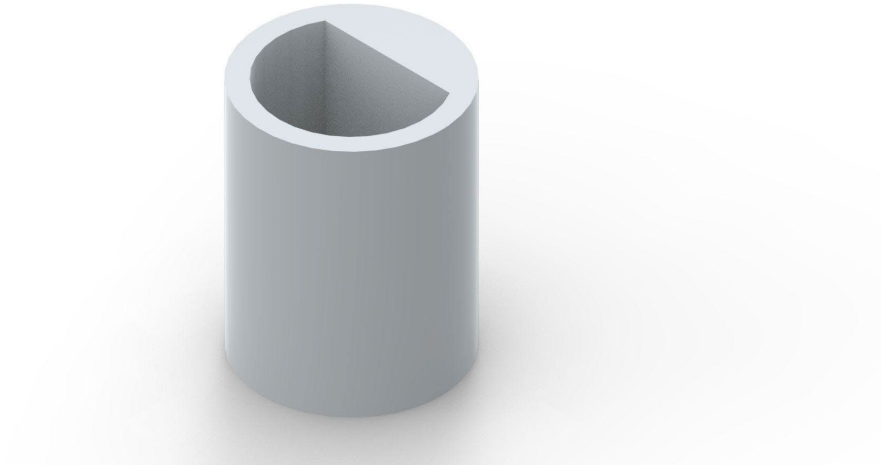

Figure #18 – Rotary Encoder Sleeve

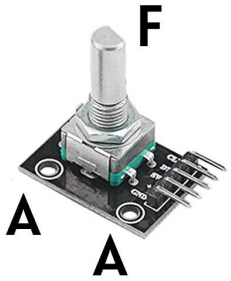

Figure #19 – Rotary Encoder

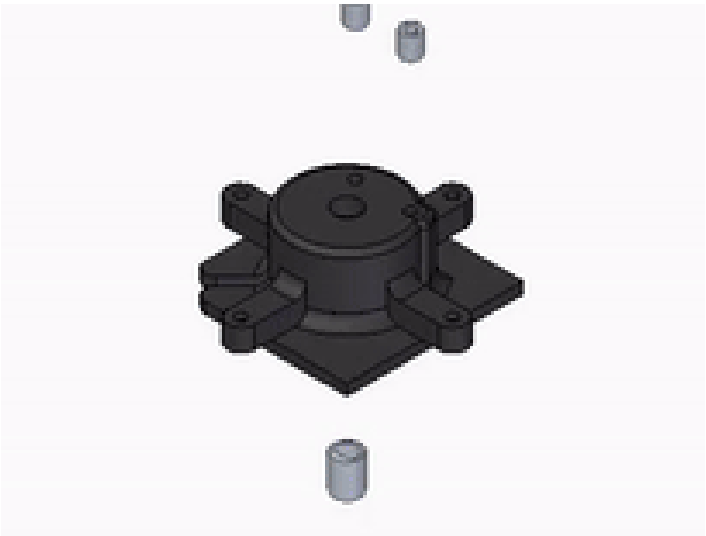

Figure #20 – Crank Housing Assembly Animation

Earth

Earth consists of 3 individual 3D-Printed components: *Shell V1, Shell V2 and Earth Hanging Hook.* Furthermore, Earth has an LCD mounted on it. Each of these items are noted in *Table 4*.

Earth Components		
Part Name	Quantity	Example Figure
Shell V1 (Front) Shell V1 (Back)	1	*Figure #21a* *Figure #21b*
Shell V2 (Front) Shell V2 (Back)	1	*Figure #22a* *Figure #22b*
Earth Hanging Hook	1	*Figure #23*
LCD	1	*Figure #24*

Table 4: Earth Component List

Full assembly of Earth is detailed in the following instructions:

1. Begin by matching holes “A”, “B”, “C”, and “D” of *Earth Shell V2-Back (Figure #22A)* with the same holes on the LCD shown in *Figure #24. Ensure* that the *LCD* is upright with the top facing hole “E” and the *LCD* screen is facing away from Earth.
2. Insert 4 of *Screw #3* through each of holes “A”, “B”, “C”, and “D” and fasten with the appropriate nut.
3. Next, insert a piece of twine, wire, string, or whatever material will be used to suspend Earth and insert it through hole “G” on the *Earth Hanging Hook (Figure #23).* Once inserted, tie a knot large enough that it cannot pass through hole “G”. (See note below)
4. Now, match hole “H” and “I” in *Figures #21b and #22b.* Ensure that *Earth Hanging Hook* is within Earth and the material used to tie the knot passes through hole “F” in *Figure #22a.* Next, insert 1 of *Screw #1* through both hole “H” and “I” and fasten with the appropriate nut.

NOTE: For the competition fields, a 1/16 inch braided cable will be used to hang the earth. A Ferrule stop will be used to keep the Earth Hanging Hook on the cable. This

cable will have a loop for mounting it on the Earth Arm Assembly. The loop is formed by using a Ferrule and Stop.

Figure 21A: Earth Shell V1 – Front View

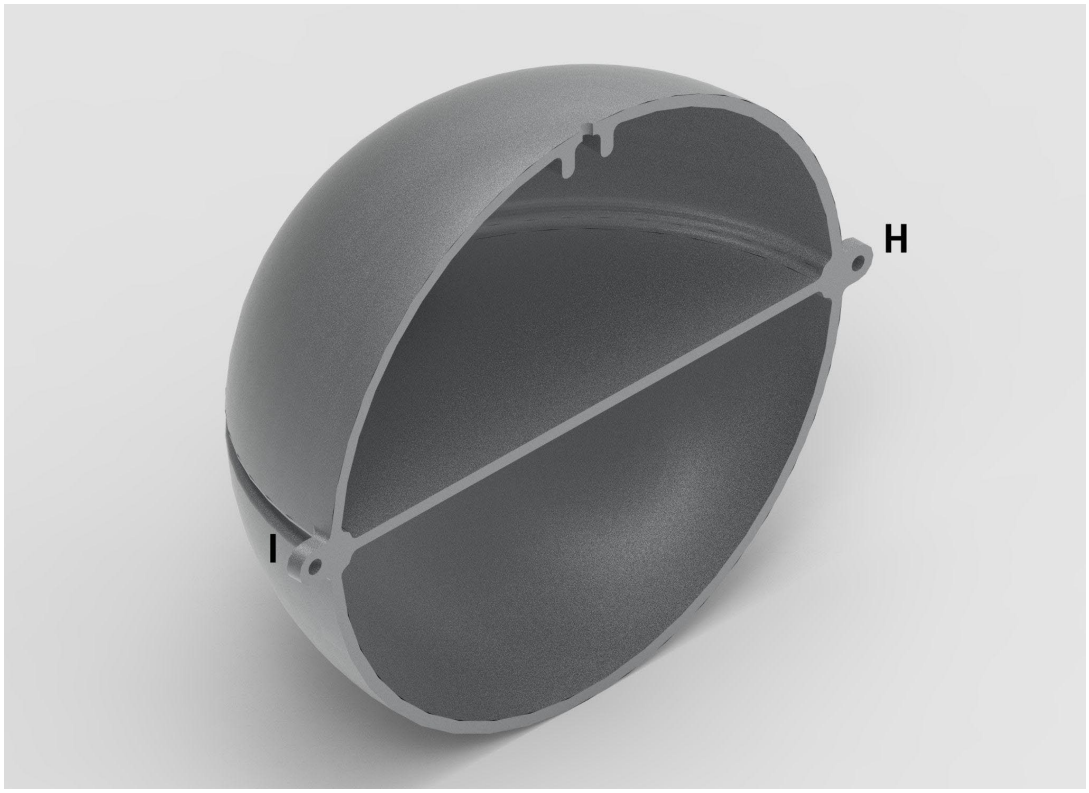

Figure 21B: Earth Shell V1 – Back View

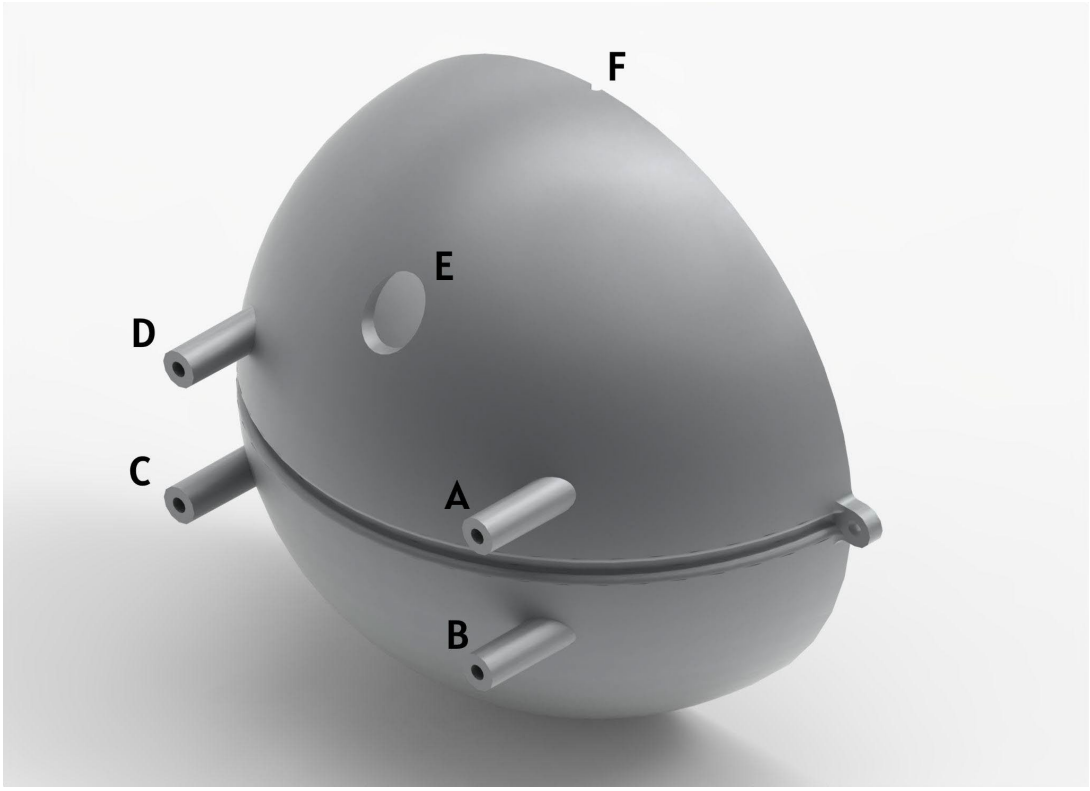

Figure 22A: Earth Shell V2 – Front View

Figure 22B: Earth Shell V2 – Back View

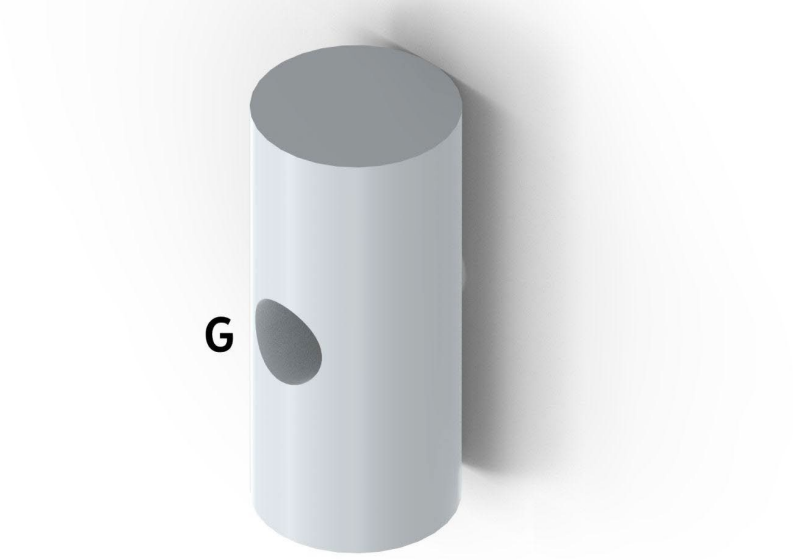

Figure 23: Earth Hanging Hook

Figure #24

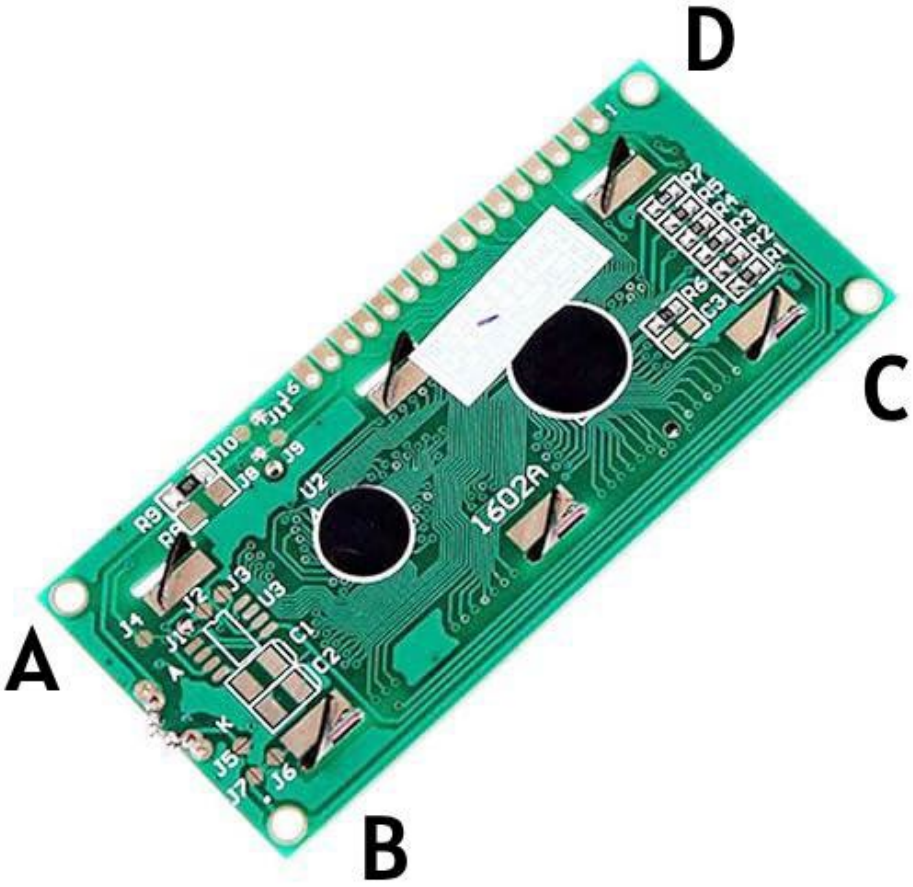

Figure 24: Back of LCD