



# SMaCK: Sensorized Manipulation Challenge Kit

Assembly Manual

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## Overview

This is the assembly instructions for all three types of 6 inch by 6 inch sensorized boxes. With the required materials and tools, it is expected to take around 2 days to complete. This estimated time includes cutting and engraving the box's sides with a laser cutter, painting, electronics assembly, sensor installations, and putting the box together.

## Lid Only Box

### Equipment and Materials

#### Materials

- 2 sheets of 24" x 12" x 1/8" of white Delrin (McMaster Carr [8573K33](#))
- 1 Package of 4-40 x 1" plastic screws (McMaster Carr [94735A725](#))
- 1 Linear Potentiometer (Digikey [404R1KL1.0](#))
- Magnetic Reed Switch (Digikey [54-629](#))
- 12mm x 12 mm L Brackets 12 Pack (Amazon [a19022200ux0403](#))
- National Hardware 3/4" x 5/8" Hinges (Amazon [N211-012](#))
- 3-48 screws (Amazon [9134194](#))
- 1.5" diameter wood dowel (any source)
- Spray paint, we found used Behr Premium paint and primer combo (any color)

#### Equipment

- 12" x 24" laser cutter or bigger
- Assortment of small screw drivers
- 4-40 tap
- 3-48 tap
- 1/4-20 tap
- #43 drill bit for 4-40 tap
- #47 drill bit for 3-48 tap
- 1/8-inch drill bit
- 1/2-inch drill bit
- Hand Drill

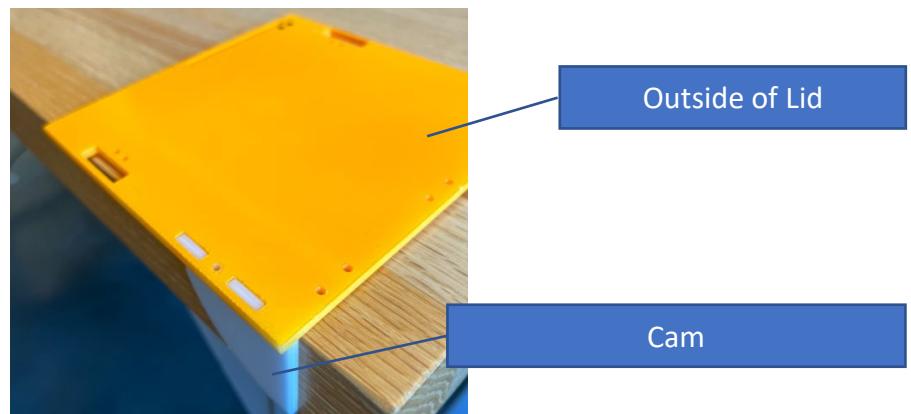
- Wood saw (hand saw or chop saw)
- Razor blades and/or knife
- Hot glue gun

## Laser Cutting

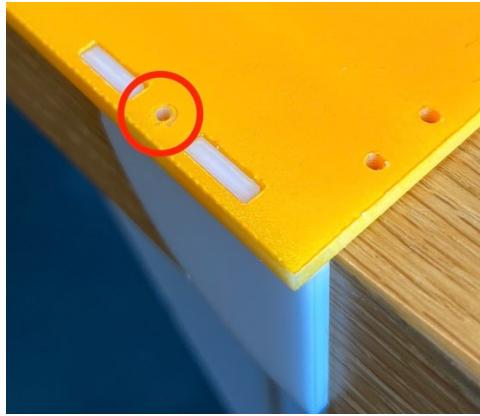
1. Upload the SolidWorks eDrawing files to the laser cutting software.
2. For the engraving parts, make sure engraving power is not set too high as this can warp the plastic sheet. Vector cut the finished engraved parts after engraving is complete.
3. For the non-engraved parts, **only** run the vector setting **only**.
4. For vector settings for both post engraved pieces and vector only pieces, we have found it best to do multiple passes on medium power (50-65%) to avoid warping the material
5. Make sure it is at a 1:1 scale and run the program.
6. After the laser cut is complete, take out any plastic pieces inside parts left over by the laser cutting process.
7. Wipe down with damp cloth to take off any dust from the laser cutting process.

## Painting Preparation and Painting

1. The engraving improves the adhesion of the spray paint, so only the engraved surfaces are meant to be painted.
2. Drill handle holes:
  - a. Take 2 of the 4 handle sides and drill out of the two small holes near the bottom with the 1/8-inch drill bit.
3. Tap the lid and cam:
  - a. Place Cam in box lid with engraved face facing up.
  - b. Use a corner of a table or other device to ensure cam and lid are at a 90-degree angle.



- c. While holding both pieces tightly together drill straight down through the lid into the cam about 1/2 inch using the #47 drill bit (Avoid drilling though side of cam).

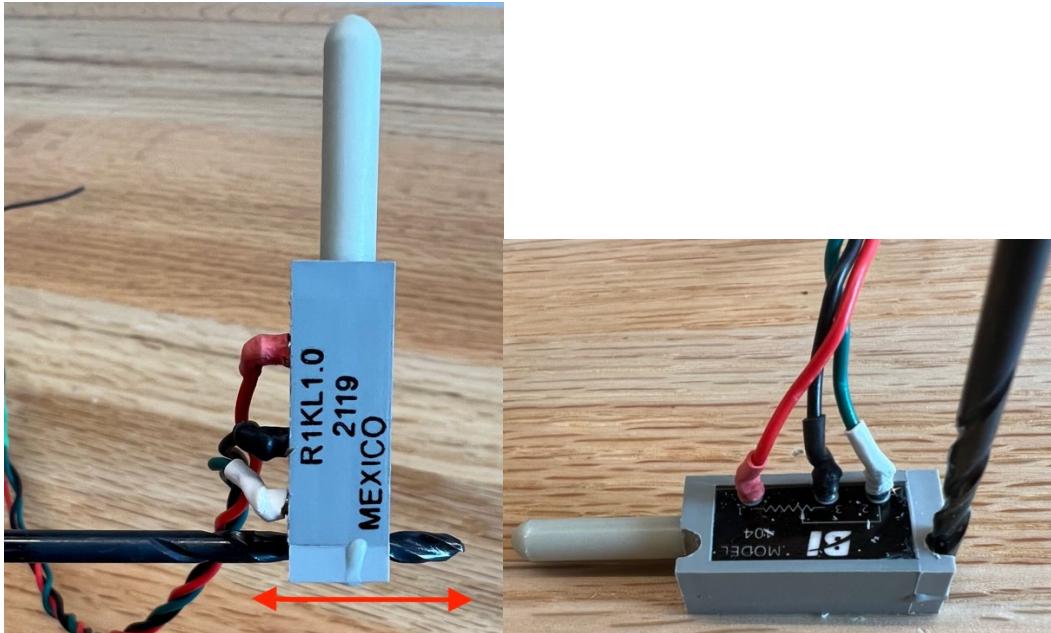


- d. With the pieces still tightly together, tap the hole that was just drilled with the 3-48 tap.
4. Tap the remaining holes:
  - a. Put the 4-40 tap in the drill.
  - b. Slowly tap all the remaining holes on the engraved pieces with the 4-40 tap, the holes that should be tapped with the 4-40 are slightly smaller than the tap itself (Do not tap the hole previous drilled out and taped with the 3-48 tap).
  - c. Using a razor blade or knife, cut any lips that may have formed around the holes from the drilling/tapping process, any pools of melted plastic from laser cutter, or any lips that may have been from incomplete laser cuts.
  - d. Now that the engraved parts have been tapped, they are ready to paint.
5. Paint engraved face of parts according to spray paint directions, multiple coats may need to be applied for best finish.

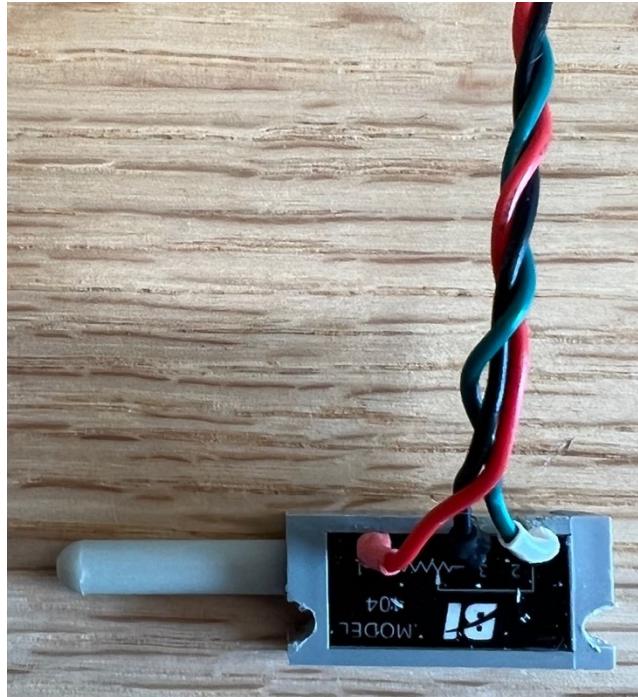
## Side Preassembly

### **Preparation**

1. Tap remaining holes on parts that were not painted using the 4-40 tap, if using drill to tap holes make sure speed is low (Rule of thumb is that if the tap does not fit through the hole, it is meant to be tapped). Cut off any lips or ridges that may have formed around tapped holes.
2. Using the 1/8-inch drill bit, clearance out the linear potentiometer to allow for the 4-40 screws to fit into the mounting grooves. The best way to do this is to have the drill bit spinning in the drill and work the potentiometer's grooves along the length of the bit. Using razor blade clear any extra plastic out and periodically check groove alignment to make sure screws fit in.



3. Solder three wires onto potentiometer for ground, positive, and signal.

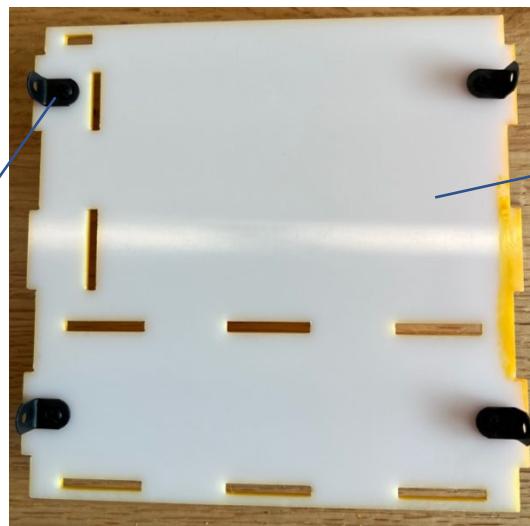


### Front

1. Screw 4 angle brackets into holes on non-painted side of box. NO NOT trim to length.

Angle bracket

Inside of front wall



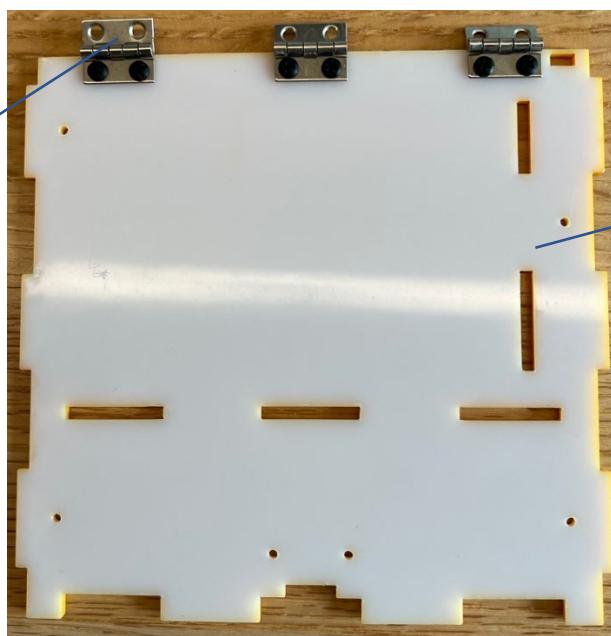
2. This part is complete, set aside and move onto next part.

## Back

1. Screw in hinges along upper edge of part, trim screws so that they are flush with painted side of part.

Hinge

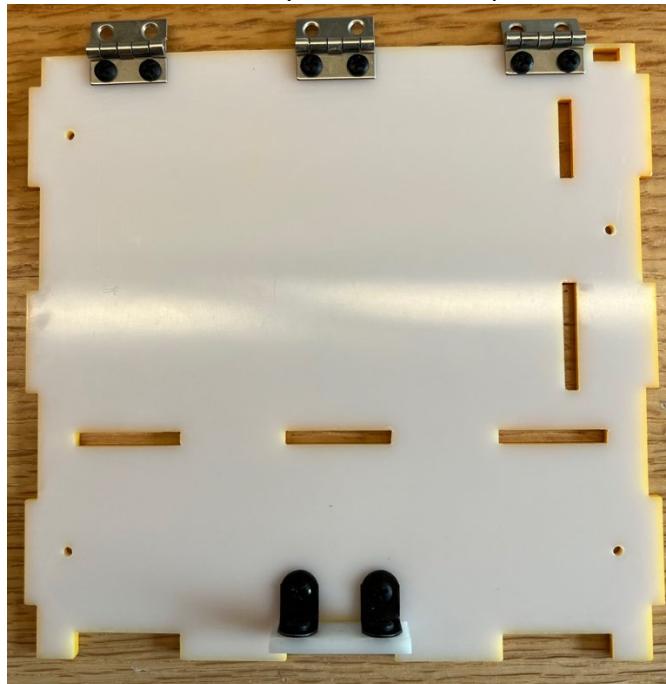
Inside of back wall



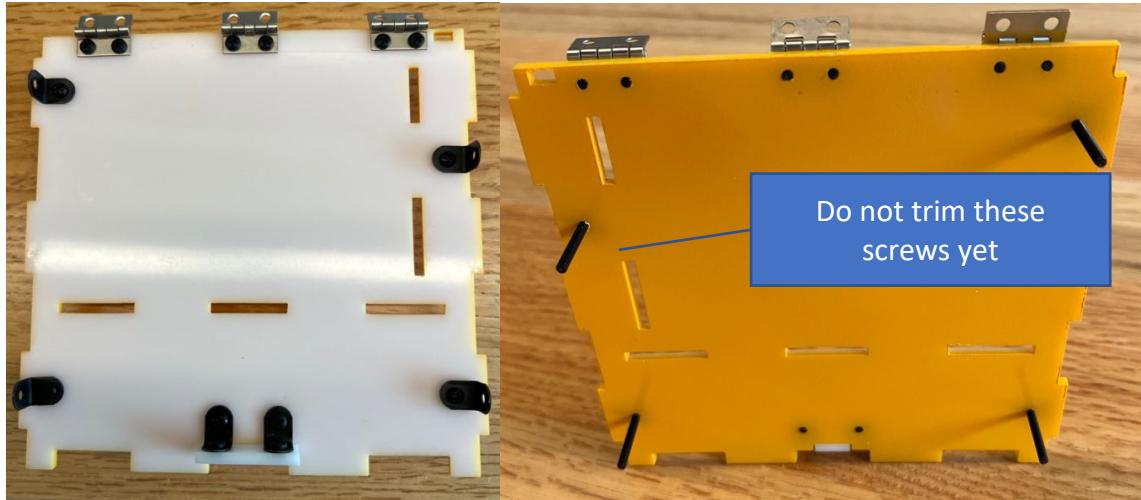
2. Screw in two angle brackets into the bottom mounting plate, trim screws so that they are flush with the bottom of the part.



3. Screw bottom mounting plate to the back, screws in the bottom mounting plate may need to be adjust for holes to align. Once all screws are in, snug them up with screwdriver. Trim screws so that they are flush with painted side of box.



4. Install 4 angle brackets in remaining holes on box, DO NOT trim screws to length as they may need to be adjusted later in the assembly process.



5. This part is complete, set aside and move onto next piece.

### Right Side

1. Using 1/2-inch drill bit, counter sink large hole to accommodate magnetic reed switch. To counter sink, run the drill in reverse. NO NOT run drill in forward, the goal is to shave off some plastic, not drill through part.

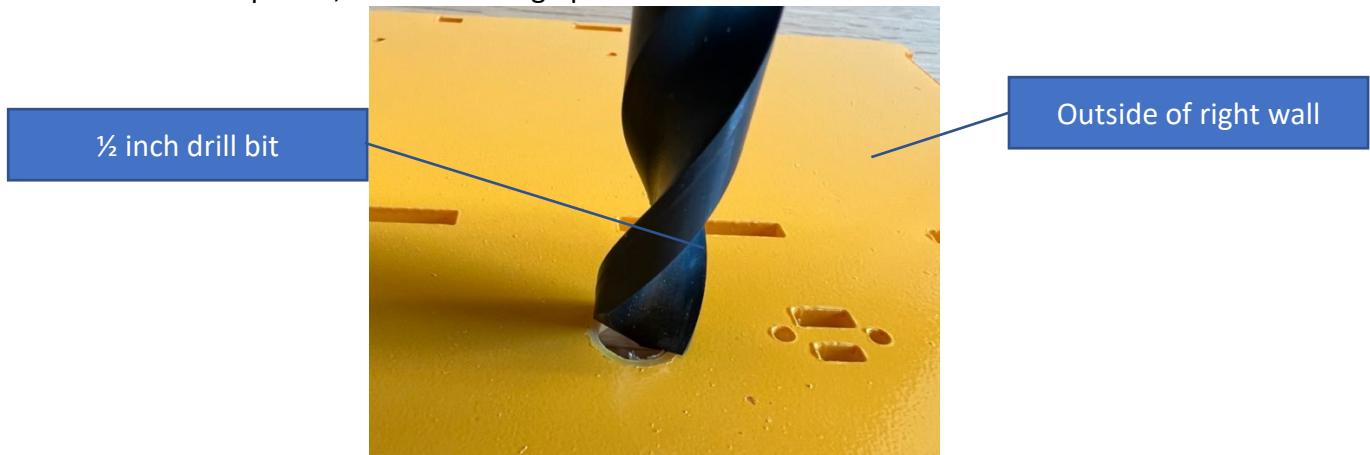
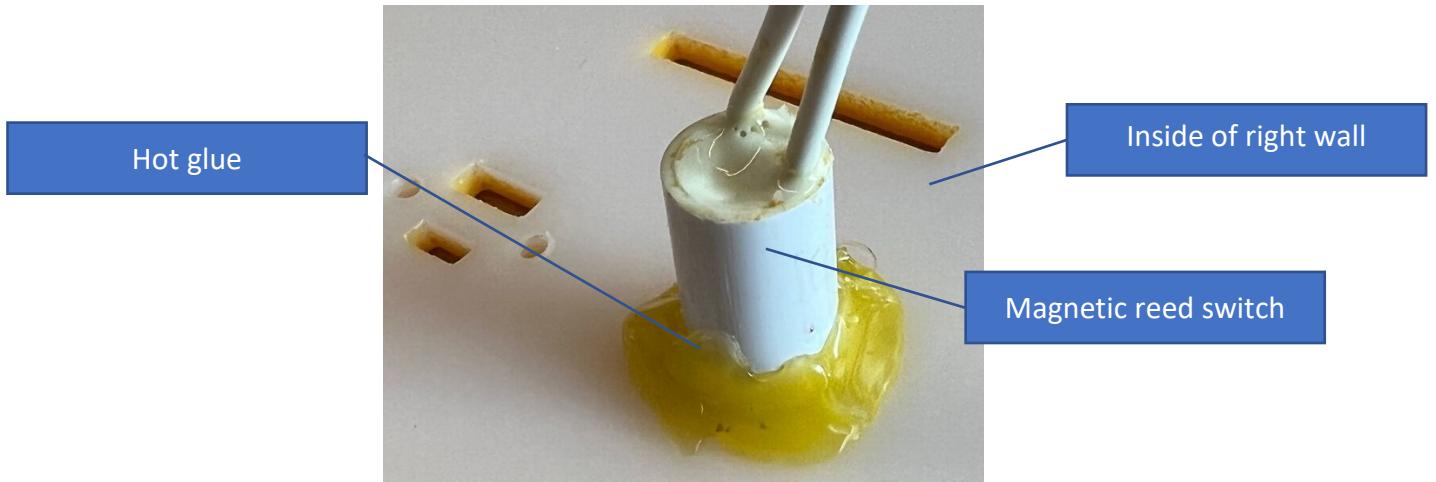


Figure 1: Countersinking Operation

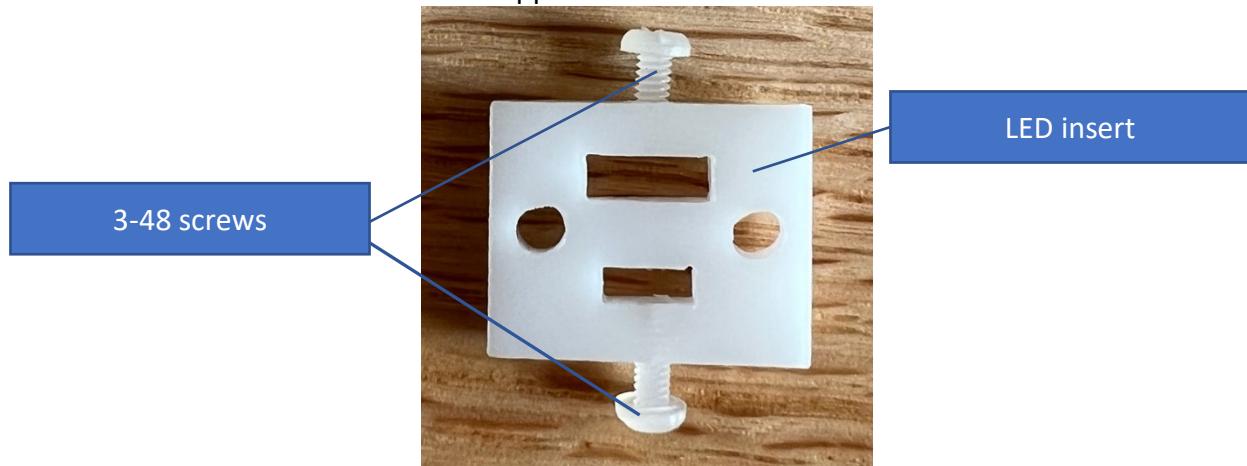
2. Insert magnetic reed switch into box so that the wires are on the non-painted side.
3. Ensure that the magnetic reed switch sits flush with painted side of box. If it does not, counter side some more.
4. Once the magnetic reed switch sits flush, hot glue in place by putting a bead of glue around the switch on inside of box.



- Using the #47 drill bit, drill one hole on each edge of LED insert. Make sure the holes are drilled as close to the center of the edge as possible. Then, tap drilled holes using 3-48 tap. The two red circles in the picture below show the location of the holes that need to be drilled.

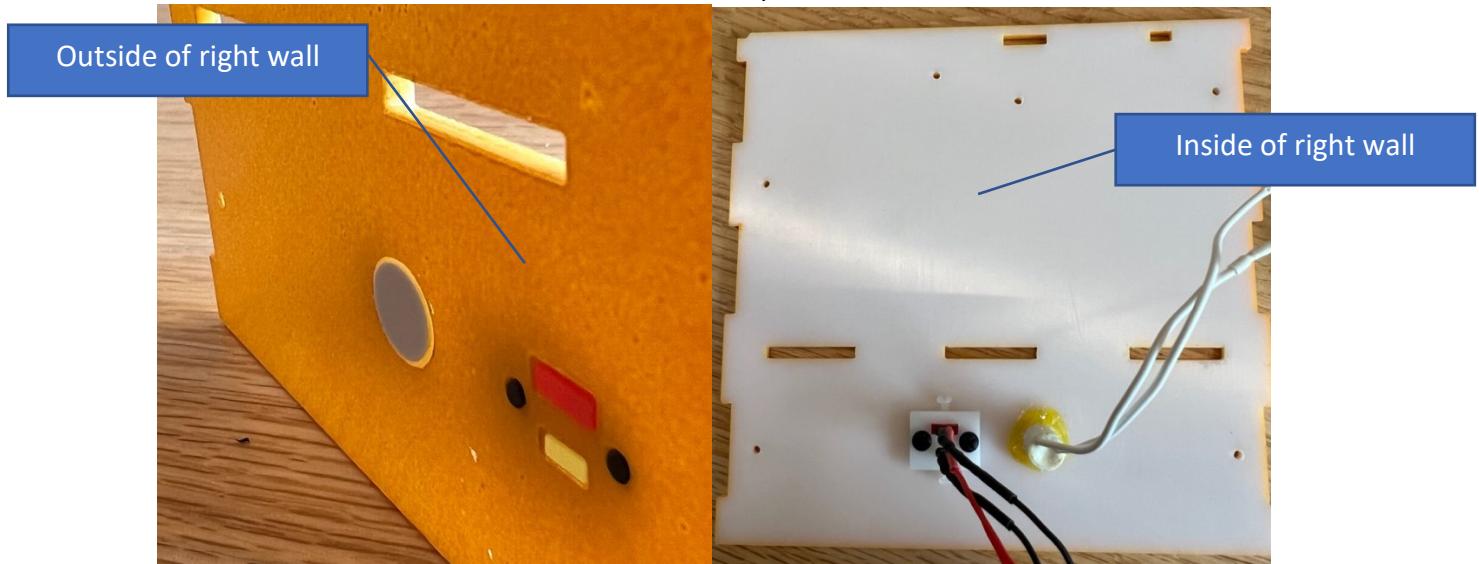


- Screw two 3-48 screws into tapped holes on LED insert.

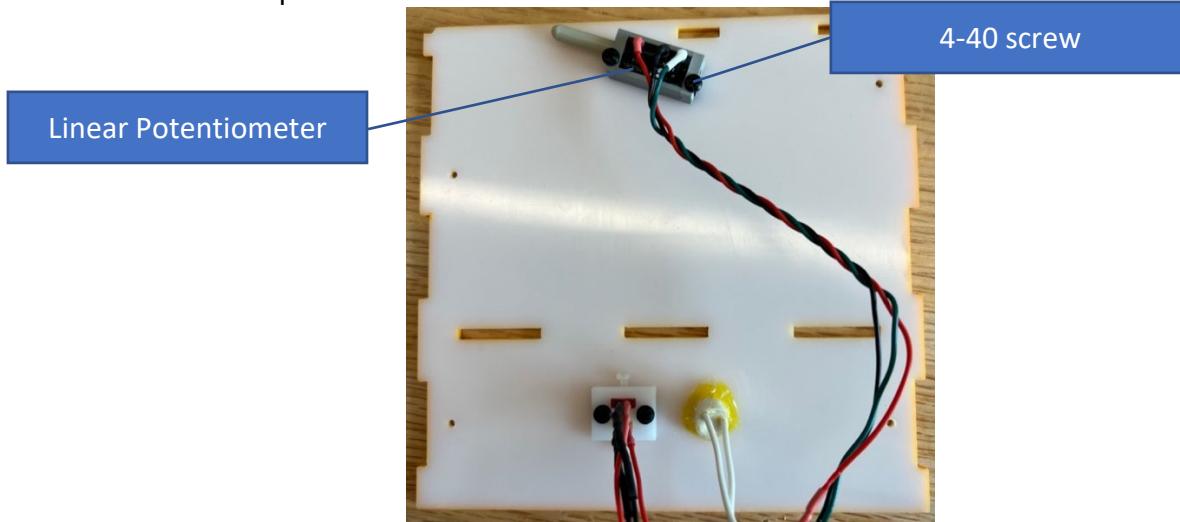


- Align the rectangles of the LED insert with the rectangles on the right-side piece. The rectangles are located next to the magnetic reed switch. Screw LED insert into place using 4-40 screws and cut them so they are flush with painted side of box.

- Insert LEDs into the rectangles and make sure they are flush with outside of box. Tighten the 3-48 screws so that the LEDs are held in place.



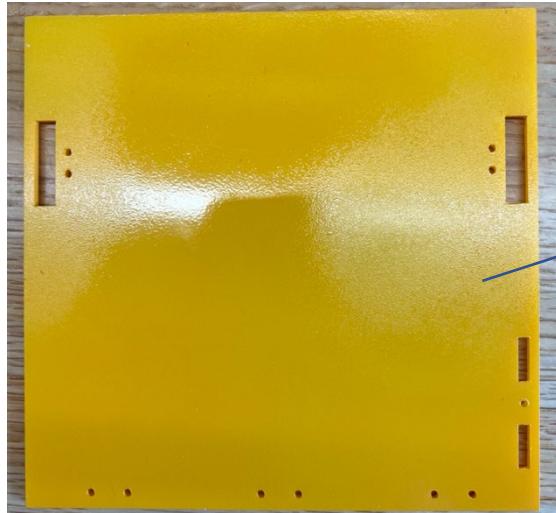
- Screw linear potentiometer into place using 4-40 screws. Trim screws so that they are flush with painted side of box.



- This part is complete, set aside and move onto next part.

## Top

- Orient the box as shown in the picture below. This is the inside, non-engraved box top. Both the outside and inside of the top are painted. The six holes along the bottom is where the top attaches to the back of the box.



Inside of box Lid

2. Next will be assembling the handles:

- Cut the dowel to  $5 \frac{1}{4}$  inches long.
- Screw the handle sides together using the 4-40 screws. Note that each handle side should have one piece that is clearance with the 1/8-inch drill bit and the other piece should be tapped. The non-painted/non-engraved sides should be touching each other. Cut screws so that they are flush with handle face.

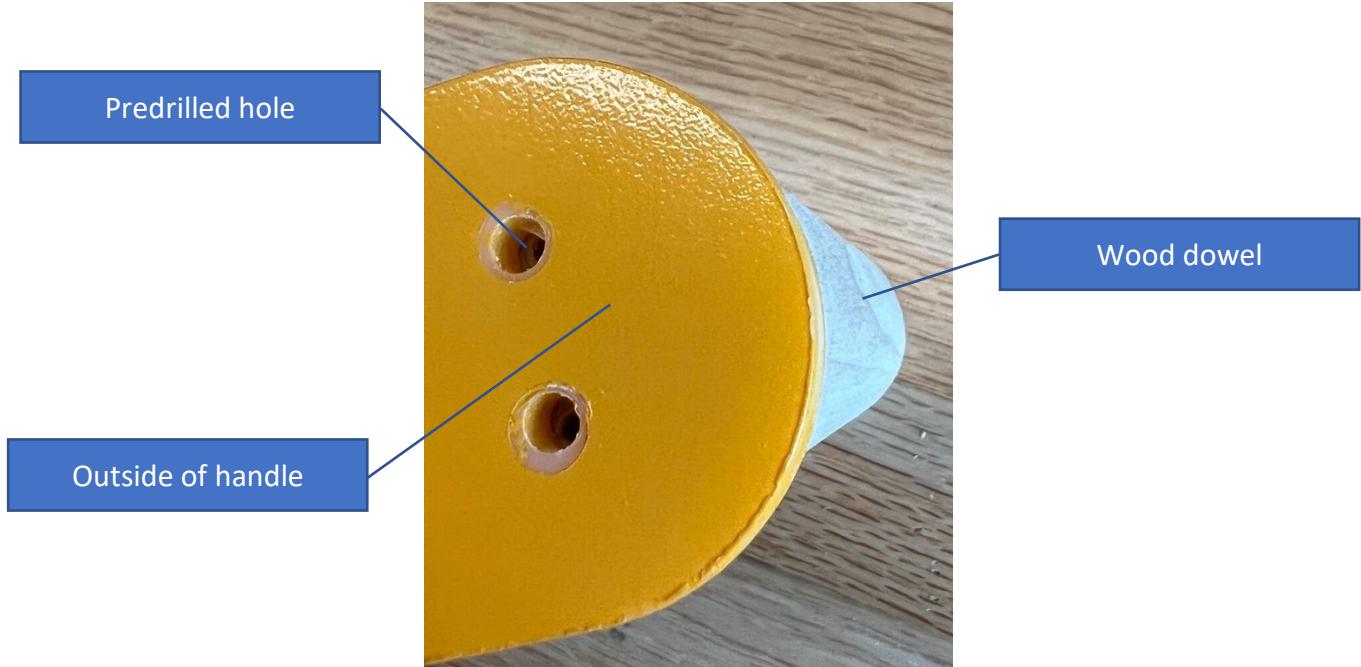


Outside of handle

Inside of handle

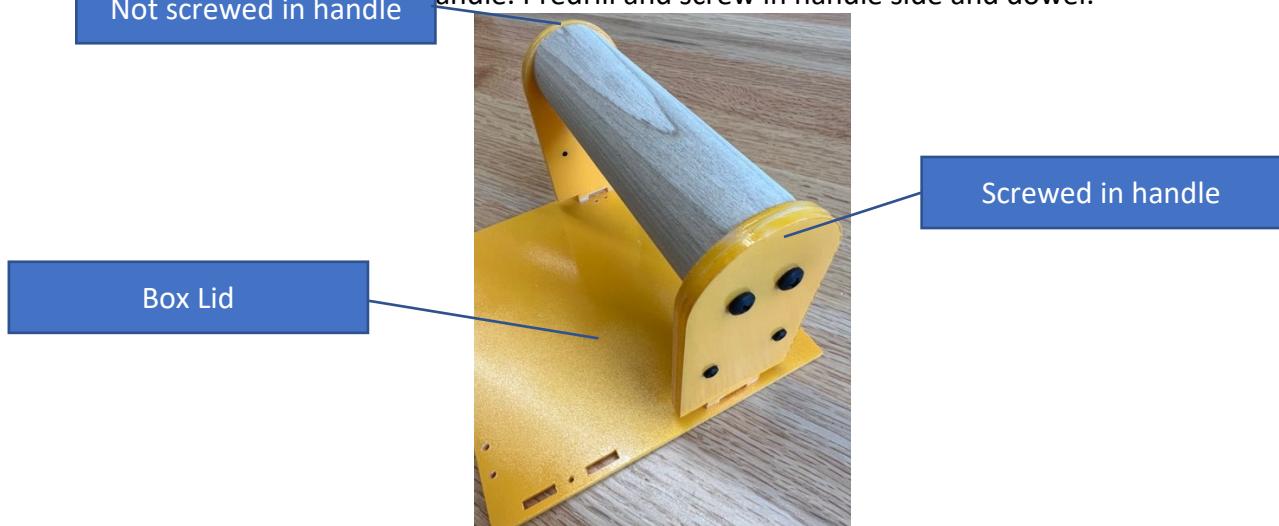
4-40 screw

- With the correct sized predrill drill bit (this will depend on what screw is being used) in the drill, line the dowel up so the top of the dowel is flush with the top of one handle side. Predrill hole if dowel and handle alignment look good.



- d. Once predrilled, put in screws to hold the handle and dowel together.
- e. With the box lid flat on a table, put both the handle sides into the lid. The dowel should be between the two handles. Now, align the handle side that has not been screwed in with the dowel, ensuring that the top of the dowel is flush with

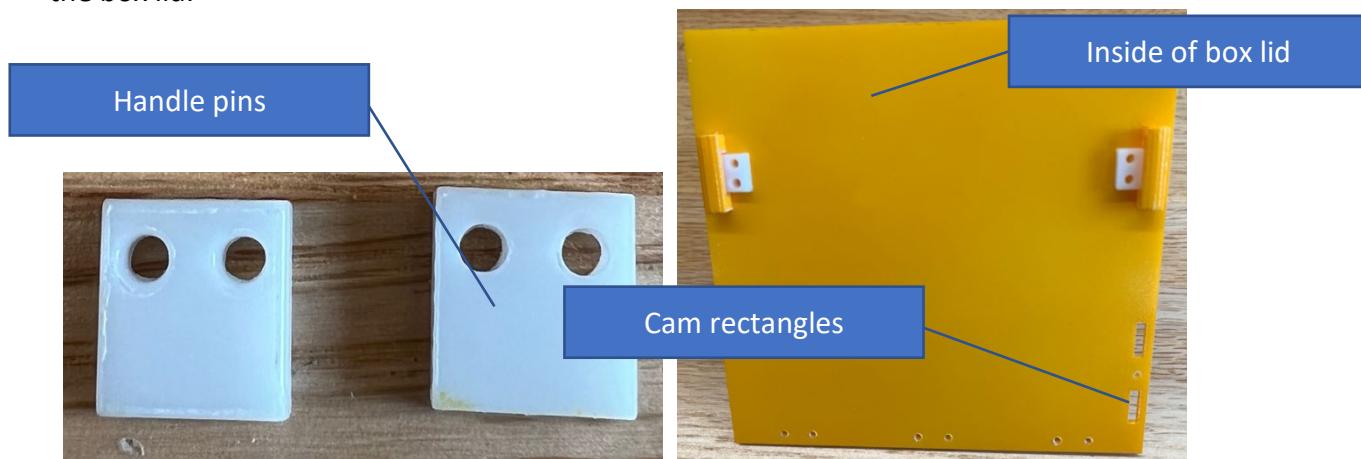
**Not screwed in handle** handle. Predrill and screw in handle side and dowel.



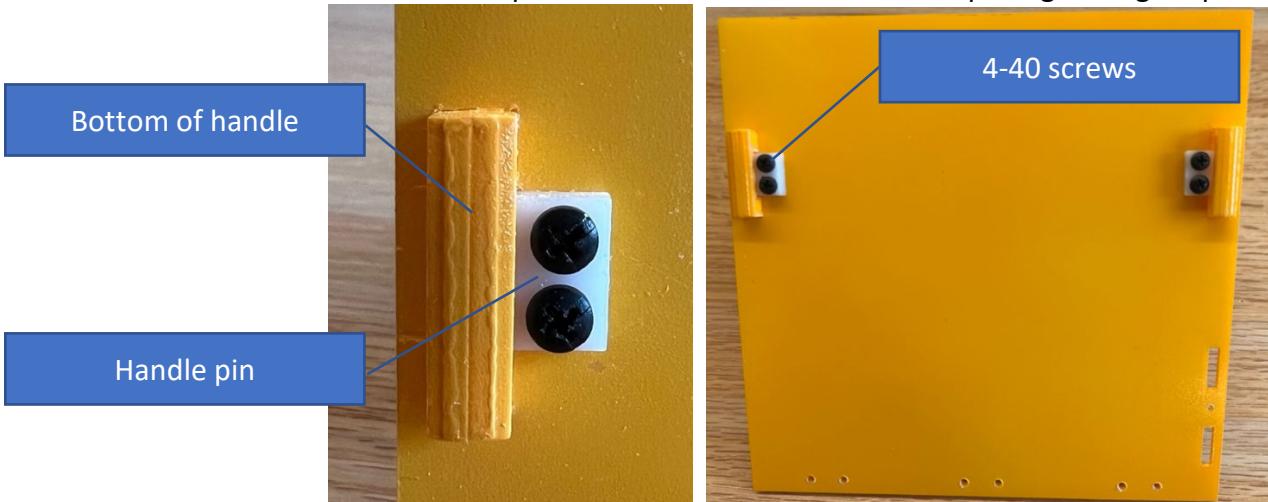
- f. Remove completed handle from top of lid.



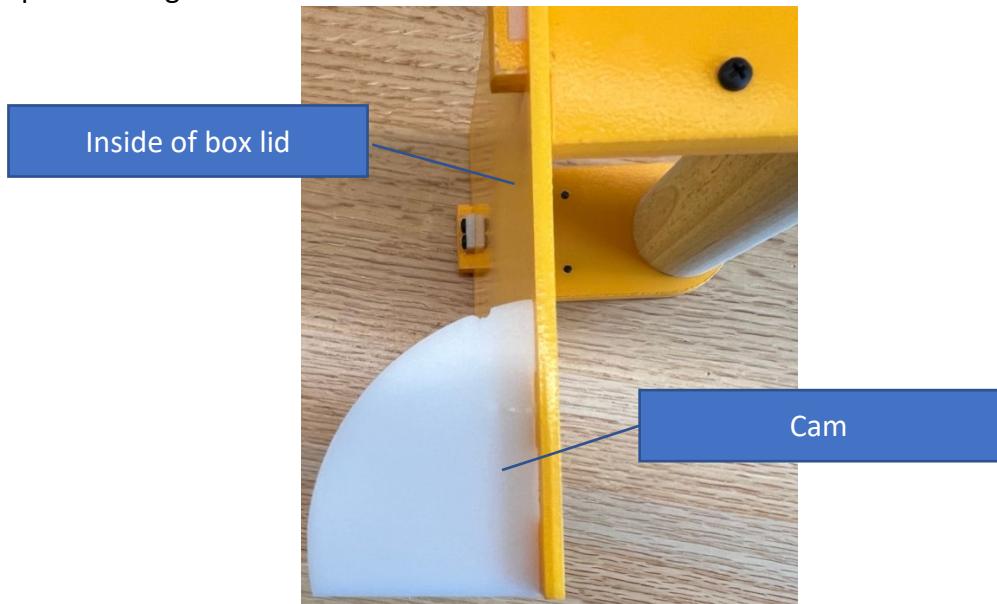
- Push the rectangles on the bottom of the handle all the way through the box lid so that they poke through. Insert the one pin into each of the rectangles on the handles. Make sure that rectangles for the cam are in the bottom right corner when looking inside of the box lid.



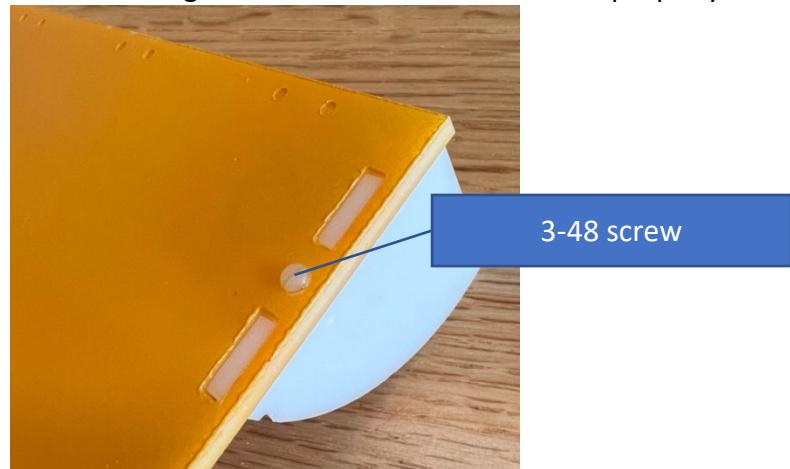
- Screw the handle pins into the lid. Cut excess screws poking through top side of lid.



5. Place the cam into lid so the cam itself is on the same side as the handle bottoms that poke through the lid.



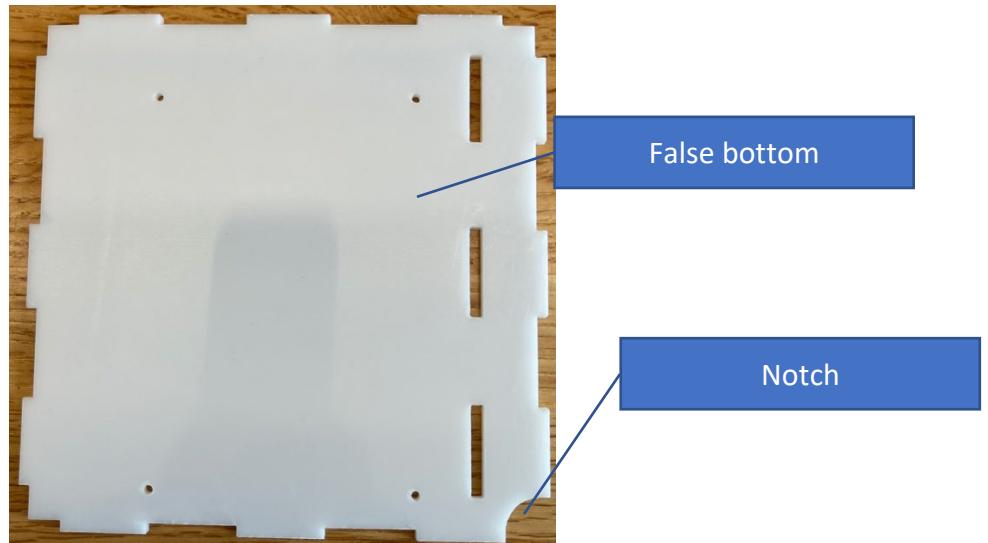
6. Using a 3-48 screw, screw them together. Make sure cam is seated properly in lid.



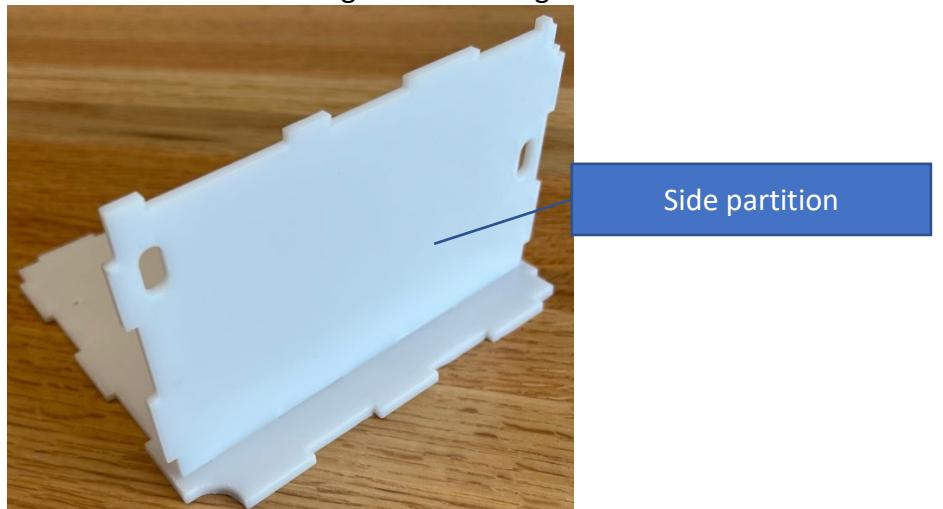
7. Set this subassembly aside and move onto next step.

## Final Assembly

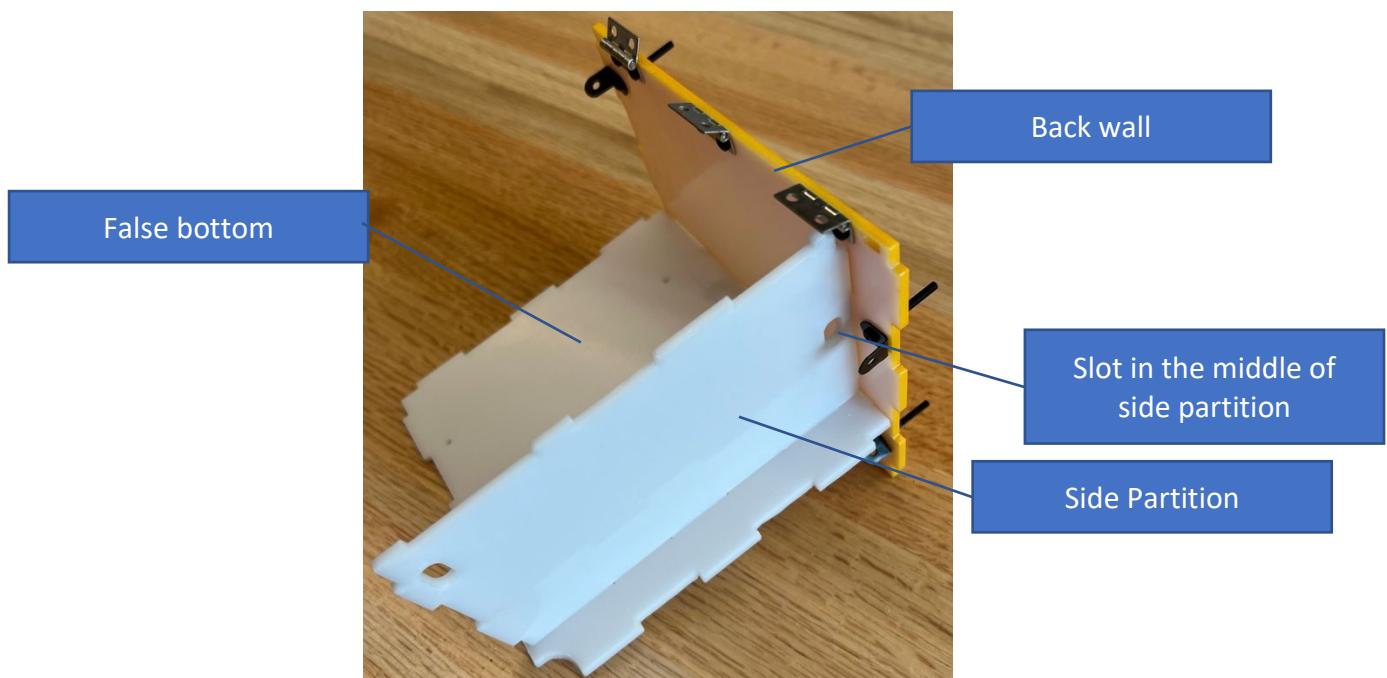
1. Orient the false bottom so that the corn with the corner with the notch is in the lower right.



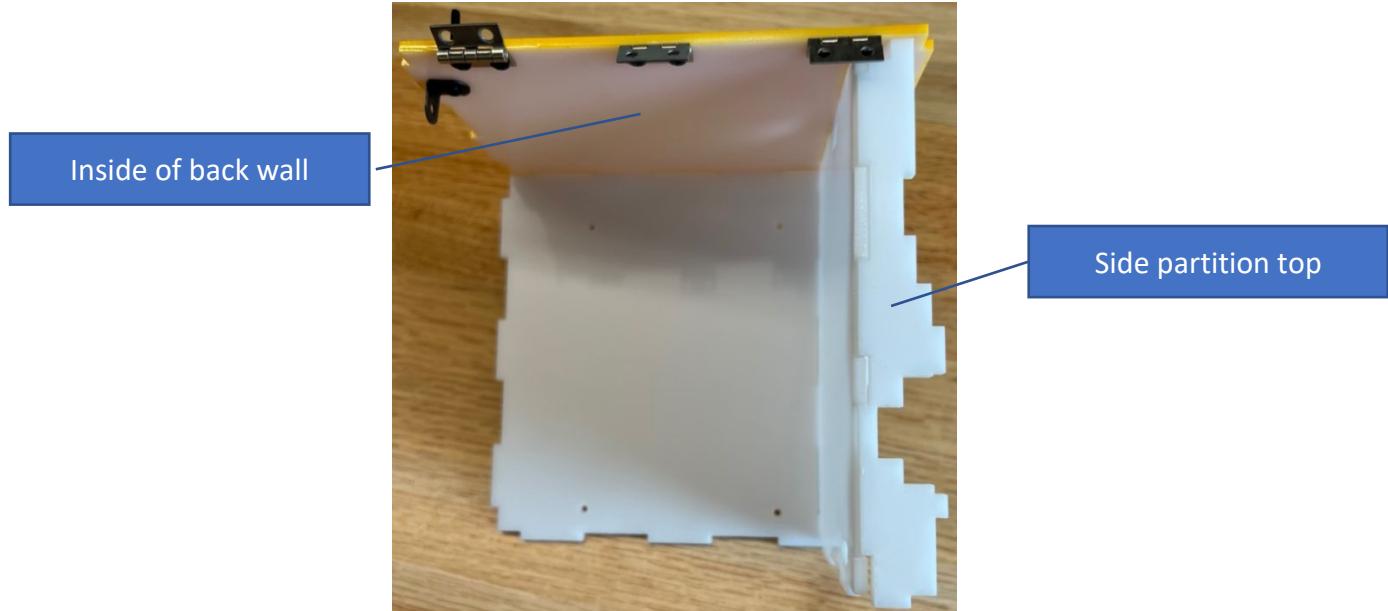
2. Place the side partition into the three rectangles near the right side of the false bottom.



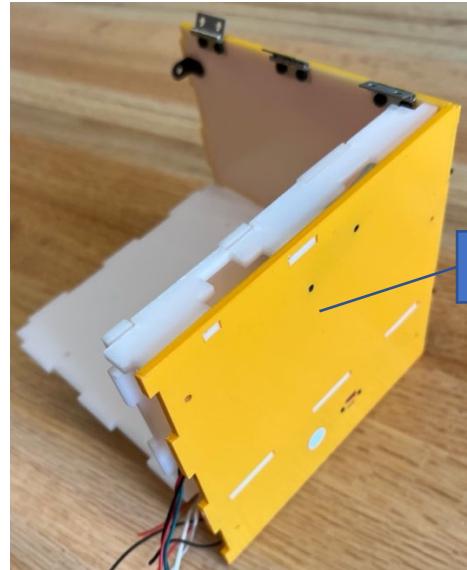
3. Put the false bottom with the side partition on it into the back of wall of the box, with the painted side facing out. Make sure the slot in the middle is near the back wall.



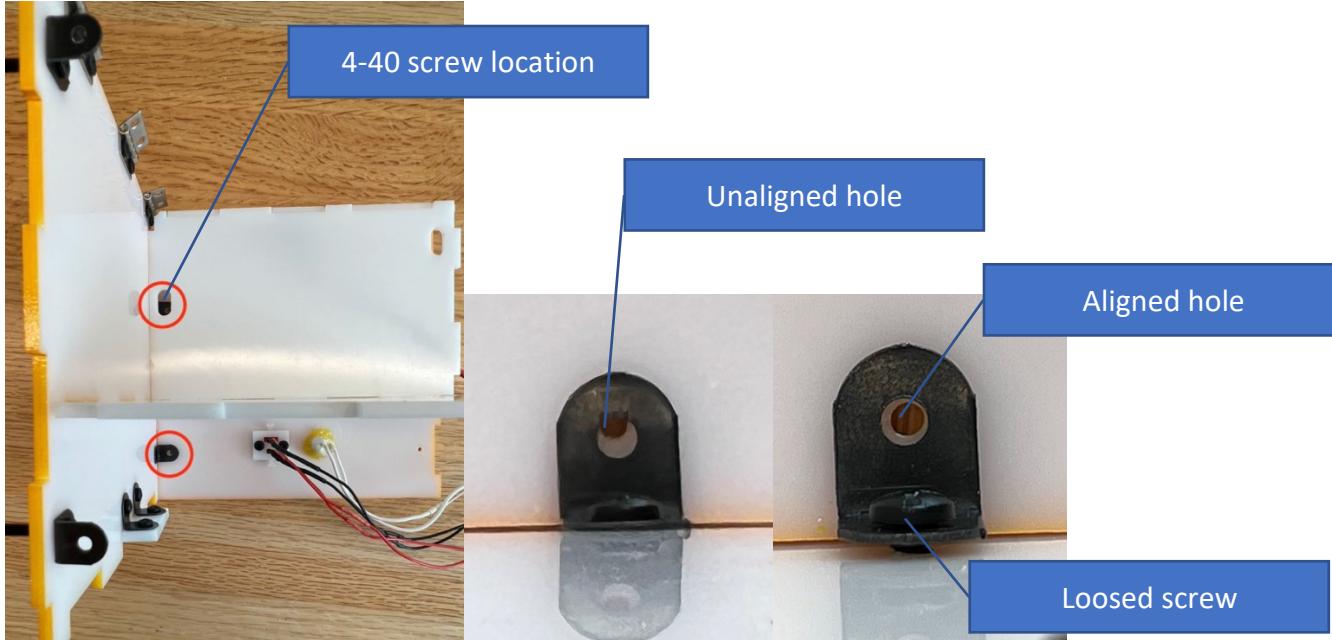
4. Place the side partition top into the back and side partition.



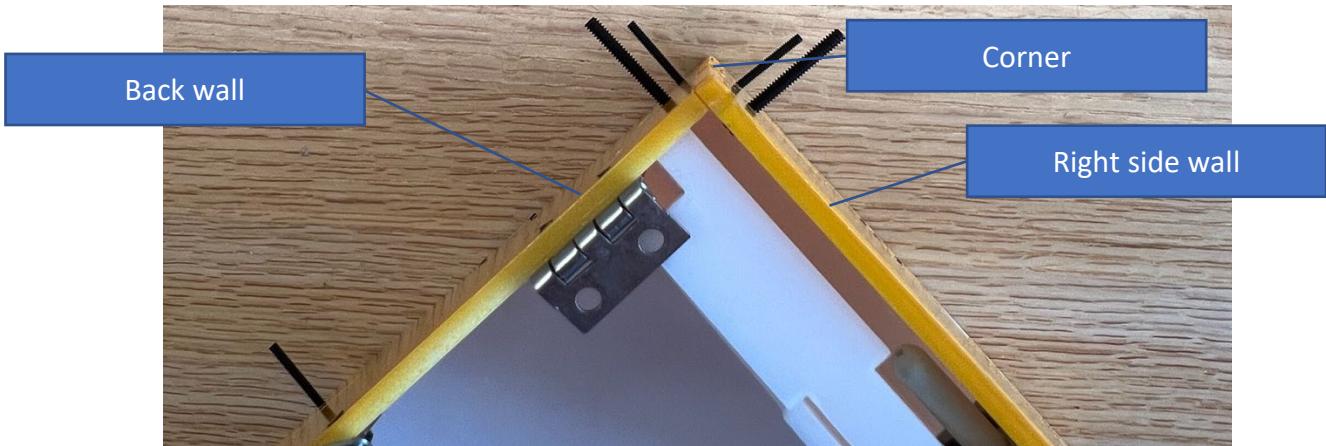
5. Take the right-side wall and attach it to the false bottom, side partition top, and back wall. The rectangles might need to be aligned properly so that it fit into place.



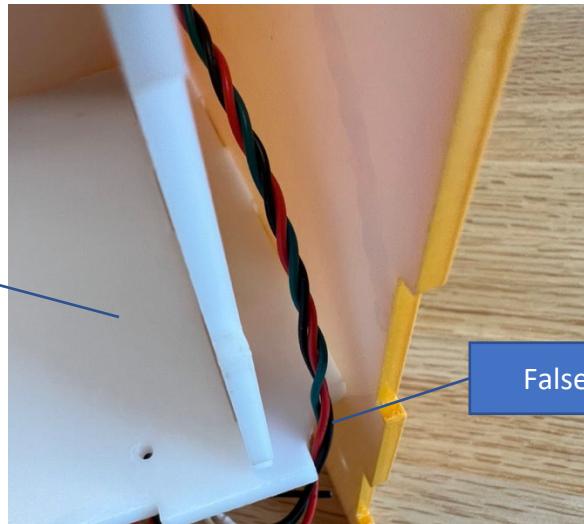
6. Line the brackets up with the holes by spinning the screws sticking through the outside of the box. Screw the brackets and the sides together.



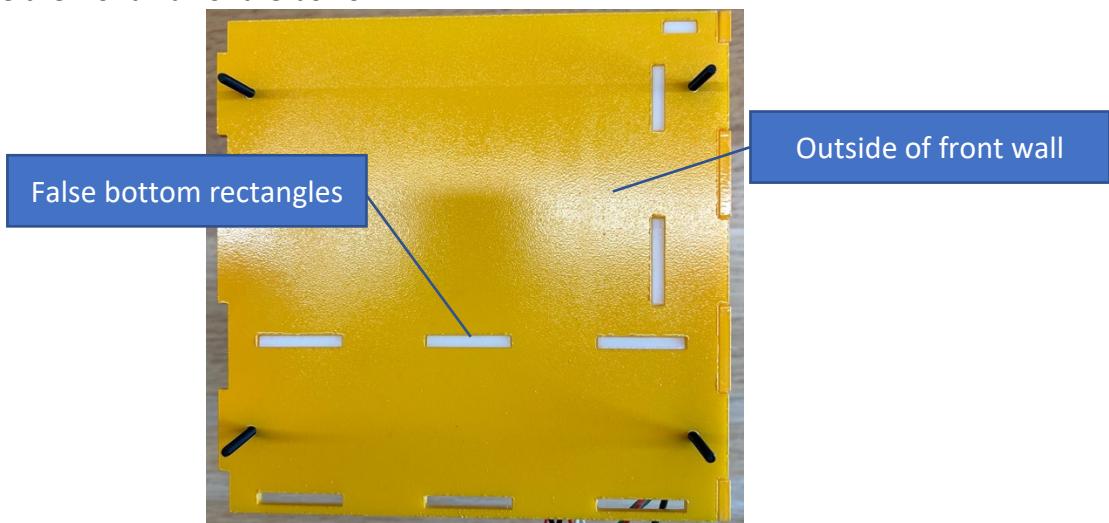
7. Tighten down all 4 of the bolts that hold the corner together. They can be finger tight. Trim screws on that finished corner so that they are flush with painted face.



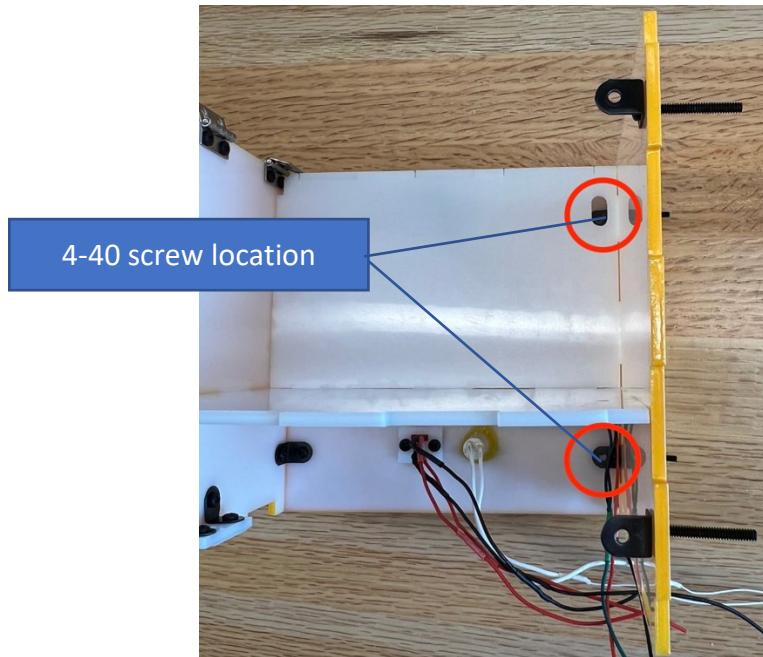
8. Move the wires coming from the potentiometer on the right-side wall so that they are in the notch of the false bottom.



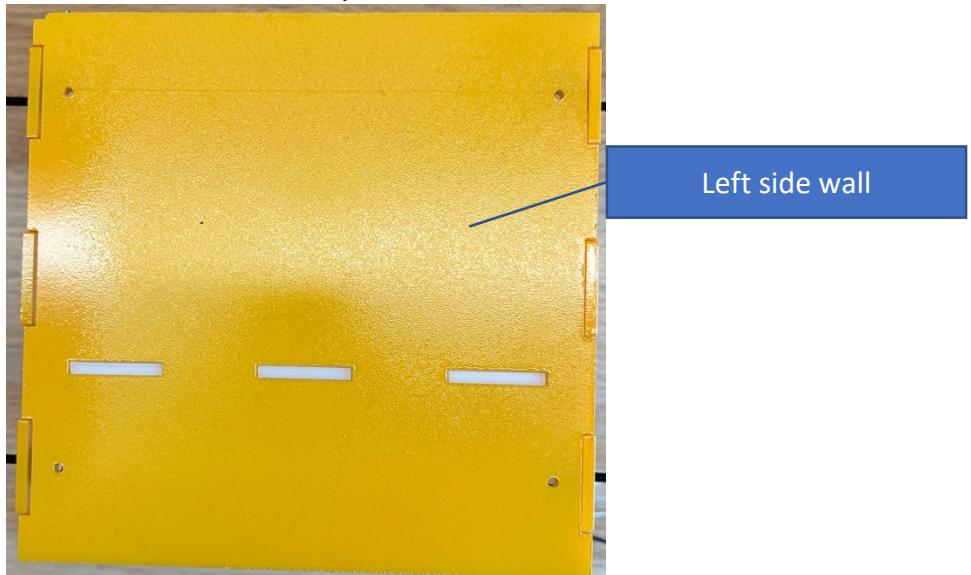
9. Place the front wall of the box on.



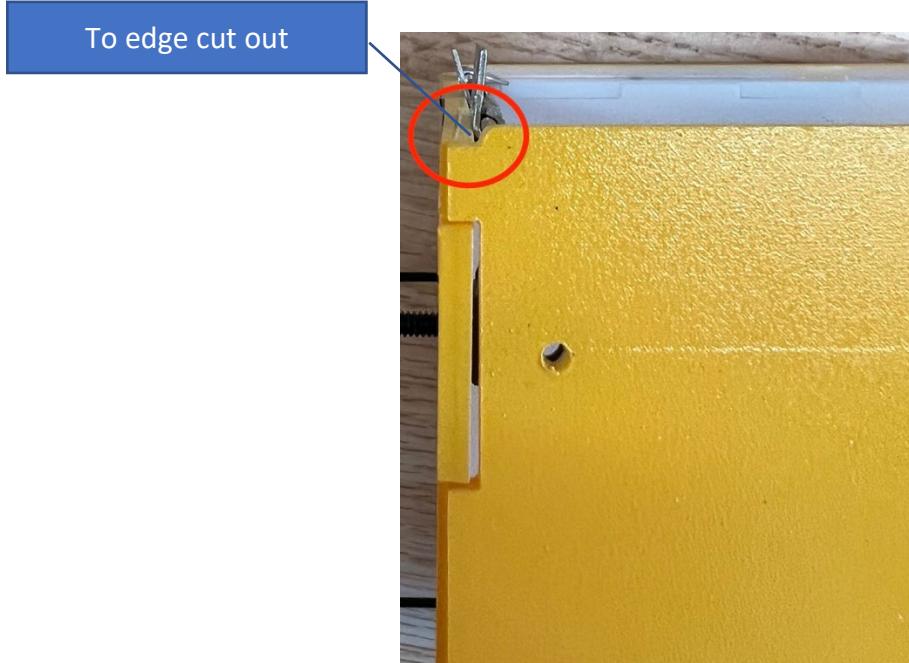
10. Align screw holes and screw right side and front wall together using the angle brackets.



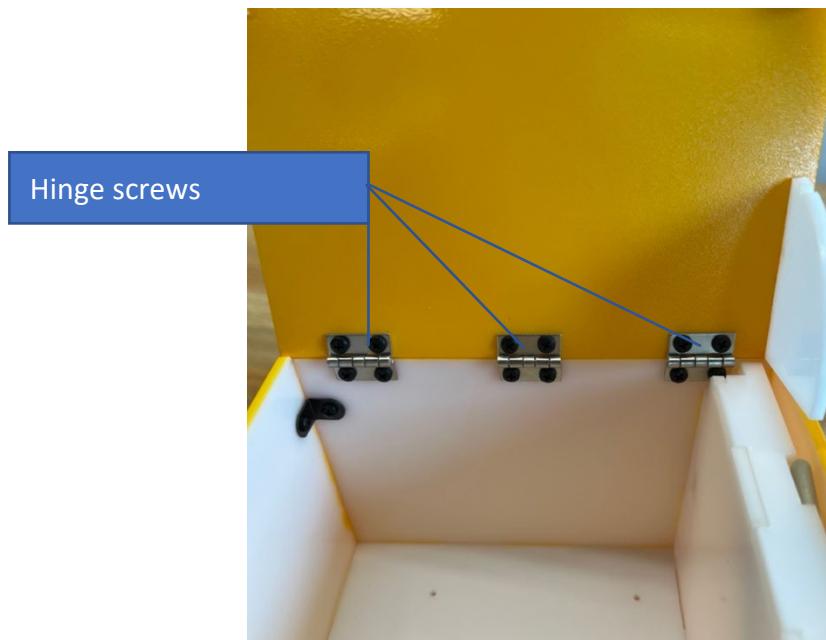
11. Tighten screws to align corner, then trim so they are flush with painted face.
12. Place the left side of the box onto the assembly.



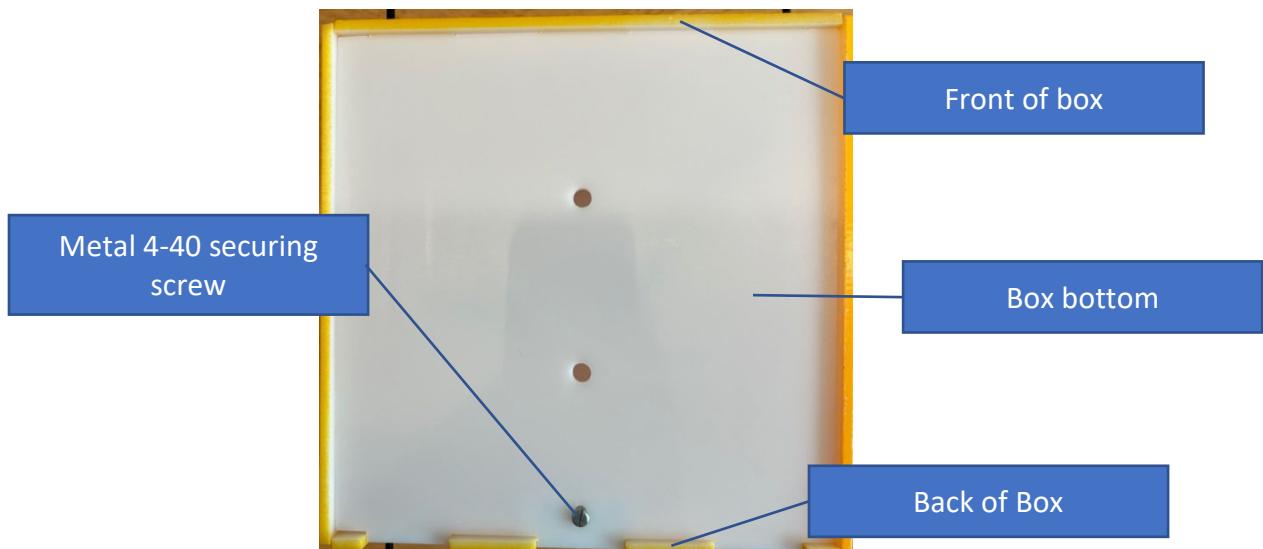
13. If the box is unpainted, make sure that corner of the left side wall that has the cut out in it is alone the edge with the hinges.



14. Screw the wall to the rest of the box assembly. Trim screws to length.
15. Screw the lid of the box into the hinges. Once all 6 screws are in, loosen them so the lid and move around a little bit. Hold the lid so it is open 90 degrees and tighten screws back down.



16. To install the bottom of the box, slide the protruding pieces on the opposite of the small slot into the inside of the front wall. Once in, push down on the small slot. This is very similar how the battery compartment door works on a TV remote. Using a metal 4-40 screw the bottom into the box using the small slot.



17. The box is now complete. Note that the screws have not been trimmed on this box so they can be reused to make the other boxes.



# Slider Box

## Equipment and Materials

### Materials

- 2 sheets of 24" x 12" x 1/8" of white Delrin (McMaster Carr [8573K33](#))
- 1 Package of 4-40 x 1" plastic screws (McMaster Carr [94735A725](#))
- 1 Rotary Potentiometers (Mouser [RK09D1130C1B](#))
- 1 Linear Potentiometer (Digikey [404R1KL1.0](#))
- Magnetic Reed Switch (Digikey [54-629](#))
- 12mm x 12 mm L Brackets (Amazon [a19022200ux0403](#))
- National Hardware 3/4" x 5/8" Hinges (Amazon [N211-012](#))
- 3-48 screws (Amazon [9134194](#))
- 4-40 nuts [only need 4 of them] (any source)
- 1.5-inch diameter wood dowel (any source)
- Spray paint, we found that Behr works well (any color)

### Equipment

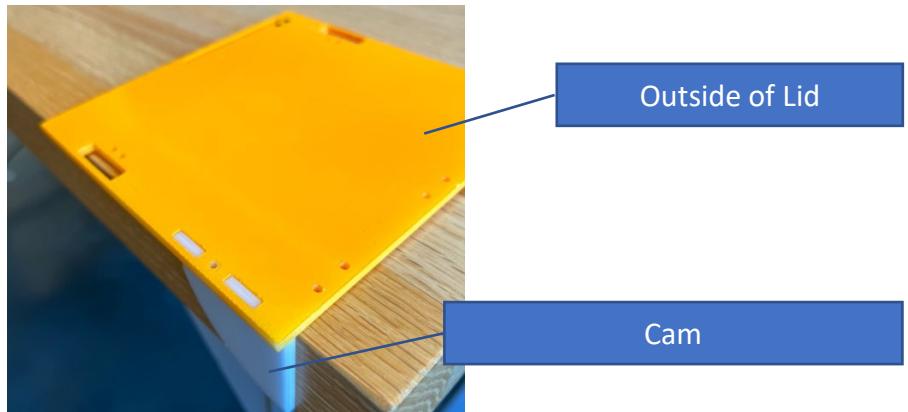
- 12" x 24" laser cutter or bigger
- Assortment of small screw drivers
- 4-40 tap
- 3-48 tap
- 1/4-20 tap
- #43 drill bit for 4-40 tap
- #47 drill bit for 3-48 tap
- 1/8-inch drill bit
- 1/2-inch drill bit
- Hand drill
- Wood saw (hand saw or chop saw)
- Razor blades and/or knife
- Hot glue Gun

## Laser Cutting

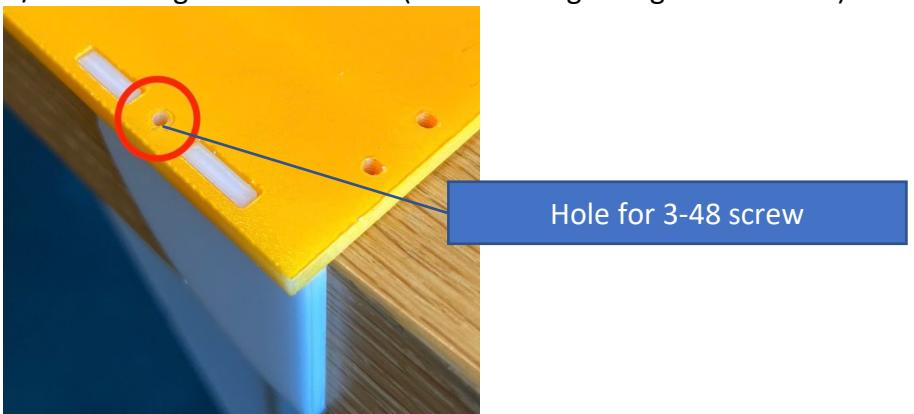
1. Upload the SolidWorks eDrawing files to the laser cutting software.
2. For the engraving parts, make sure engraving power is not set too high as this can warp the plastic sheet. Vector cut the finished engraved parts after engraving is complete.
3. For the non-engraved parts, **only** run the vector setting **only**.
4. For vector settings for both post engraved pieces and vector only pieces, we have found it best to do multiple passes on medium power (50-65%) to avoid warping the material
5. Make sure it is at a 1:1 scale and run the program.
6. After the laser cut is complete, take out any plastic pieces inside parts left over by the laser cutting process.
7. Wipe down with damp cloth to take off any dust from the laser cutting process.

## Painting Preparation and Painting

1. The engraving improves the adhesion of the spray paint, so only the engraved surfaces are meant to be painted.
2. Drill handle holes:
  - a. Take 2 of the 4 handle sides and drill out of the two small holes near the bottom with the 1/8-inch drill bit.
3. Tap the lid and cam:
  - a. Place Cam in box lid with engraved face facing up.
  - b. Use a corner of a table or other device to ensure cam and lid are at a 90-degree angle.



- c. While holding both pieces tightly together drill straight down through the lid into the cam about 1/2 inch using the #47 drill bit (Avoid drilling though side of cam).



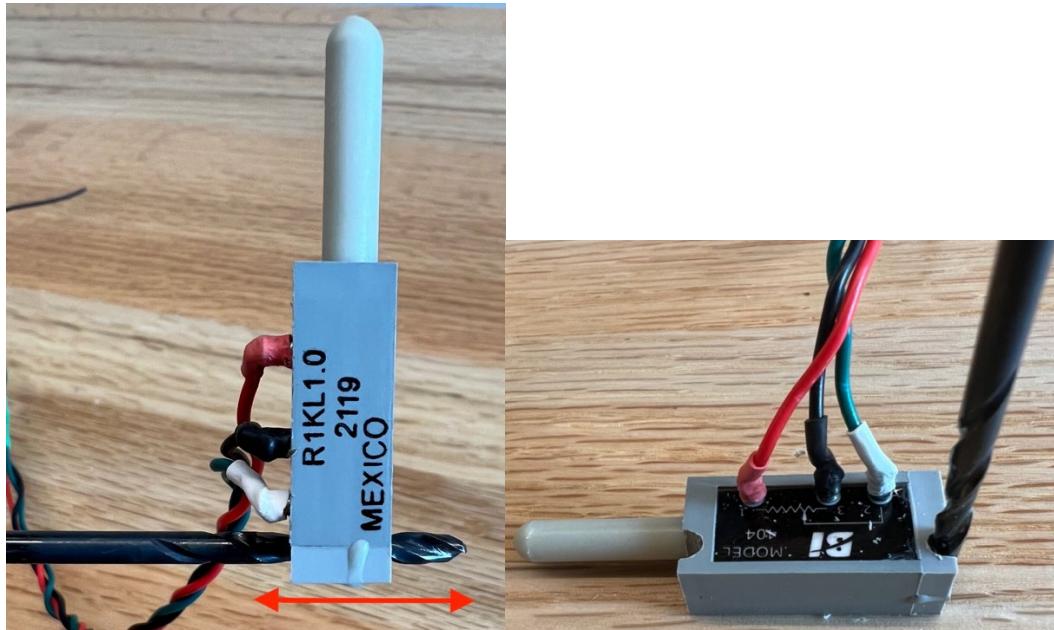
- d. With the pieces still tightly together, tap the hole that was just drilled with the 3-48 tap.
4. Tap the remaining holes:
  - a. Put the 4-40 tap in the drill.
  - b. Slowly tap all the remaining holes on the engraved pieces with the 4-40 tap, the holes that should be tapped with the 4-40 are slightly smaller than the tap itself (Do not tap the hole previous drilled out and taped with the 3-48 tap).
  - c. Using a razor blade or knife, cut any lips that may have formed around the holes from the drilling/tapping process, any pools of melted plastic from laser cutter, or any lips that may have been from incomplete laser cuts.
  - d. Now that the engraved parts have been tapped, they are ready to paint.

5. Paint engraved face of parts according to spray paint directions, multiple coats may need to be applied for best finish.

## Side Preassembly

### Preparation

1. Tap remaining holes on parts that were not painted using the 4-40 tap, if using drill to tap holes make sure speed is low (Rule of thumb is that if the tap does not fit through the hole, it is supposed to be tapped). Cut off any lips or ridges that may have formed around tapped holes.
2. Linear potentiometer preparation
  - a. Using the 1/8-inch drill bit, clearance out the linear potentiometer to allow for the 4-40 screws to fit into the mounting grooves. The best way to do this is to have the drill bit spinning in the drill and work the potentiometer's grooves along the length of the bit. Using razor blade clear any extra plastic out and periodically check groove alignment to make sure screws fit in.



- b. Solder three wires onto potentiometer for ground, positive, and signal.



3. Rotatory potentiometer preparation

- Straighten out sensor terminations so that they do not bend at a 90-degree angle.



- Cut off little knobs on back of potentiometer with razor blade.

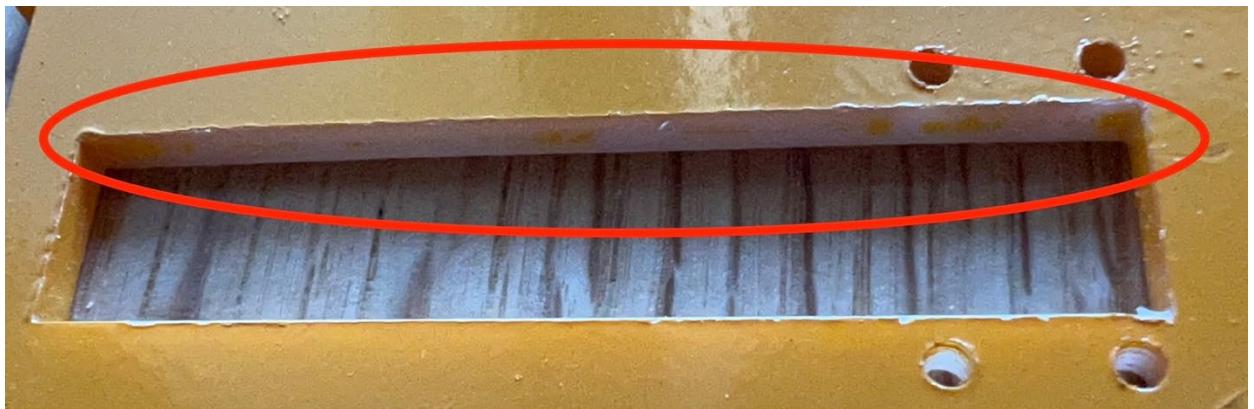


- Solder wires onto potentiometers positive, ground, and data terminals.



## Front

1. Using razor blade or sandpaper, remove paint from inside edge of large rectangle. Do this for both long edges.



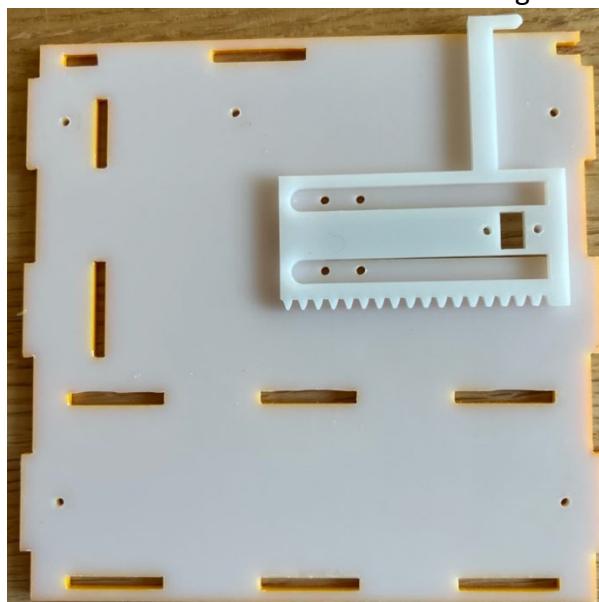
2. Take 4 screws and screw 1 nut onto each all the way to the head of the screw.



3. Put the slot spacer together and put push two screws all the way through it. Using the razor blade, trim the screws so that they are flush with the outside of the slot spacer. Take the screws out and cut an additional 2-3 threads off the end of the screw.



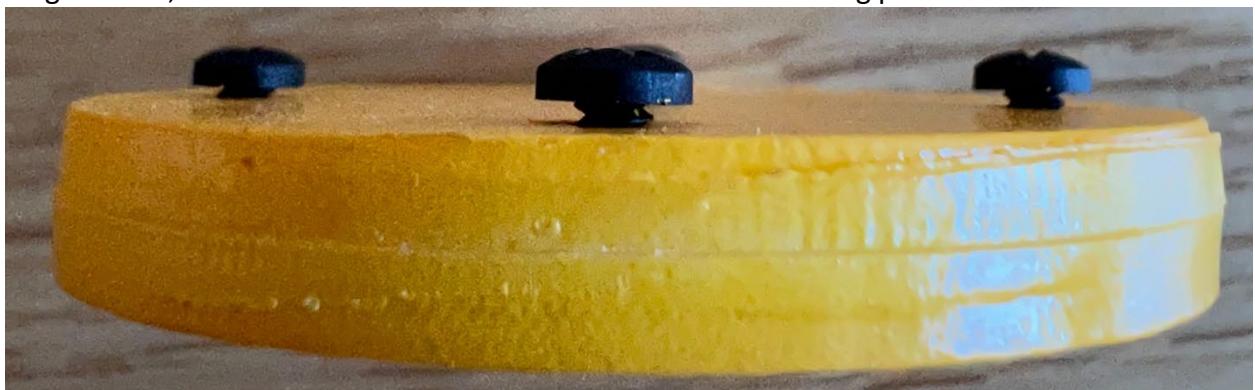
4. With the non-painted side facing up. Place the slider lock onto non-painted side, lining up the slots with the four screw holes near the left of the large rectangle.



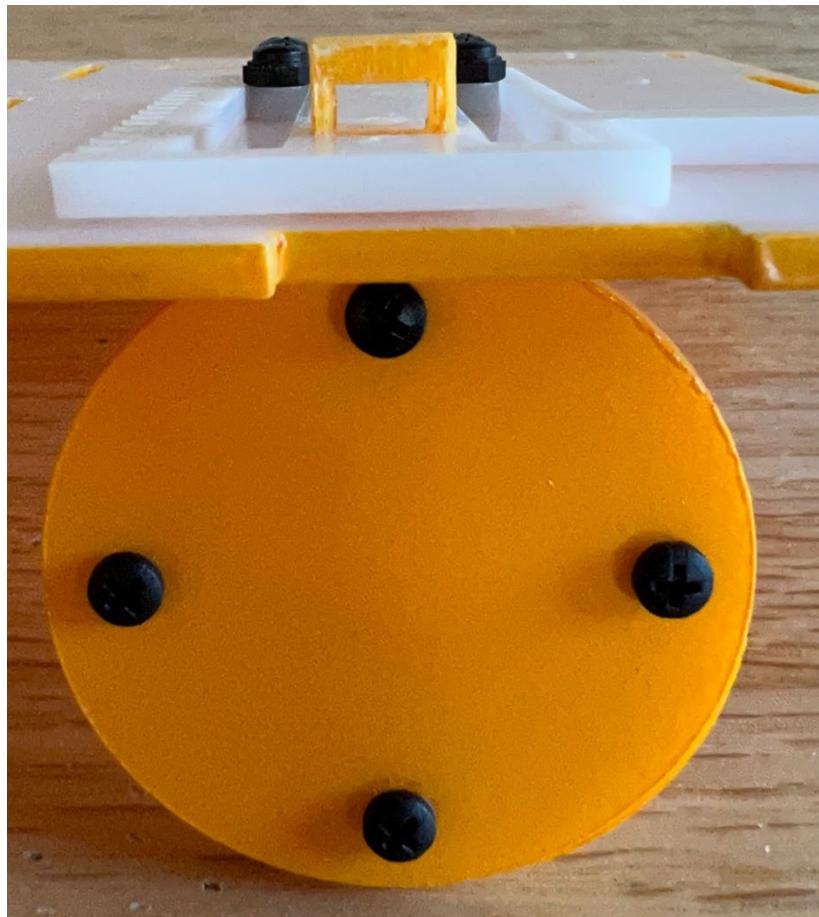
5. Place the slot spacer into slot of the slider lock, lining up the screw holes. Using the screws with the nuts on them, screw the slot spacer to the front. Trip screws to length so that they are flush with painted side of front.



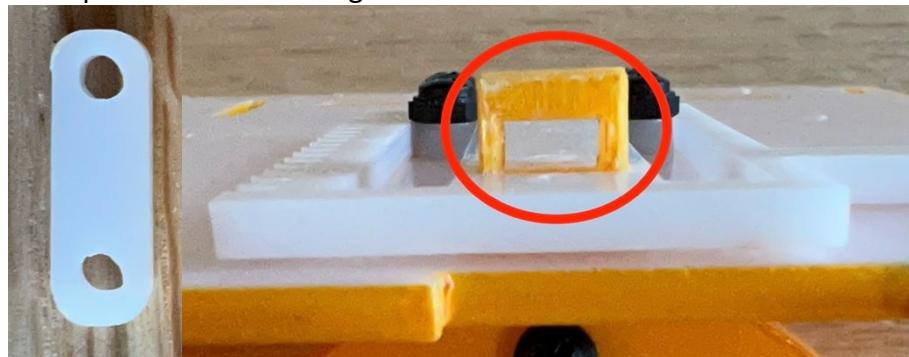
6. Take the slider tabs and place them together, screw them together. Trim screws to length. Then, back screws off so that screw heads are not touching painted face.



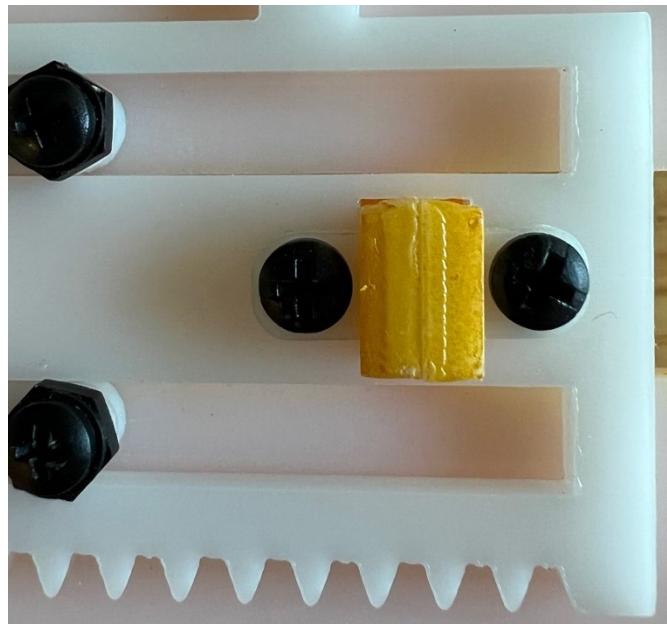
7. Push the arm protruding off the slider tab into the slider lock with the circular part of the slider tab on the painted side of the front of the box.



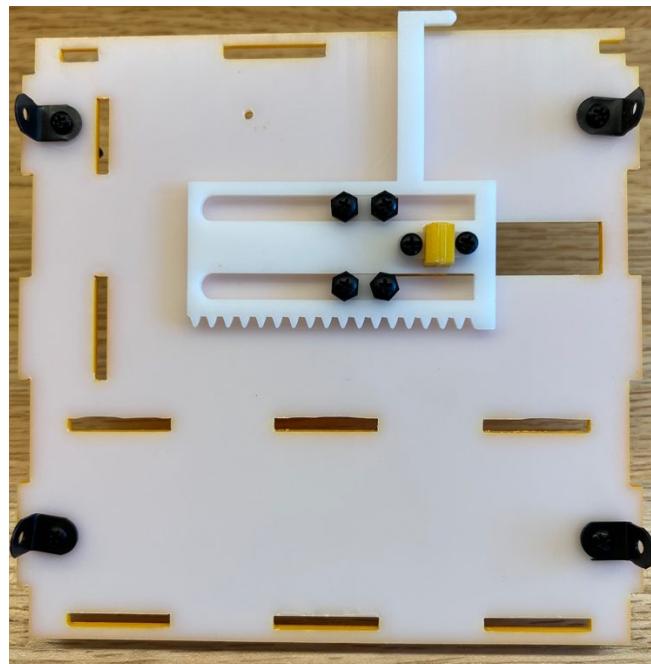
8. Push slider tab pin into small rectangle circled in red below.



9. Using precut screws from step 3, screw slider tab pin into slider lock.



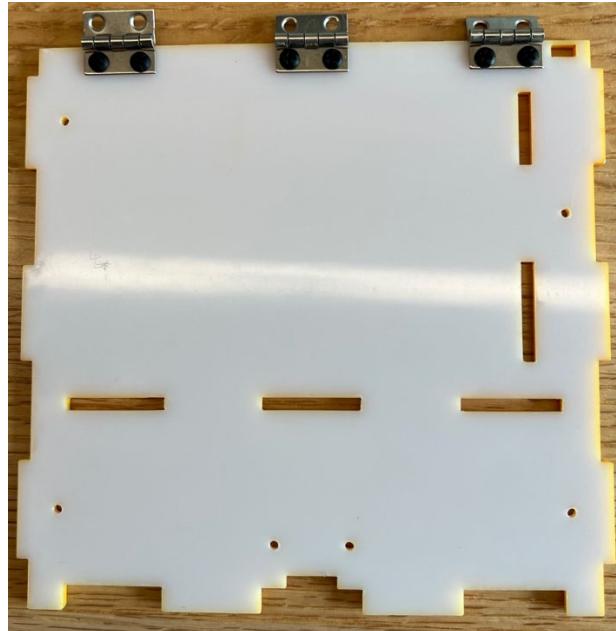
10. Tighten the 4 screws on the painted part of the slider tab.
11. On the non-painted side, screw in 4 angle brackets into holes nears the corners of the front piece.



12. Work the sliding lock back and forth.
13. Set assembled front aside and move onto next step.

### Back

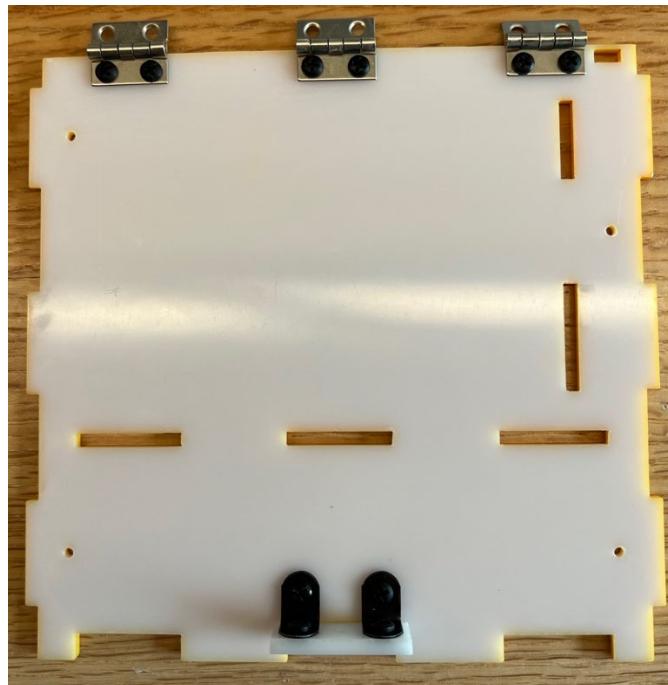
1. Screw in hinges along upper edge of part, trim screws so that they are flush with painted side of part



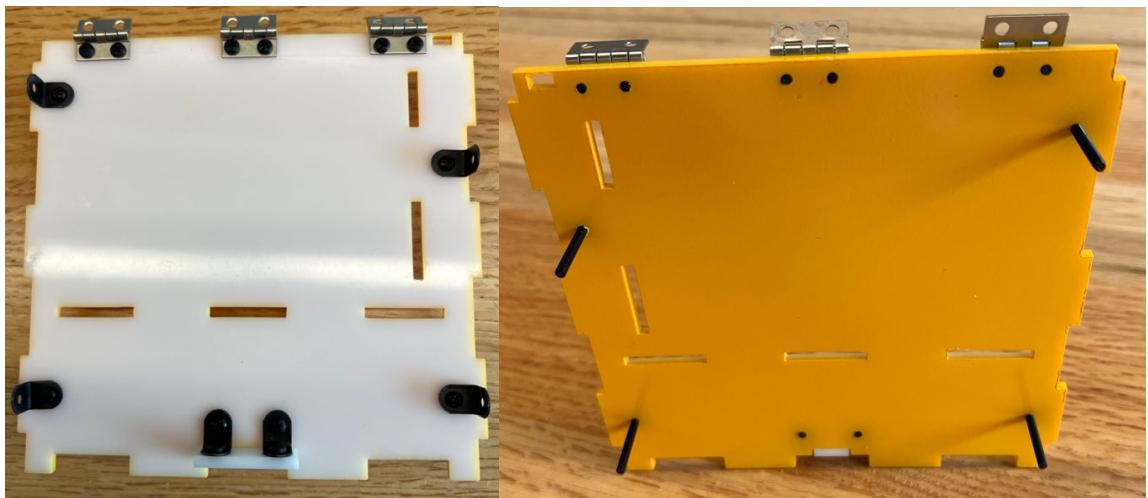
2. Screw in two angle brackets into the bottom mounting plate, trim screws so that they are flush with the bottom of the part



3. Screw bottom mounting plate to the back, screws in the bottom mounting plate may need to be adjust for holes to align. Once all screws are in, snug them up with screwdriver. Trim screws so that they are flush with painted side of box.



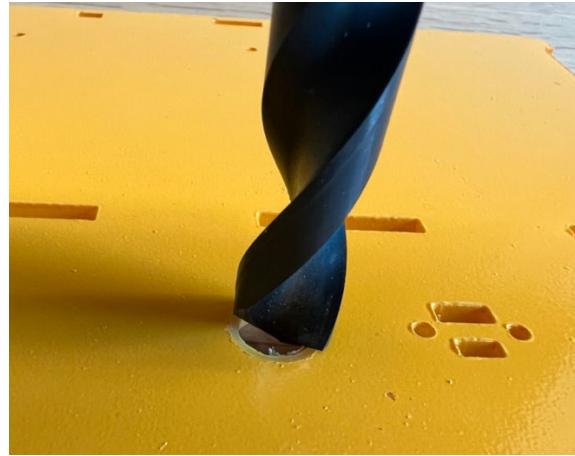
4. Install 4 angle brackets in remaining holes on box, DO NOT trim screws to length as they may need to be adjusted later in the assembly process



5. This part is done, set aside and move onto next piece

### Right Side

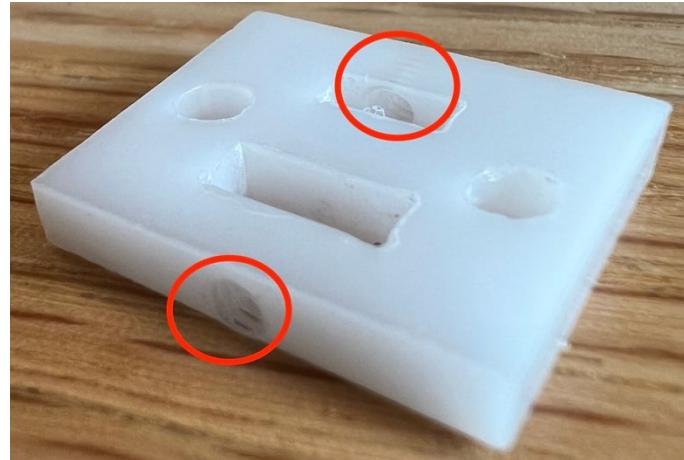
1. Using 1/2-inch drill bit, counter sink large hole to accommodate magnetic reed switch. To counter sink, run the drill in reverse. NO NOT run drill in forward, the goal is to shave off some plastic, not drill through part.



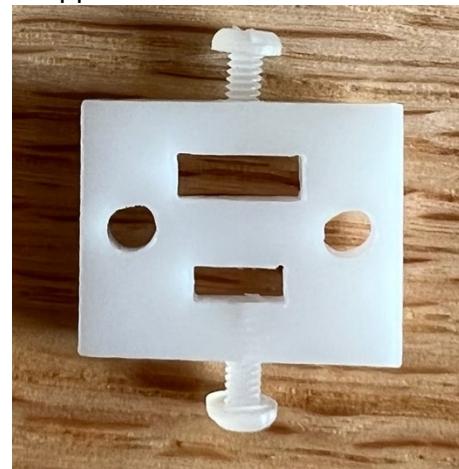
2. Insert magnetic reed switch into box so that the wires are on the non-painted side.
3. Ensure that the magnetic reed switch sits flush with painted side of box. If it does not, counter side some more.
4. Once the magnetic reed switch sits flush, hot glue in place by putting a bead of glue around the switch on inside of box.



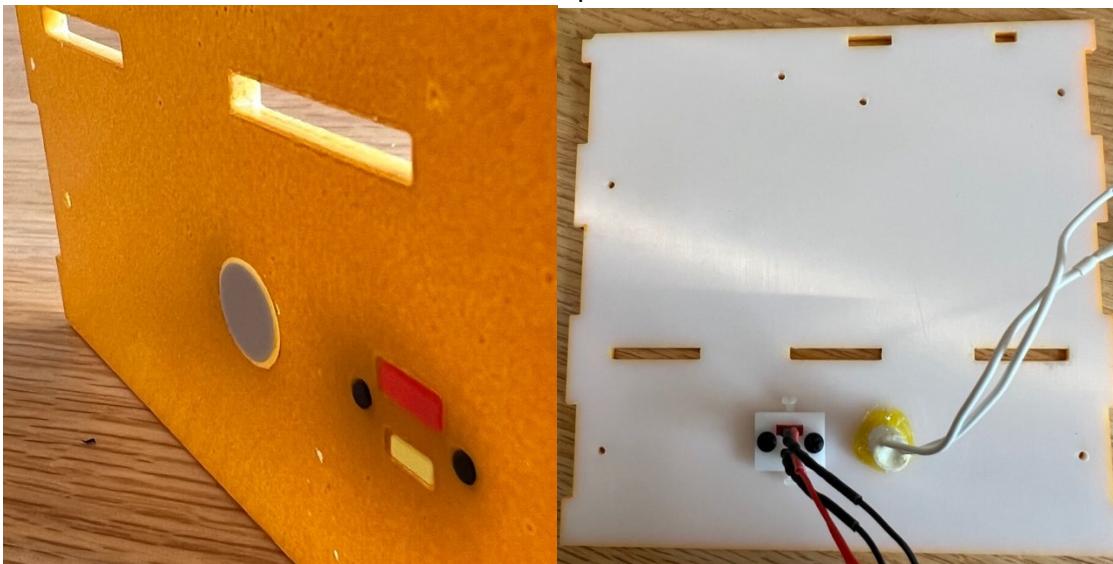
5. Using the #47 drill bit, drill one hole on each edge of LED insert. Make sure the holes are drilled as close to the center of the edge as possible. Then, tap drilled holes using 3-48 tap. The two red circles in the picture below show the location of the holes that need to be drilled.



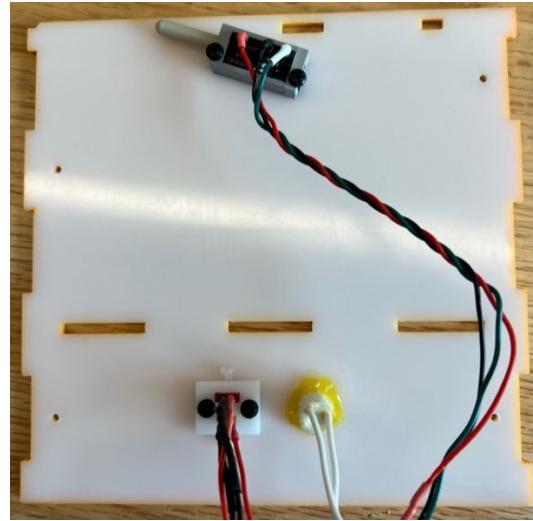
6. Screw two 3-48 screws into tapped holes on LED insert.



7. Align the rectangles of the LED insert with the rectangles on the right-side piece. The rectangles are located next to the magnetic reed switch. Screw LED insert into place using 4-40 screws and cut them so they are flush with painted side of box.
8. Insert LEDs into the rectangles and make sure they are flush with outside of box. Tighten the 3-48 screws so that the LEDs are held in place.



9. Screw linear potentiometer into place using 4-40 screws. Trim screws so that they are flush with painted side of box.



10. This part is assembled, set aside and move onto next part.

## Top

1. First, assemble the handles:
  - a. Cut the dowel to 5 1/4 inches long.
  - b. Screw the handle sides together using the 4-40 screws. Note that each handle side should have one piece that is clearance with the 1/8-inch drill bit and the other piece should be tapped. The non-painted/non-engraved sides should be touching each other. Cut screws so that they are flush with handle face.



- c. With the correct sized predrill drill bit (this will depend on what screw is being used) in the drill, line the dowel up so the top of the dowel is flush with the top of one handle side. Predrill hole if dowel and handle alignment look good.



- d. Once predrilled, put in screws to hold the handle and dowel together.
- e. With the box lid flat on a table, put both the handle sides into the lid. The dowel should be between the two handles. Now, align the handle side that has not been screwed in with the dowel, ensuring that the top of the dowel is flush with the top of the handle. Predrill and screw in handle side and dowel.



- f. Remove completed handle from top of lid.



2. With the lid oriented so that the two rectangles for the cam are in the upper right-hand corner, place the completed handle into the lid. Push all the way through so the rectangles on the handles poke through the bottom.



3. Insert the one pin into each of the rectangles on the handles.



4. Screw the handle pins into the lid. Cut excess screws poking through top side of lid.



5. Place the cam into lid so the cam itself is on the same side as the handle bottoms that poke through the lid.



6. Using a 3-48 screw, screw them together. Make sure cam is seated properly in lid.



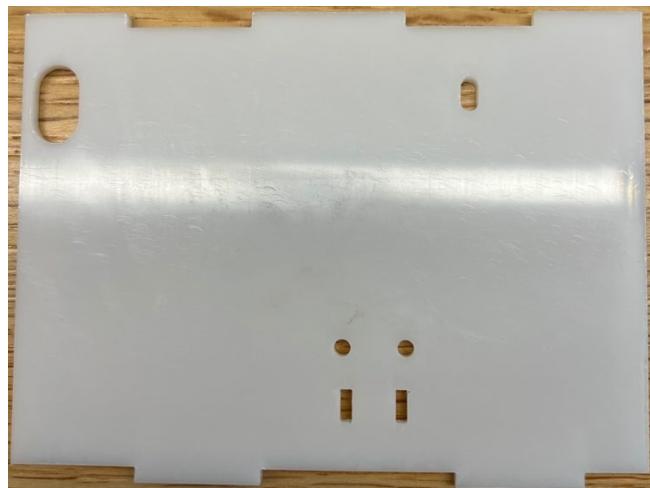
7. Screw the latch slider into the lid. Make sure it is on the same side of the lid as the handle pins and cam.



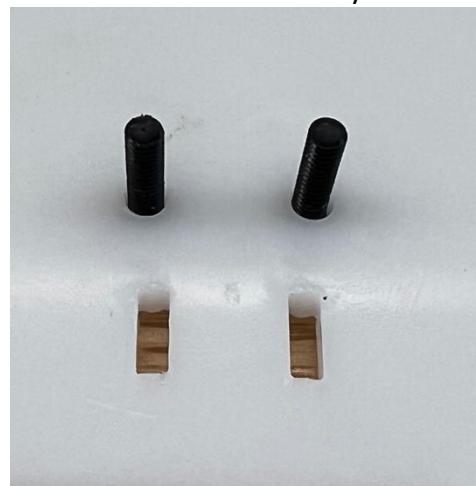
8. Set this subassembly aside and move onto next step.

### Front Partition

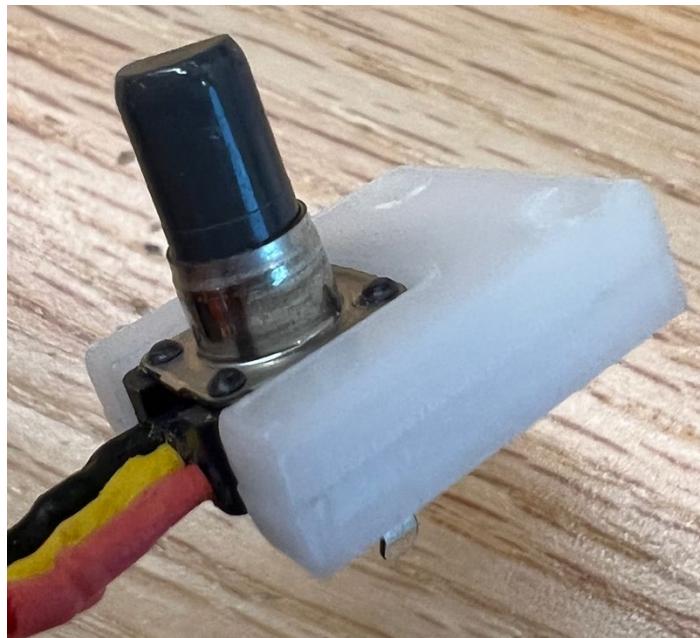
1. Orient the front partition so that the large slot is in the left corner and the two small rectangles are towards the bottom.



2. Put 2, 4-40 screws in the holes above the rectangles so that the threads are sticking up into the air and the front partition is oriented the same way.



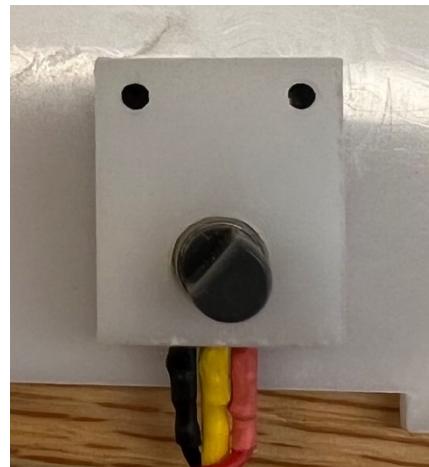
3. Place the 2 rotary potentiometer spacers around the sides of the potentiometer so that the holes are on the opposite side of the wires.



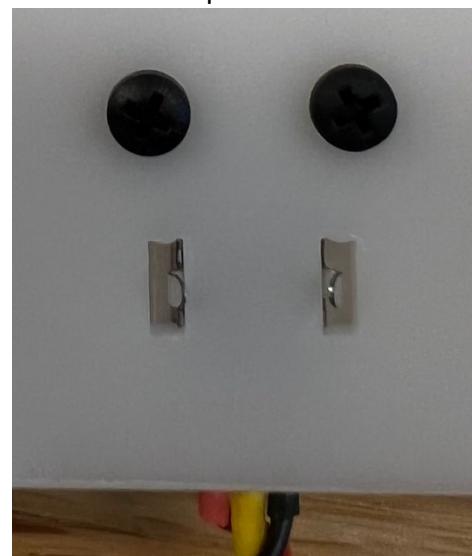
4. Place the potentiometer spacers onto the two screws sticking up from the front partition with the shaft of the potentiometer facing up.



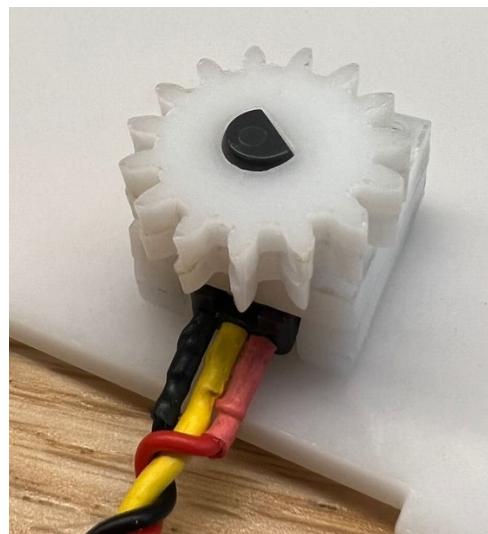
5. Place the potentiometer holder onto the potentiometer with the shaft going through the large hole.



6. Flip front partition with the rotary potentiometer attached to it over and tighten screws. Trim screws so that they are flush with the potentiometer holder.



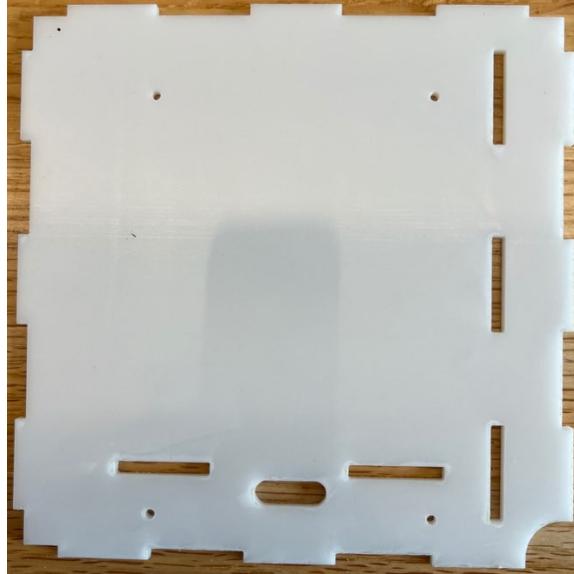
7. Place 2, 15 tooth gears into the shaft of the potentiometer, making sure that the teeth are lined up.



8. Set subassembly aside and move onto next step.

## Final Assembly

1. Orient the false bottom so that he notch is in the bottom right corner.



2. Place the side partition into the three rectangles running vertically along the right side of the false bottom. Make sure the slot on the top corner of the side partition is on the same side as the notch in the false bottom.



3. Attach the false bottom and side partition subassembly into the nonpainted side of the back wall.



4. Place the side partition top into the back wall and side partition.



5. Attach the right-side wall with the painted side facing out, the rectangles of the false bottom and side partition top might need some aligning, so it fits together.



6. Align the angle brackets and the screw holes on the side wall by spinning the screws on the back wall. Once the holes line up, put screw through the angle bracket into the side wall. Snug up all the screws on that corner to make sure the box joints fit well together. Cut screws on that corner so they are flush once tight.



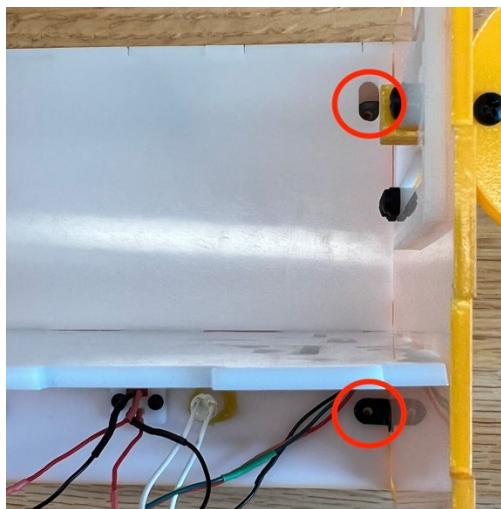
7. Ensure that the wire to the right-side wall potentiometer is seated in the notch on the false bottom.



8. Put the front of the box onto the assembly.



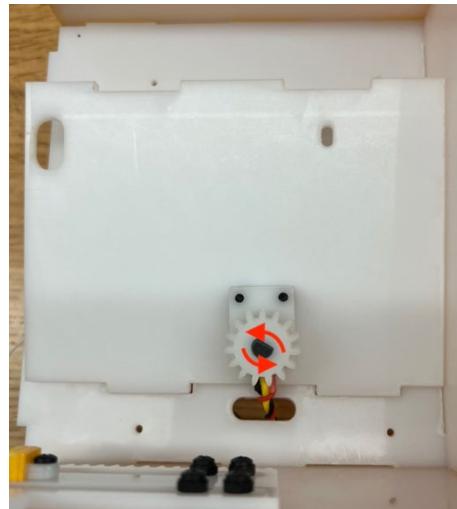
9. Align the angle brackets with the holes. Put screws in and snug up corner. Trim screws on that corner when done.



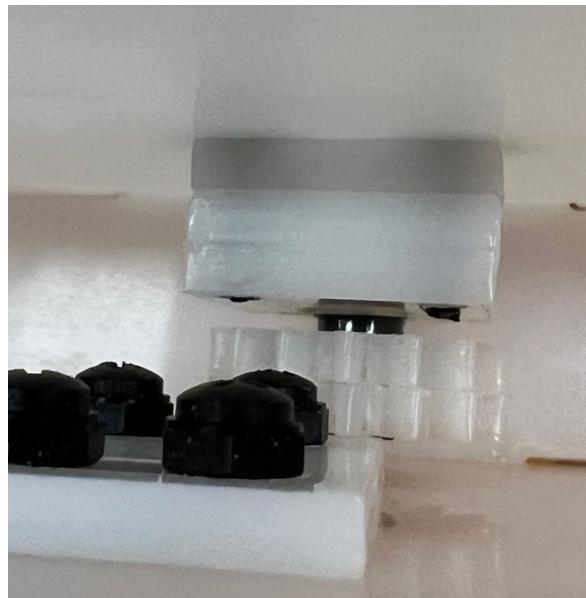
10. Feed wire of potentiometer on the front partition into the slot on the false bottom.



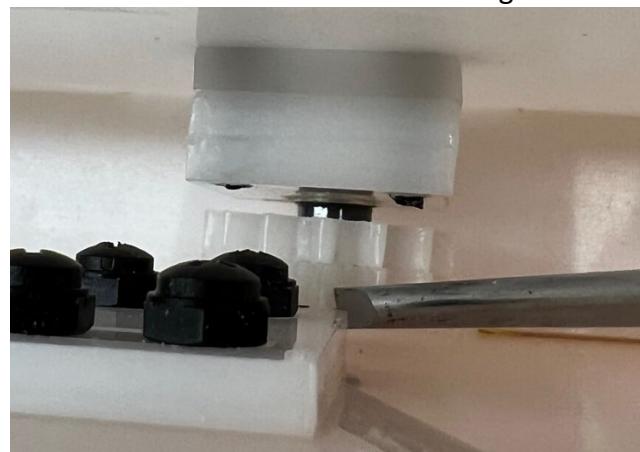
11. Spin the gears on the potentiometer counterclockwise until they stop.



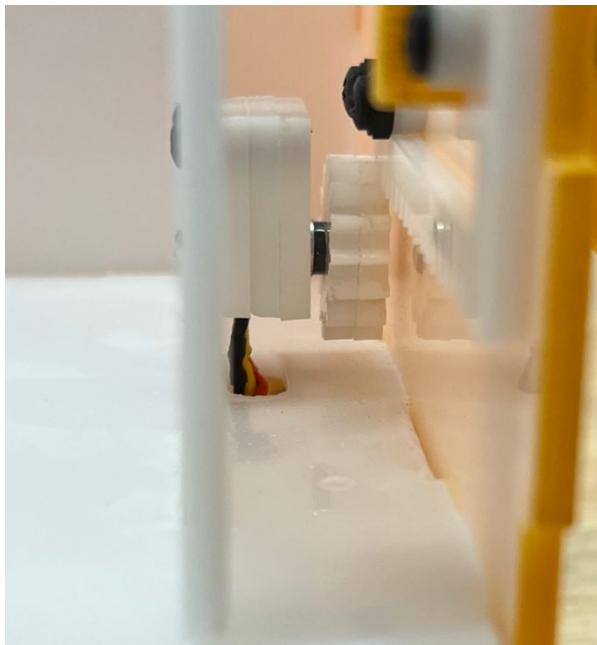
12. Slide the front slider all the way to the left. Stand the front partition upright. Note that the gear will not automatically mesh with the rack and pinion.



13. Using a long screwdriver or pick, push down on the gear closest to the rack and pinion. It might need to be moved side to side to mate the teeth together.



14. Once the gear and pinion have meshed, move slider side to side and make sure gear is engaged properly.



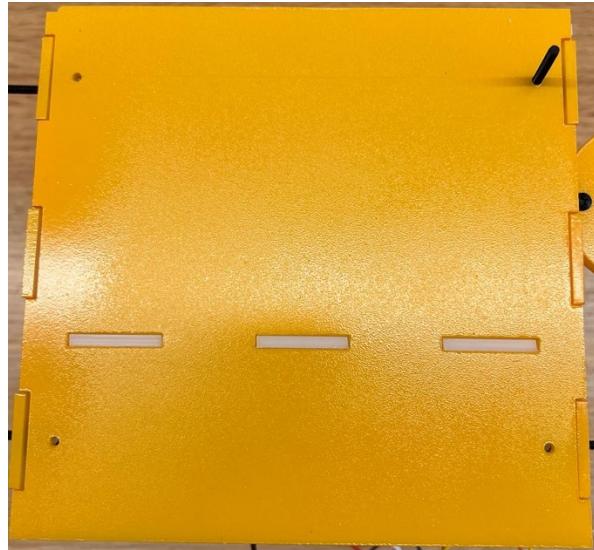
15. Place the top of the front partition into the front wall and front partition.



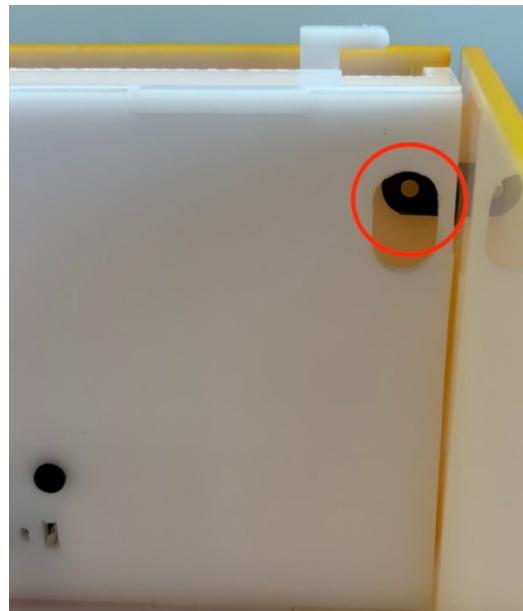
16. Put a screw into the small slot on the inside of the front partition. Screw front partition and front wall together.



17. Place the left side wall onto the partially assembled box.



18. Screw the top corner of the left-side wall and the front wall together using the access slot on the front partition.

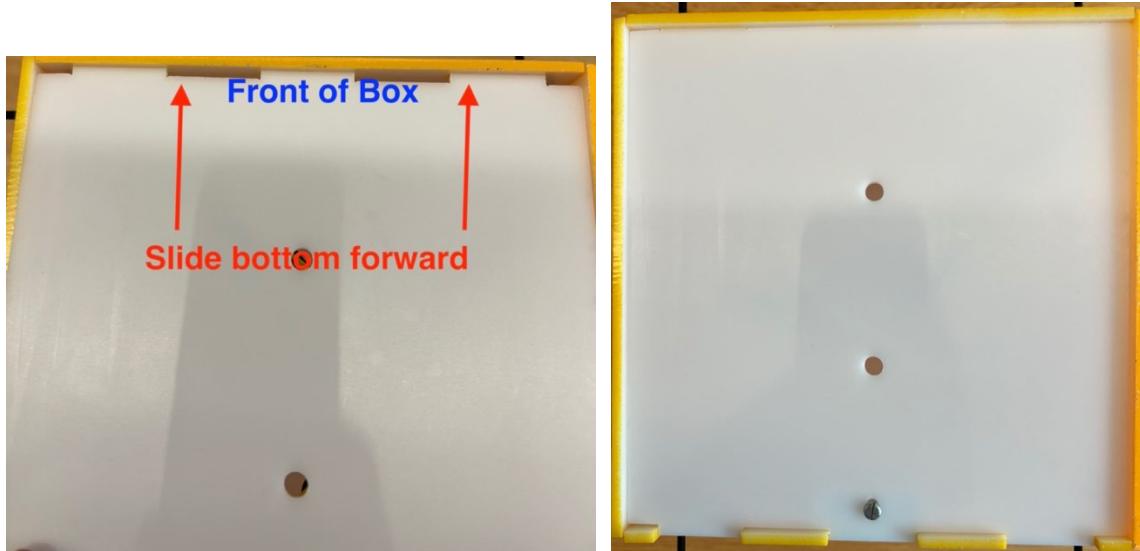


19. Screw the remaining angle brackets into the left-side wall using the 3 remaining holes.  
Trim all screws to length.

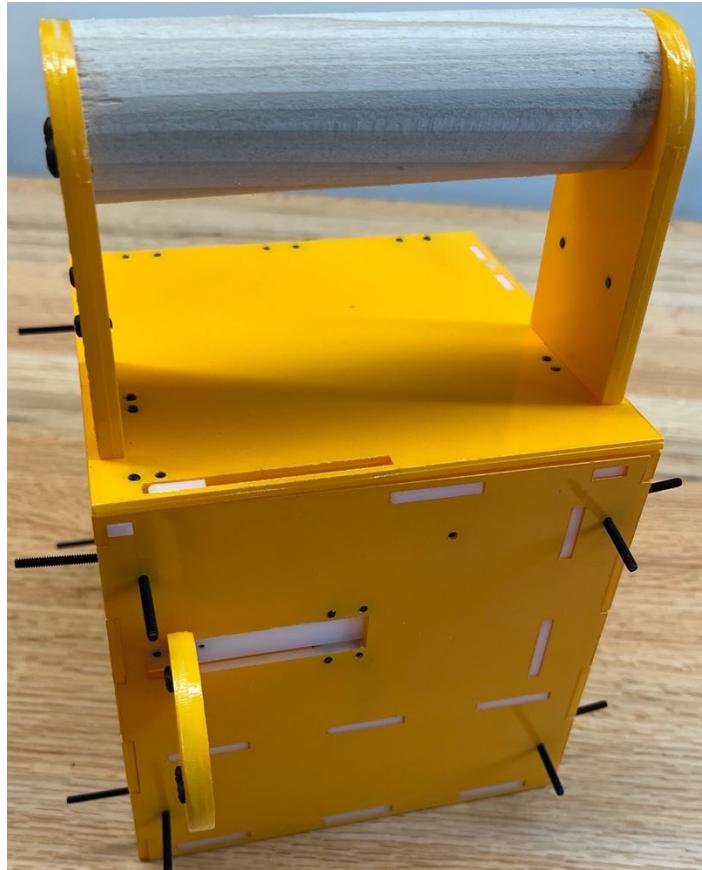
20. Screw the lid of the box into the hinges. Once all 6 screws are in, loosen them so the lid and move around a little bit. Hold the lid so it is open 90 degrees and tighten screws back down.



21. To install the bottom of the box, slide the protruding pieces on the opposite of the small slot into the inside of the front wall. Once in, push down on the small slot. This is very similar how the battery compartment door works on a TV remote. Using a metal 4-40 screw the bottom into the box using the small slot.



22. The box is now complete. Note that the screws have not been trimmed on this box so they can be reused to make the other boxes.



## Slider and Lever Box

### Equipment and Materials

#### Materials

- 2 sheets of 24" x 12" x 1/8" of white Delrin (McMaster Carr [8573K33](#))
- 1 Package of 4-40 x 1" plastic screws (McMaster Carr [94735A725](#))
- 2 Rotary Potentiometers (Mouser [RK09D1130C1B](#))
- 1 Linear Potentiometer (Digikey [404R1KL1.0](#))
- Magnetic Reed Switch (Digikey [54-629](#))
- 12mm x 12 mm L Brackets (Amazon [a19022200ux0403](#))
- National Hardware 3/4" x 5/8" Hinges (Amazon [N211-012](#))
- 3-48 screws (Amazon [9134194](#))
- 4-40 nuts [only need 6 of them] (local hardware store)
- 1.5-inch diameter wood dowel (any source)
- Spray paint, we found that Behr works well (any color)

#### Equipment

- 12" x 24" laser cutter or bigger
- Assortment of small screw drivers
- 4-40 tap
- 3-48 tap

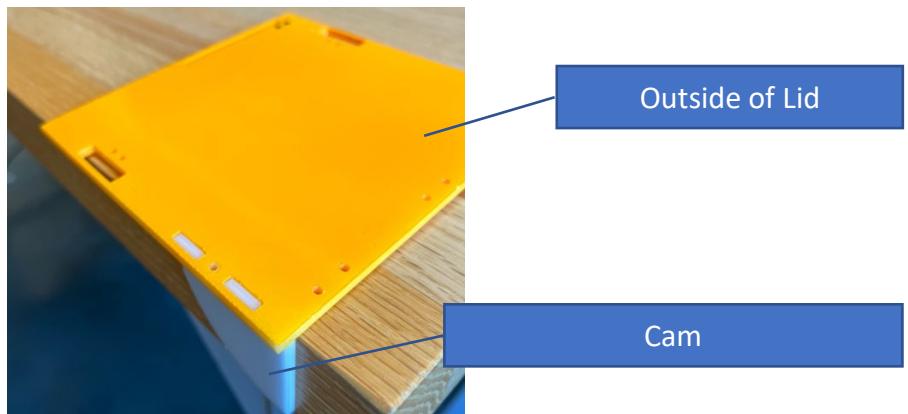
- 1/4-20 tap
- #43 drill bit for 4-40 tap
- #47 drill bit for 3-48 tap
- 1/8-inch drill bit
- 1/2-inch drill bit
- Hand drill
- Wood saw (hand saw or chop saw)
- Razor blades and/or knife
- Hot glue gun

## Laser Cutting

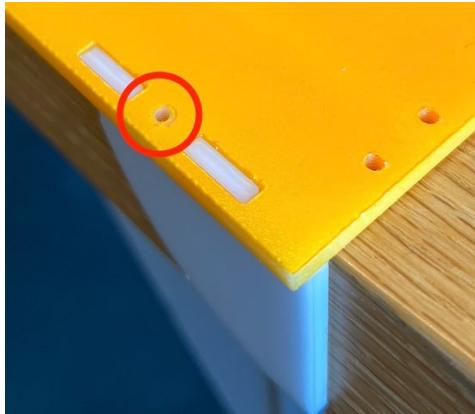
1. Upload the SolidWorks eDrawing files to the laser cutting software.
2. For the engraving parts, make sure engraving power is not set too high as this can warp the plastic sheet. Vector cut the finished engraved parts after engraving is complete.
3. For the non-engraved parts, **only** run the vector setting **only**.
4. For vector settings for both post engraved pieces and vector only pieces, we have found it best to do multiple passes on medium power (50-65%) to avoid warping the material
5. Make sure it is at a 1:1 scale and run the program.
6. After the laser cut is complete, take out any plastic pieces inside parts left over by the laser cutting process.
7. Wipe down with damp cloth to take off any dust from the laser cutting process.

## Painting Preparation and Painting

1. The engraving improves the adhesion of the spray paint, so only the engraved surfaces are meant to be painted.
2. Drill handle holes:
  - a. Take 2 of the 4 handle sides and drill out of the two small holes near the bottom with the 1/8-inch drill bit.
3. Tap the lid and cam:
  - a. Place Cam in box lid with engraved face facing up.
  - b. Use a corner of a table or other device to ensure cam and lid are at a 90-degree angle.



- c. While holding both pieces tightly together drill straight down through the lid into the cam about 1/2 inch using the #47 drill bit (Avoid drilling though side of cam).

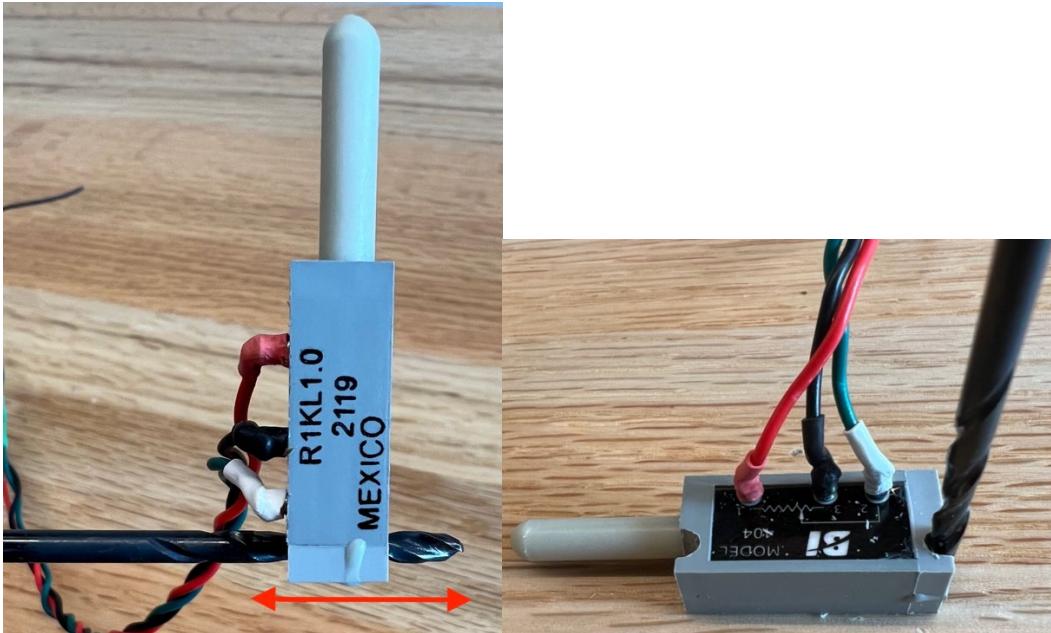


- d. With the pieces still tightly together, tap the hole that was just drilled with the 3-48 tap.
4. Tap the remaining holes:
    - a. Put the 4-40 tap in the drill.
    - b. Slowly tap all the remaining holes on the engraved pieces with the 4-40 tap, the holes that should be tapped with the 4-40 are slightly smaller than the tap itself (Do not tap the hole previous drilled out and tapped with the 3-48 tap).
    - c. Using a razor blade or knife, cut any lips that may have formed around the holes from the drilling/tapping process, any pools of melted plastic from laser cutter, or any lips that may have been from incomplete laser cuts.
    - d. Now that the engraved parts have been tapped, they are ready to paint.
  5. Paint engraved face of parts according to spray paint directions, multiple coats may need to be applied for best finish.

## Side Preassembly

### Preparation

1. Tap remaining holes on parts that were not painted using the 4-40 tap, if using drill to tap holes make sure speed is low (Rule of thumb is that if the tap does not fit through the hole, it is supposed to be tapped). Cut off any lips or ridges that may have formed around tapped holes.
2. Linear potentiometer preparation
  - a. Using the 1/8-inch drill bit, clearance out the linear potentiometer to allow for the 4-40 screws to fit into the mounting grooves. The best way to do this is to have the drill bit spinning in the drill and work the potentiometer's grooves along the length of the bit. Using razor blade clear any extra plastic out and periodically check groove alignment to make sure screws fit in.



b. Solder three wires onto potentiometer for ground, positive, and signal.

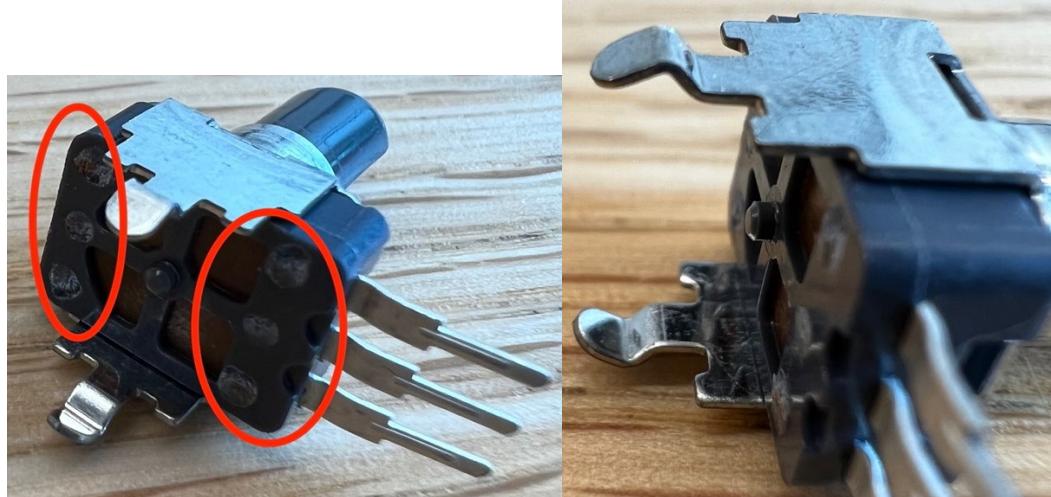


3. Rotatory potentiometer preparation

- Straighten out sensor terminations so that they do not bend at a 90-degree angle.



- b. Cut off little knobs on back of potentiometer with razor blade.



- c. Solder wires onto potentiometers positive, ground, and data terminals.



- d. Repeat step so that there are 2 cut and wired potentiometers. It is a good idea to use different color wires to differentiate between the potentiometers.
4. Using 1/8-inch drill bit, drill out all 4 holes in 2 out of 3 of the lever-prong bending preventer. Tap all the holes on the 1 remaining piece with the 4-40 tap.



5. Using the 1/8-inch drill bit, drill out the 2 holes in 3 of the 4 U-shaped connecting rod guide. Tap all the holes on the 1 remaining piece with the 4-40 tap.

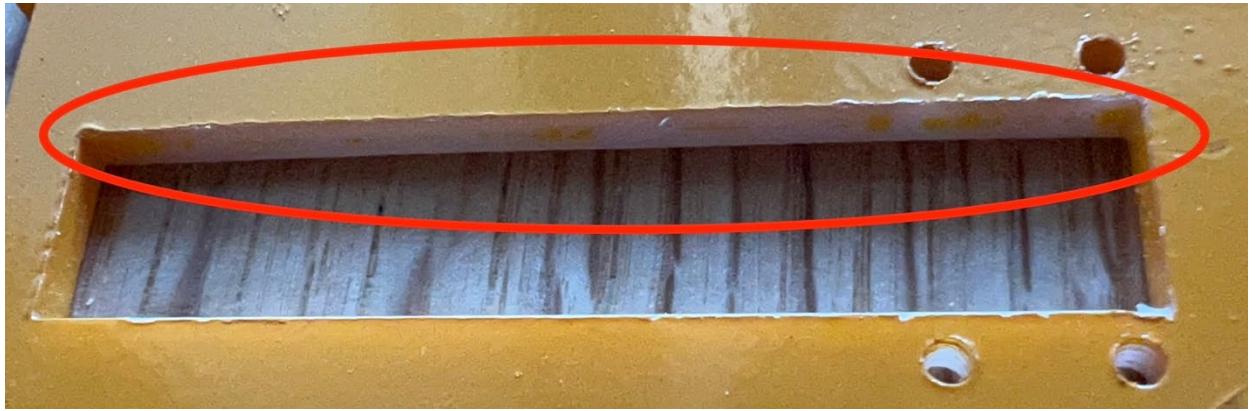


6. Tap all the 2 small holes on both rotary potentiometer holders.



### Front

1. Using razor blade or sandpaper, remove paint from inside edge of large rectangle. Do this for both long edges.



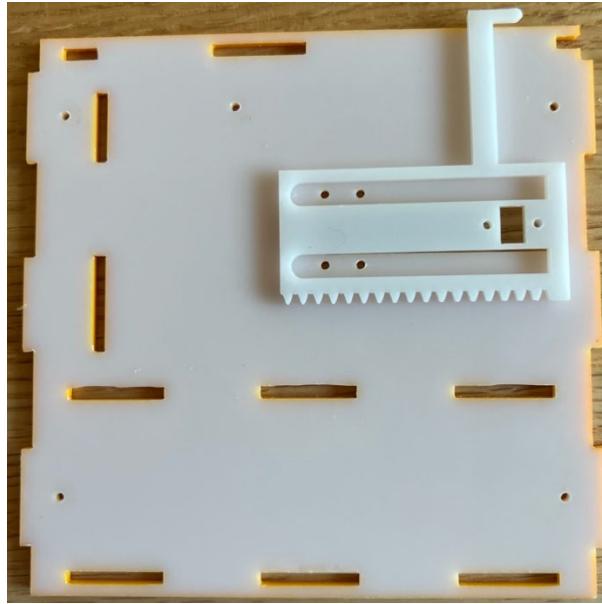
2. Take 4 screws and screw 1 nut onto each all the way to the head of the screw.



3. Put the slot spacer together and put push two screws all the way through it. Using the razor blade, trim the screws so that they are flush with the outside of the slot spacer. Take the screws out and cut an additional 2-3 threads off the end of the screw.



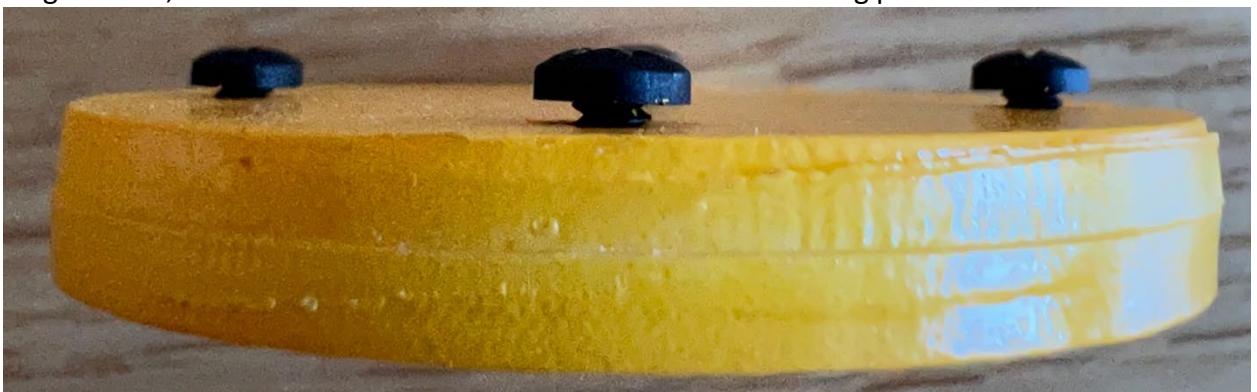
4. With the non-painted side facing up. Place the slider lock onto non-painted side, lining up the slots with the four screw holes near the left of the large rectangle.



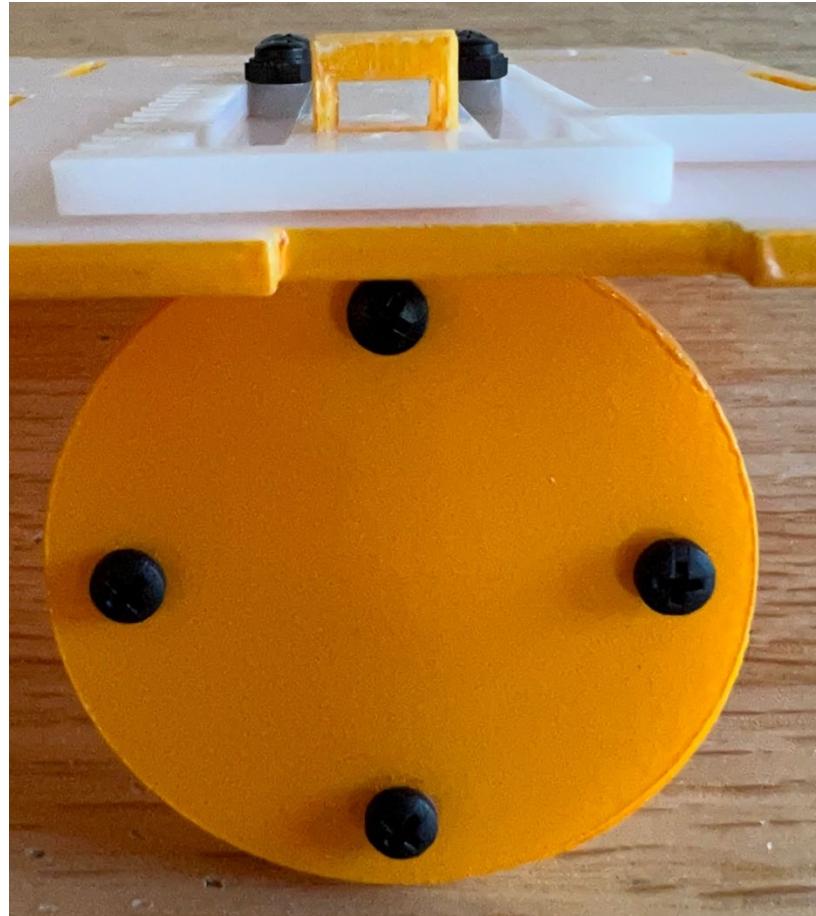
5. Place the slot spacer into slot of the slider lock, lining up the screw holes. Using the screws with the nuts on them, screw the slot spacer to the front. Trim screws to length so that they are flush with painted side of front.



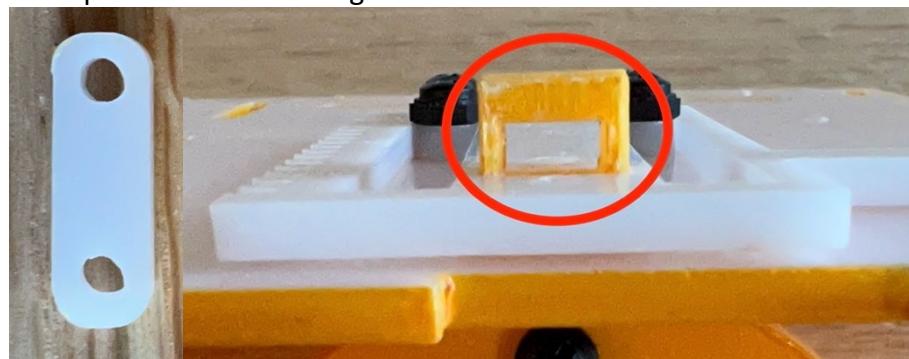
6. Take the slider tabs and place them together, screw them together. Trim screws to length. Then, back screws off so that screw heads are not touching painted face.



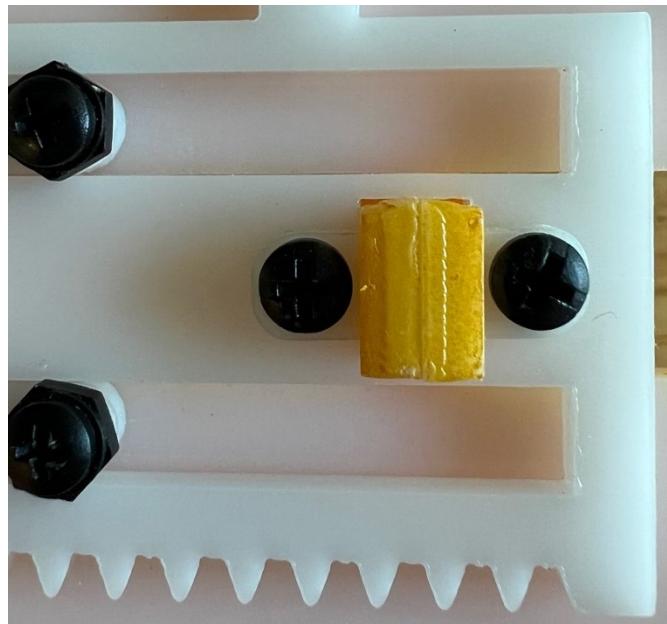
7. Push the arm protruding off the slider tab into the slider lock with the circular part of the slider tab on the painted side of the front of the box.



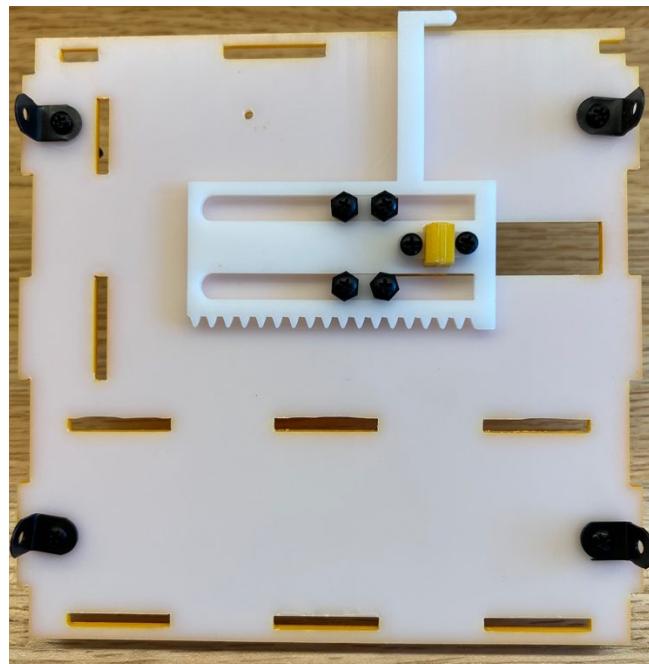
8. Push slider tab pin into small rectangle circled in red below.



9. Using precut screws from step 3, screw slider tab pin into slider lock.



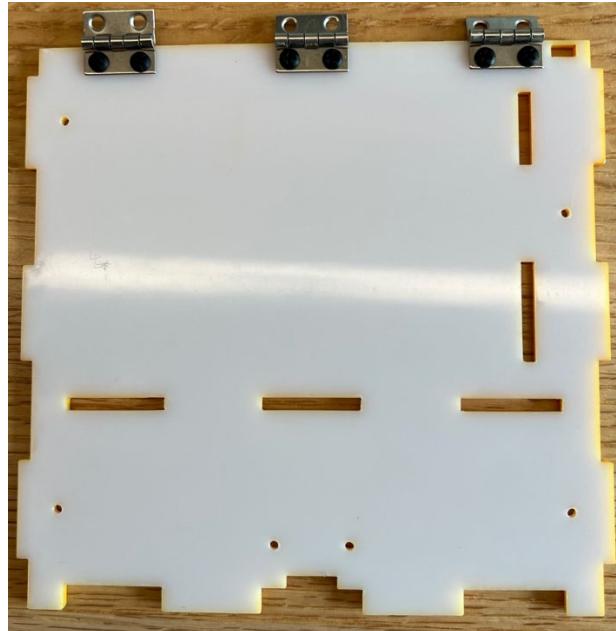
10. Tighten the 4 screws on the painted part of the slider tab.
11. On the non-painted side, screw in 4 angle brackets into holes nears the corners of the front piece.



12. Work the sliding lock back and forth.
13. Set assembled front aside and move onto next step.

### Back

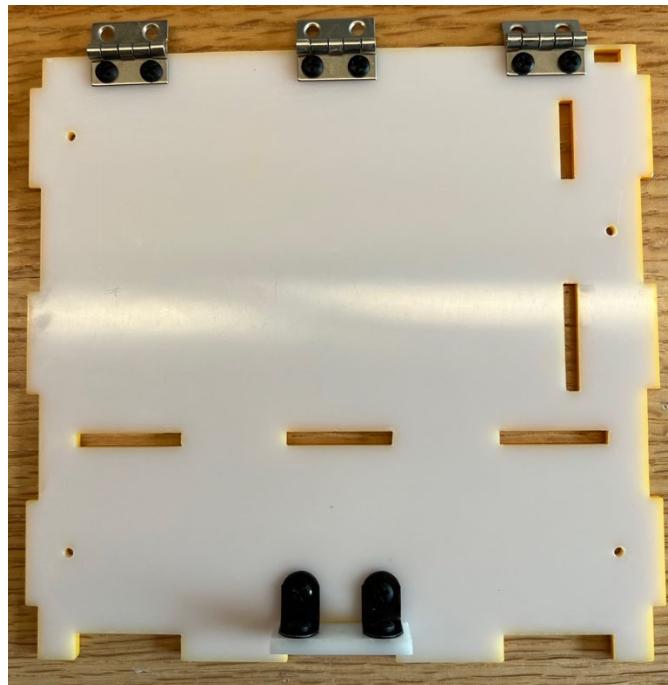
1. Screw in hinges along upper edge of part, trim screws so that they are flush with painted side of part



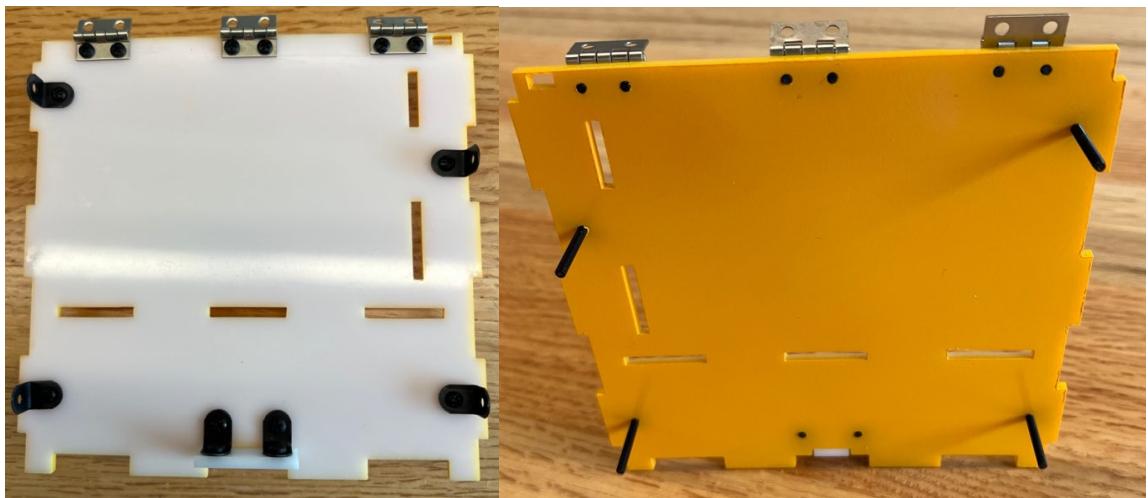
2. Screw in two angle brackets into the bottom mounting plate, trim screws so that they are flush with the bottom of the part



3. Screw bottom mounting plate to the back, screws in the bottom mounting plate may need to be adjust for holes to align. Once all screws are in, snug them up with screwdriver. Trim screws so that they are flush with painted side of box.



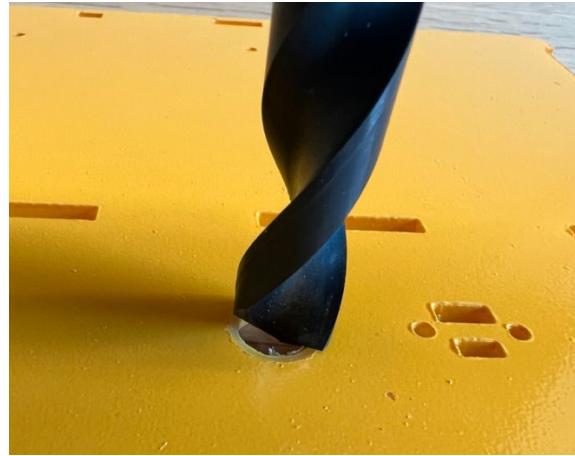
4. Install 4 angle brackets in remaining holes on box, DO NOT trim screws to length as they may need to be adjusted later in the assembly process



5. This part is done, set aside and move onto next piece

### Right Side

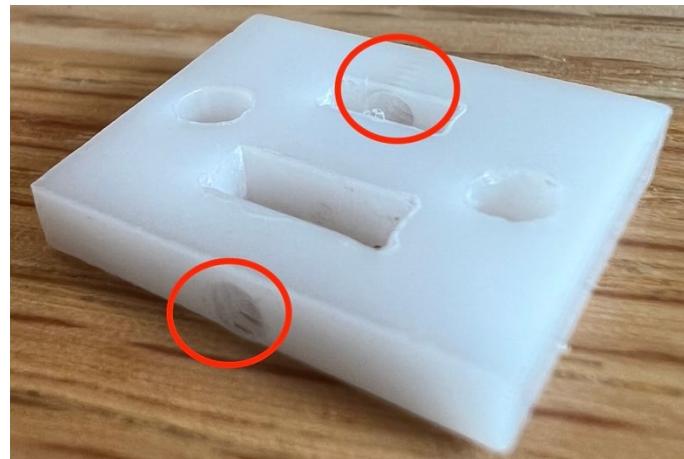
1. Using 1/2-inch drill bit, counter sink large hole to accommodate magnetic reed switch. To counter sink, run the drill in reverse. NO NOT run drill in forward, the goal is to shave off some plastic, not drill through part.



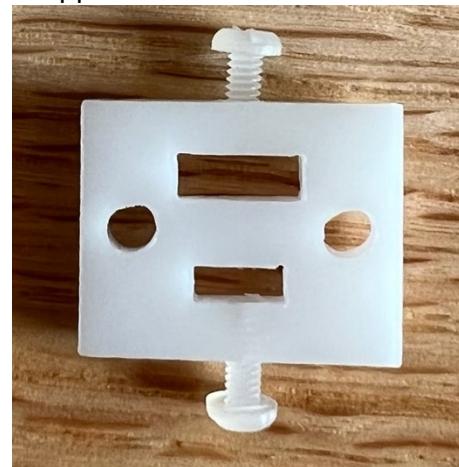
2. Insert magnetic reed switch into box so that the wires are on the non-painted side.
3. Ensure that the magnetic reed switch sits flush with painted side of box. If it does not, counter side some more.
4. Once the magnetic reed switch sits flush, hot glue in place by putting a bead of glue around the switch on inside of box.



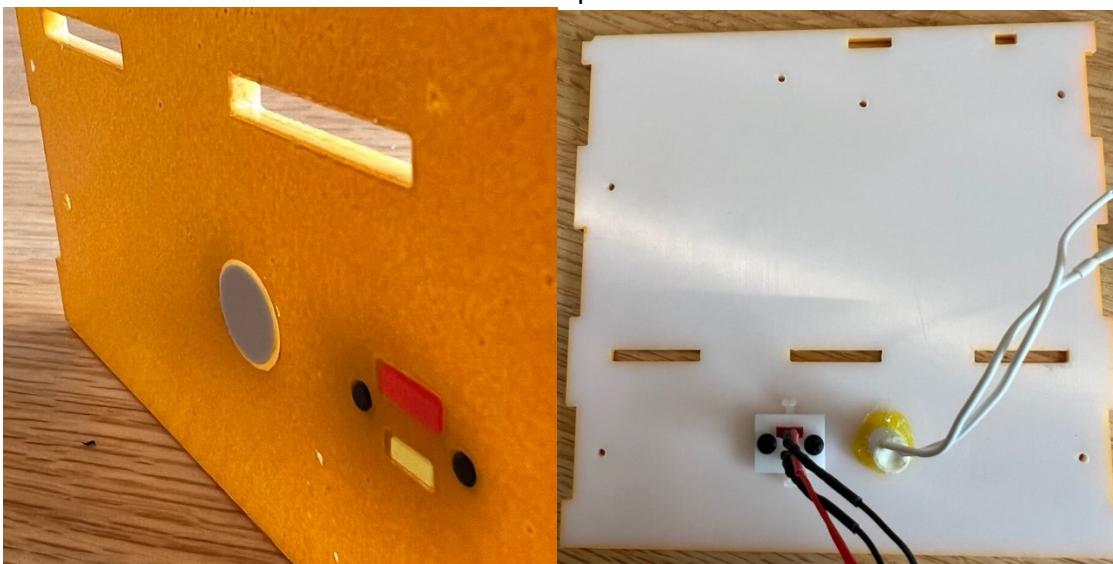
5. Using the #47 drill bit, drill one hole on each edge of LED insert. Make sure the holes are drilled as close to the center of the edge as possible. Then, tap drilled holes using 3-48 tap. The two red circles in the picture below show the location of the holes that need to be drilled.



6. Screw two 3-48 screws into tapped holes on LED insert.



7. Align the rectangles of the LED insert with the rectangles on the right-side piece. The rectangles are located next to the magnetic reed switch. Screw LED insert into place using 4-40 screws and cut them so they are flush with painted side of box.
8. Insert LEDs into the rectangles and make sure they are flush with outside of box. Tighten the 3-48 screws so that the LEDs are held in place.



- Screw linear potentiometer into place using 4-40 screws. Trim screws so that they are flush with painted side of box.
- Set this subassembly aside and move onto next part.

### **Left Side**

- Using the 1/8-inch drill bit, drill out the holes on one of the lever prong spacers, circled in blue. Tap the two holes circled in red on the other spacer.



- Using a razor blade or sandpaper, take the paint off the inside of the big circle on the right side all as well as the off the outside edge of the small circle with the rectangle in the middle.



- Screw the two lever arms together with the painted sides facing out. Before tightening the screws all the way, put the lever pin into the rectangle on the lever arm so they are lined up properly. Remove the pin after the screws are tight.



4. Take the lever arm centering plate and slide it on the little nub with the rectangle on it on the lever arm. Make sure the painted side of the plate is facing the part of the lever arm with the screws.

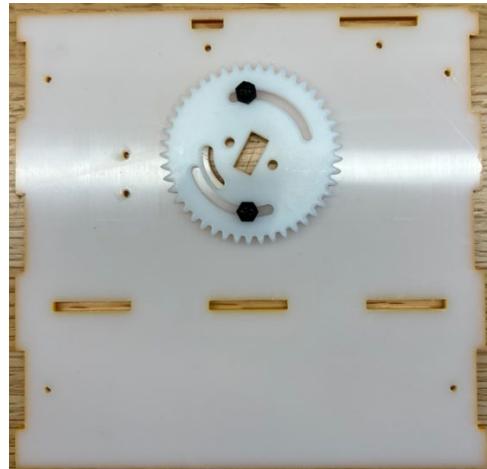


5. Screw two nuts all the way onto two different screws.

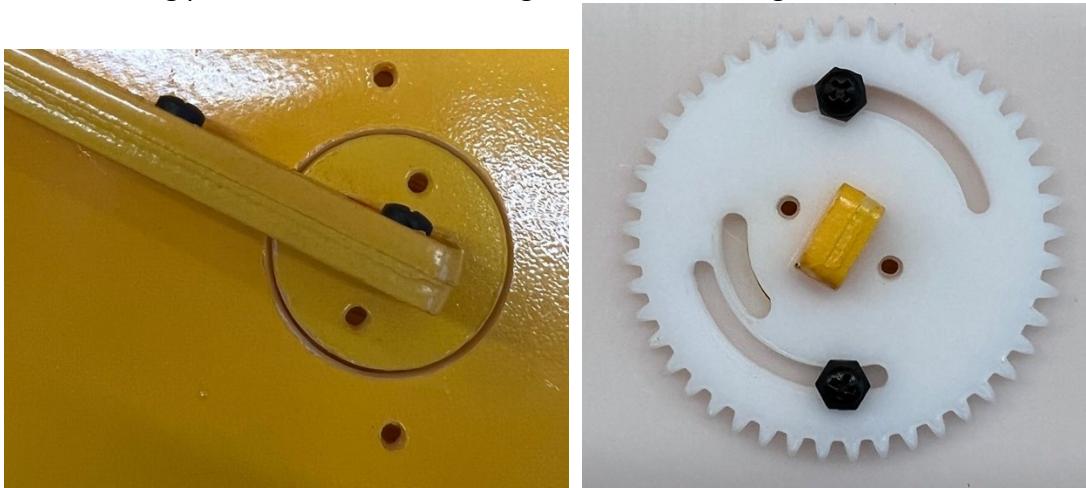


6. Flip the side over so that the non-engraved side is facing up. Place the 45-tooth gear onto the non-engraved side so that smallest slot on the circle is in the lower left. Line the two larger slots up with the screw holes to the top and bottom of the large circle on

the box wall. Screw the two screws with nuts on them into the holes lined up with the slots. Trim screws so they are flush with the painted side of the wall.



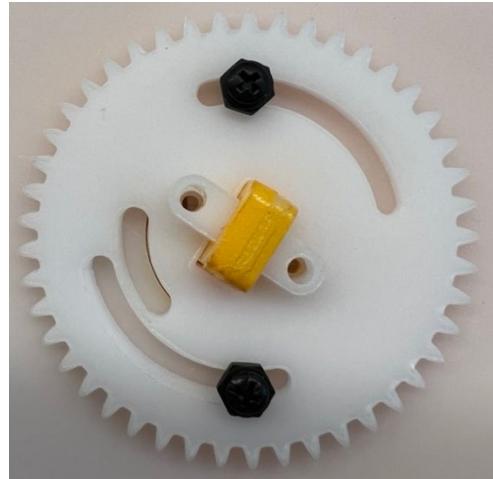
7. Flip the side over so the painted side is facing up and push the nub of the lever arm with the centering plate on it into the rectangle of the 45-tooth gear.



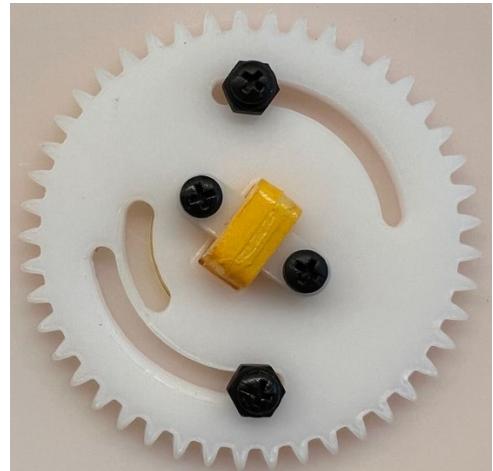
8. Make sure the lever arm is pushed in all the way so that the outside is flush.



9. Insert the centering pin into the small rectangle in lever arm so that holes of the pin, gear, and centering plate line up.



10. Screw the pin, gear, and centering plate together. Trim screws so they are flush with the painted side of the wall. When screwing the pin in, the lever arm should move away from the painted side of the wall a little, so they don't rub. Make sure the lever arm rotates smoothly.



11. Stack the two lever prong spacers together and place two screws into the two holes along the short side with the semicircle. Trim these screws so that they are flush with the face of the spacer. Set those screws aside.



12. Screw the lever prong spacers into the non-engraved side of the wall, using the holes closest to the 45-tooth gear. The drilled-out spacer should be the one next to the wall, on top of the drilled one should be the tapped one. Screw into place and cut the screws to length.



13. Tap both ends of the connecting rod. Screw one screw into one end of the rod. Trim the side of the screw with the head on it so that it is flush with the rod.



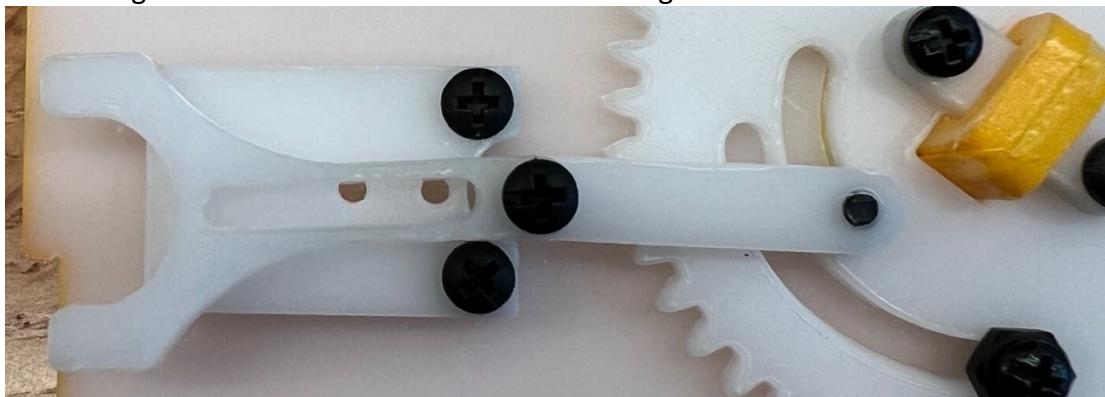
14. Place the uncut side of the screw sticking out the connecting rod into the hole on the lever prong. Trim the screw so that it is flush with the prong.



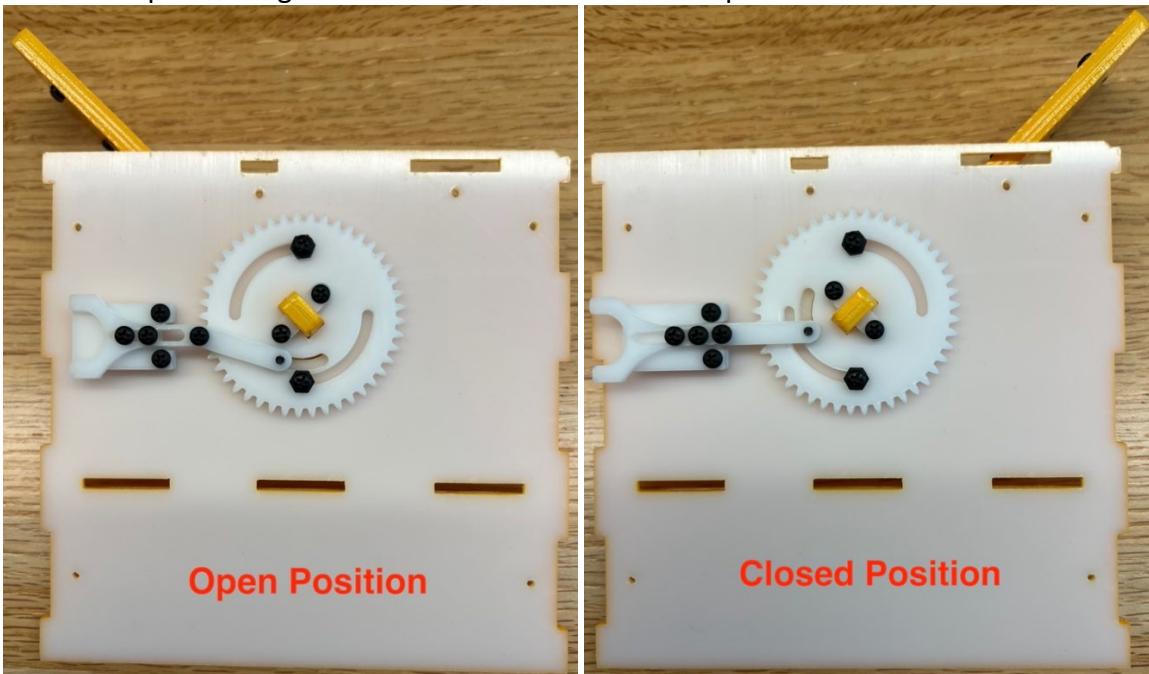
15. Using the other hole on the connecting rod, screw the connecting rod and lever prong together using the hole on lever prong. Make sure the little thread on the other end of the connecting rod is facing way from the lever prong. Screw together tightly, then trim the screw so it is flush. Then back the screw off so the two pieces can rotate freely.



16. Place the slot of the lever prong over the two empty holes on the lever prong spacer. Make sure that the screw threat poking out from the non-conjoined side of the connecting rod is in the small slot on the 45-tooth gear.



17. Screw into place using those two screws set aside in step 11 and test lever action.



18. Set subassembly aside and move onto next step.

## Top

1. First, assemble the handles:
  - a. Cut the dowel to 5  $\frac{1}{4}$  inches long.
  - b. Screw the handle sides together using the 4-40 screws. Note that each handle side should have one piece that is clearance with the 1/8-inch drill bit and the other piece should be tapped. The non-painted/non-engraved sides should be touching each other. Cut screws so that they are flush with handle face.



- c. With the correct sized predrill drill bit (this will depend on what screw is being used) in the drill, line the dowel up so the top of the dowel is flush with the top of one handle side. Predrill hole if dowel and handle alignment look good.



- d. Once predrilled, put in screws to hold the handle and dowel together.
  - e. With the box lid flat on a table, put both the handle sides into the lid. The dowel should be between the two handles. Now, align the handle side that has not

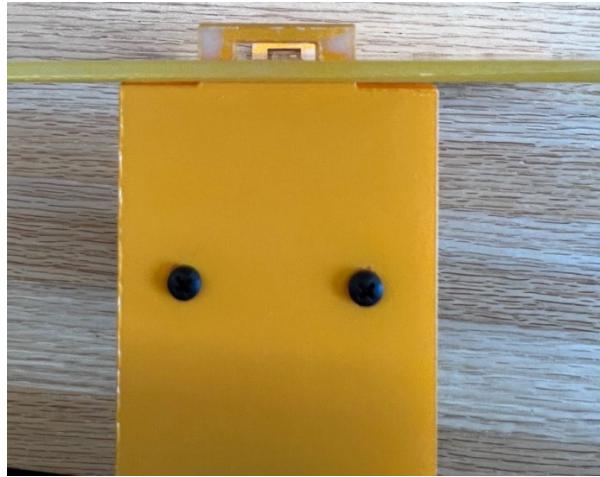
been screwed in with the dowel, ensuring that the top of the dowel is flush with the top of the handle. Predrill and screw in handle side and dowel.



f. Remove completed handle from top of lid.



2. With the lid oriented so that the two rectangles for the cam are in the upper right-hand corner, place the completed handle into the lid. Push all the way through so the rectangles on the handles poke through the bottom.



3. Insert the one pin into each of the rectangles on the handles.



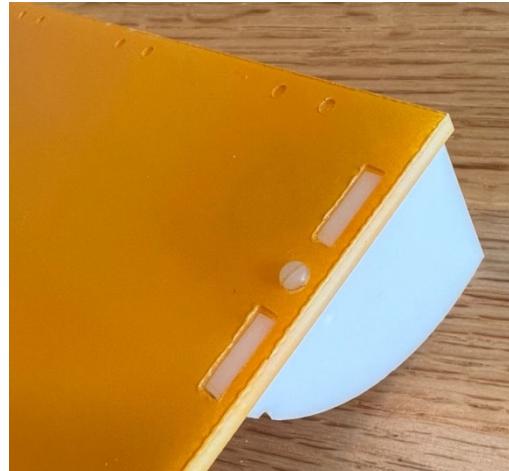
4. Screw the handle pins into the lid. Cut excess screws poking through top side of lid.



5. Place the cam into lid so the cam itself is on the same side as the handle bottoms that poke through the lid.



6. Using a 3-48 screw, screw them together. Make sure cam is seated properly in lid.



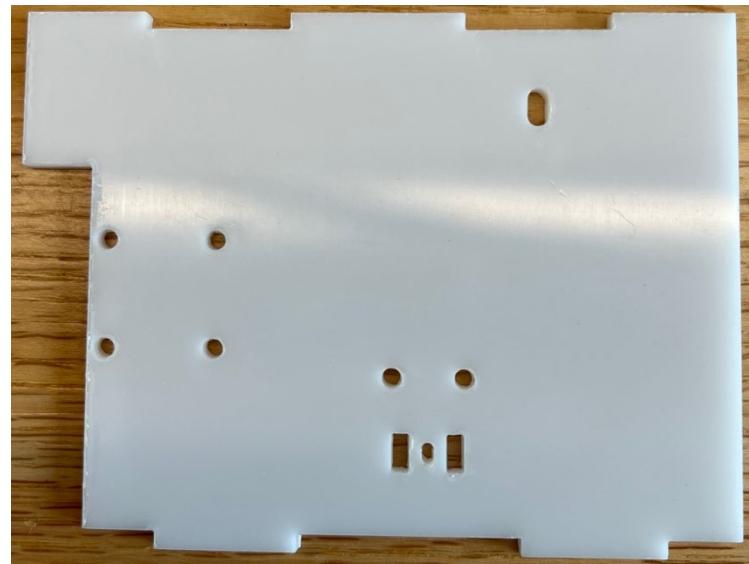
7. Screw the latch slider into the lid. Make sure it is on the same side of the lid as the handle pins and cam.



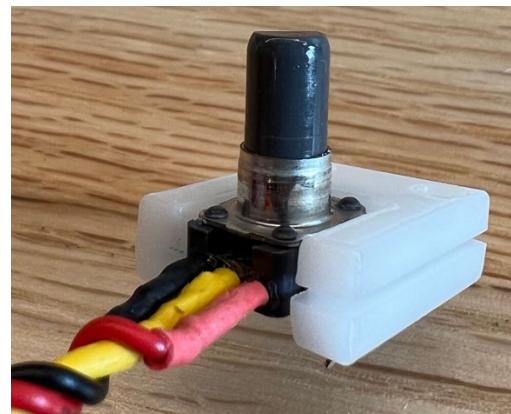
8. Set this subassembly aside and move onto next step.

### Front Partition

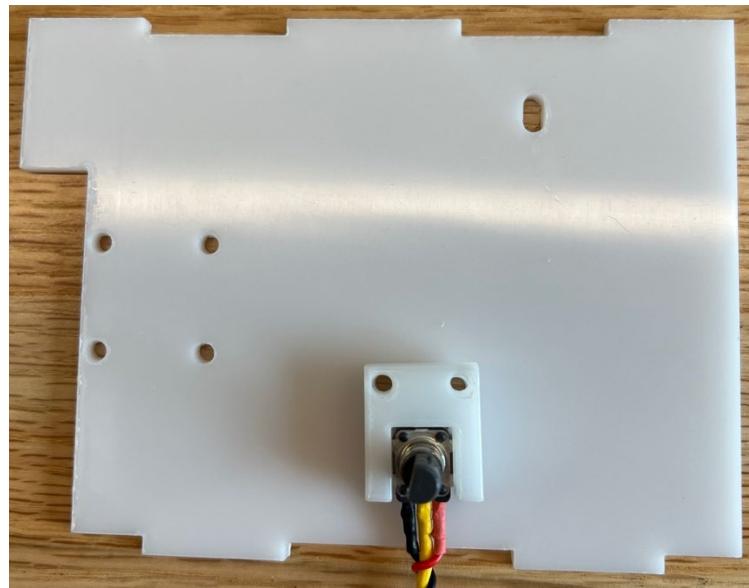
1. Orient the front partition so that the large cut out is to the left and two small rectangles are towards the bottom.



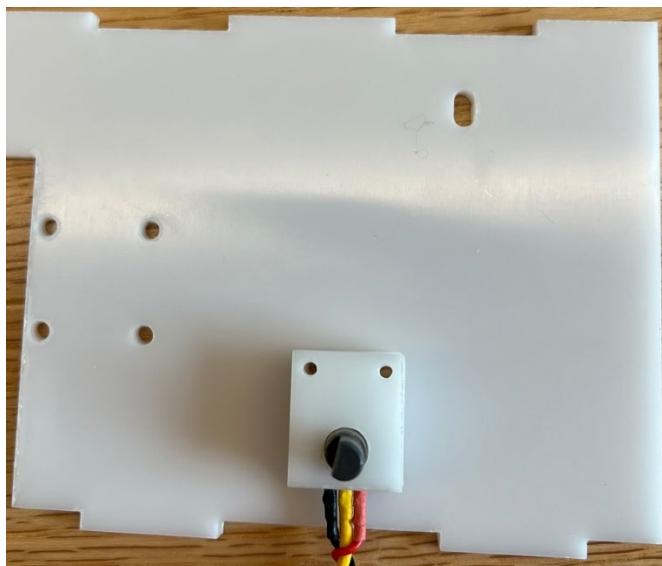
2. Put 2 of the rotary potentiometer spacers around the potentiometer on the opposite side of the wires.



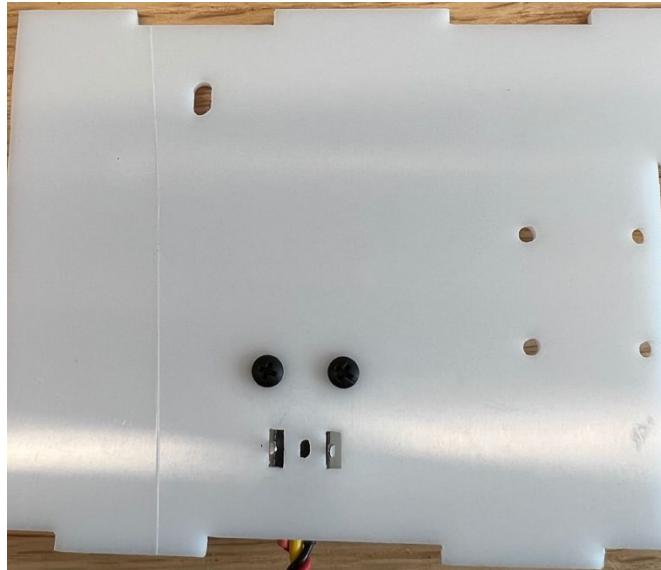
3. Place the metal prongs of the potentiometer into the two rectangles near the bottom right of the front partition.



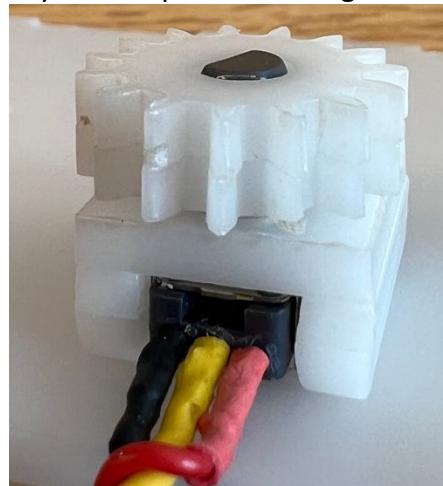
4. Place the rotary potentiometer holder onto the potentiometer so that the shaft does through the large hole.



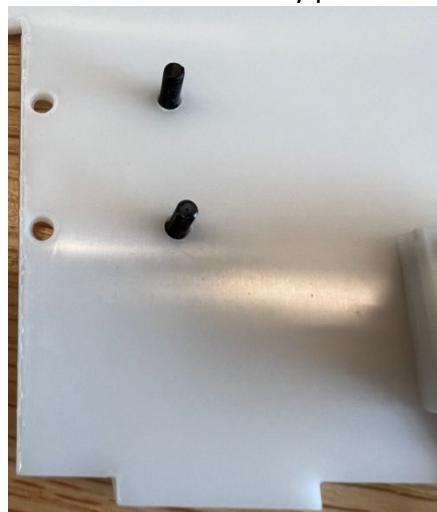
5. Holding the front partition and rotary potentiometer pieces together, flip over so that the potentiometer is facing the table. Screw together using 4-40 screws. Flip back over and trim screw so that it is flush with the rotatory potentiometer holder.



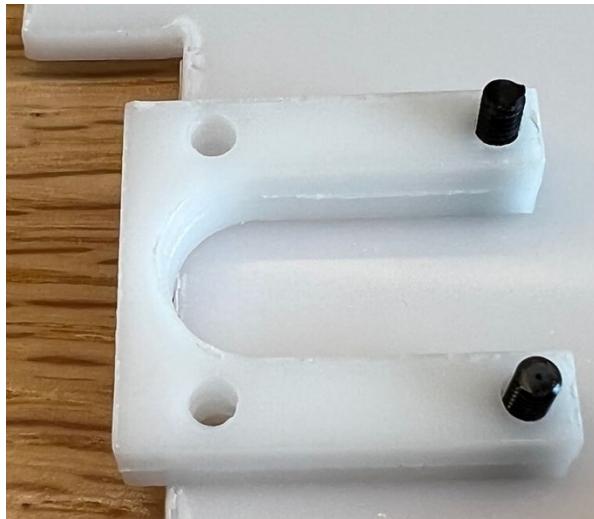
6. Using stack 2, 15 tooth gears onto the shaft of the potentiometer. Make sure the teeth line up with each other. If they don't flip the outside gear over and put back on.



7. Put 2, 4-40 screws into 2 of the screw holes off to the left of the front partition so that the threaded side is on the same side as the rotary potentiometer.



8. Place the lever-prong bending preventor that have been clearance with the 1/8-inch drill bit onto the screws.



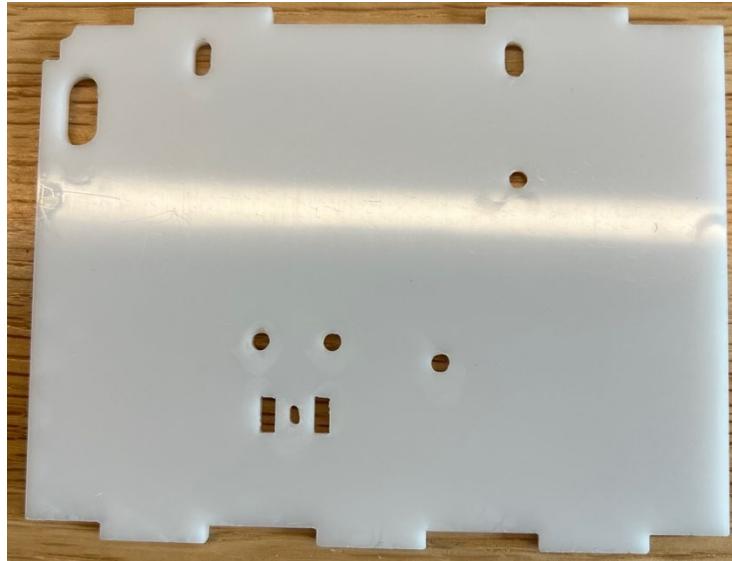
9. Screw on the lever-prong bending preventor. Put an additional 2 screws into the remaining holes.



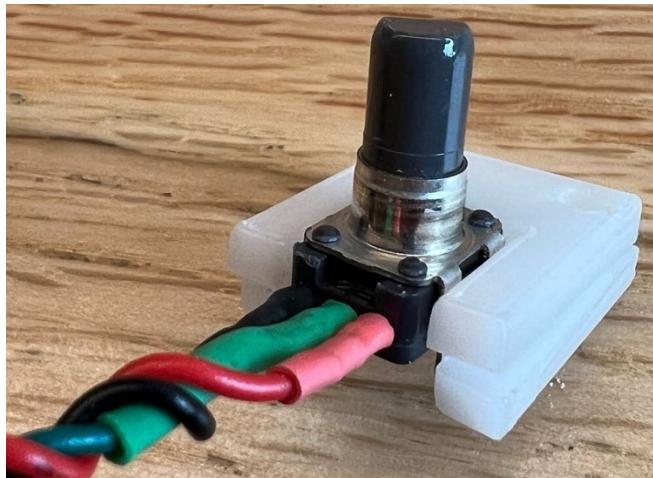
10. This subassembly is now complete, set aside and move on.

### Lever Partition

1. Orient the lever partition so that the large slot is on the left side and the two small rectangles are on the bottom.



2. Put 2 of the rotary potentiometer spacers around the potentiometer on the opposite side of the wires.



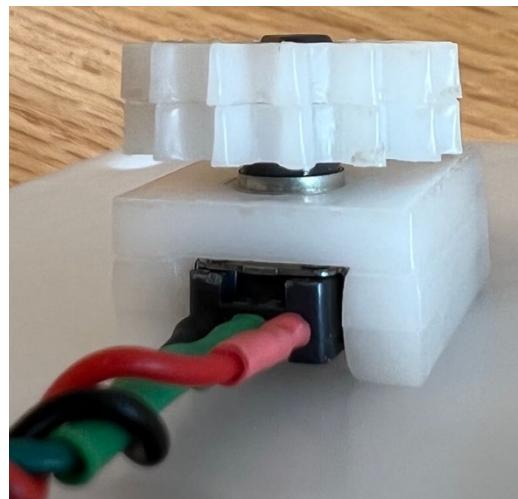
3. Put the metal tabs on the bottom of the potentiometer into the two small rectangles. Put the large hole on the rotary potentiometer holder onto the shaft of the potentiometer.



4. Flip over the screw together using 4-40 screw. Cut screws so that they are flush with the rotary potentiometer holder.



5. Place 2, 15 tooth gears onto the shaft of the potentiometer making sure the teeth line up.



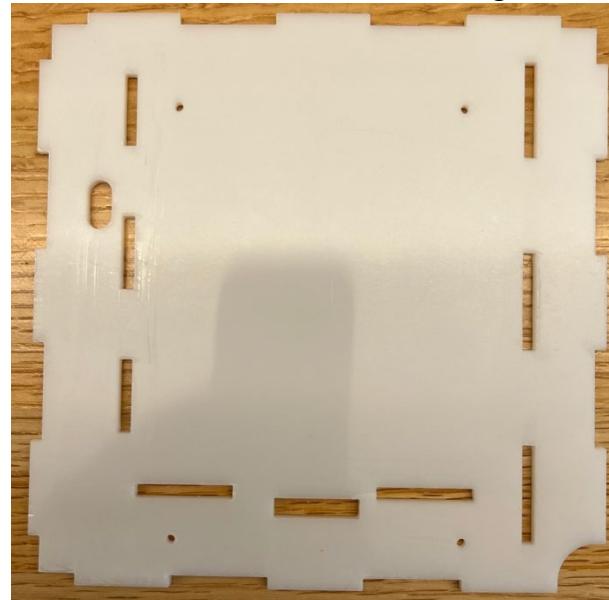
6. Place 2 screws into the holes to the right of the potentiometer so that the threads are on the same side as the potentiometer. Place the 3 drilled-out U-shape connecting rod holders onto the screws.



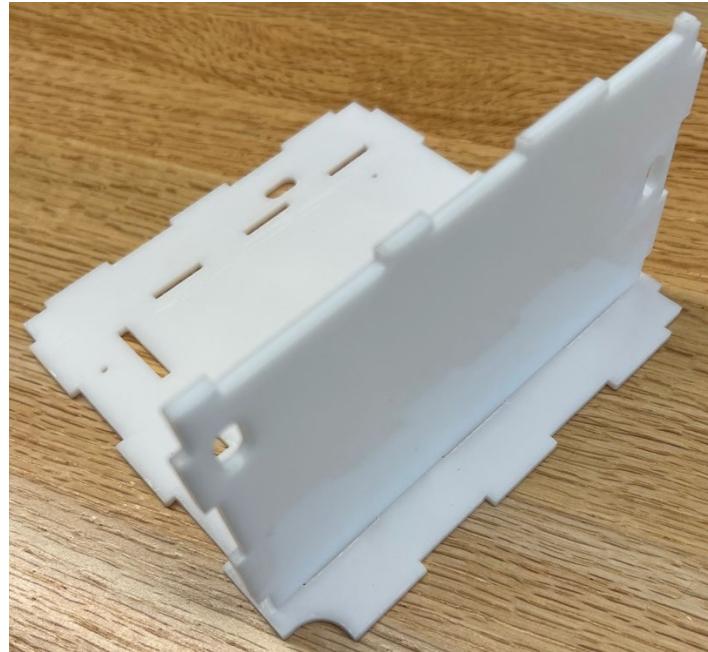
7. Screw the tapped connecting rod holder onto the stack of the other connecting rod holders.
8. Set this subassembly aside and move onto the next step.

### Final Assembly

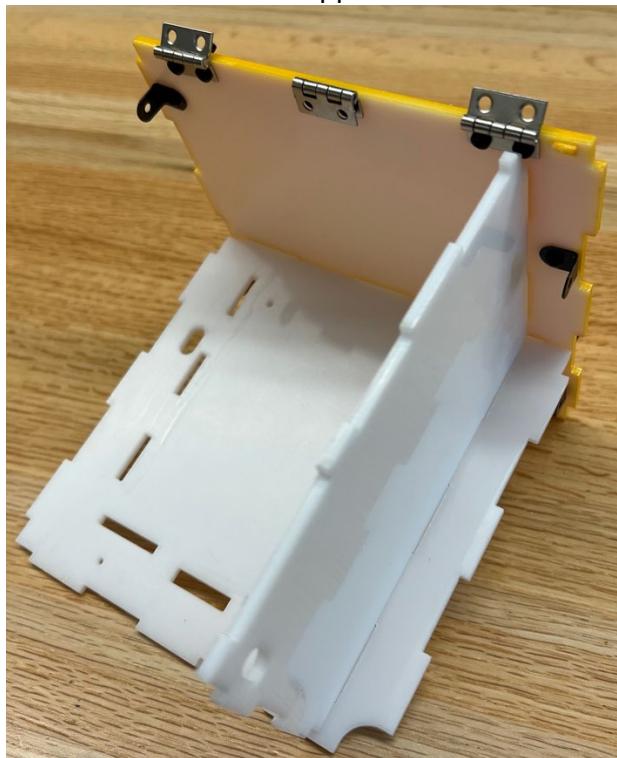
1. Orient the false bottom so that the notch is in the lower right-hand corner.



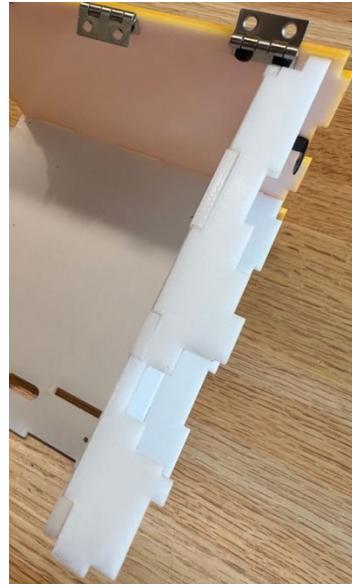
2. Place the side partition in the three rectangles on the right of the false bottom. Make sure that the slot that is near the top of the partition is on the same side as the notch.



3. Attach the back wall of the box on the side opposite of the notch.



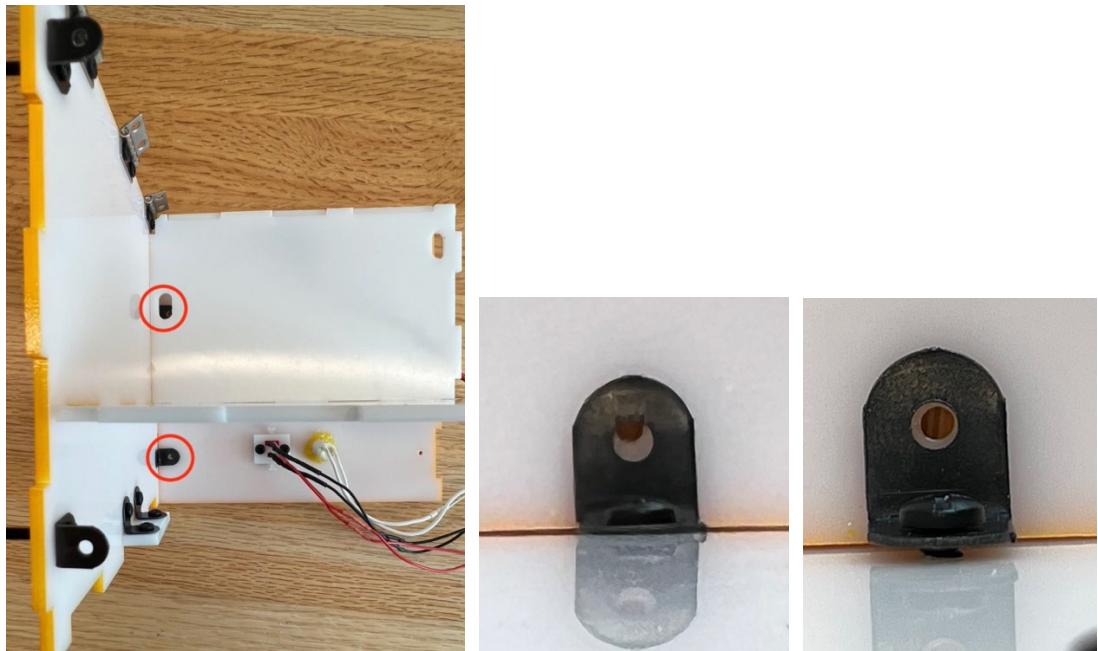
4. Insert the top of the side partition into the back wall and side partition.



5. Attach the right-side wall.



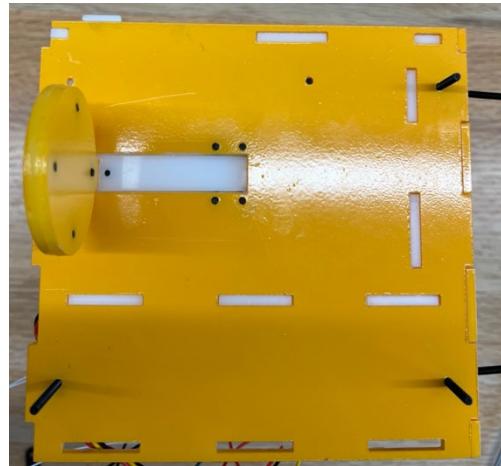
6. Align the angle brackets and the screw holes on the side wall by spinning the screws on the back wall. Once the holes line up, put screw through the angle bracket into the side wall. Snug up all the screws on that corner to make sure the box joints fit well together. Cut screws on that corner so they are flush once tight.



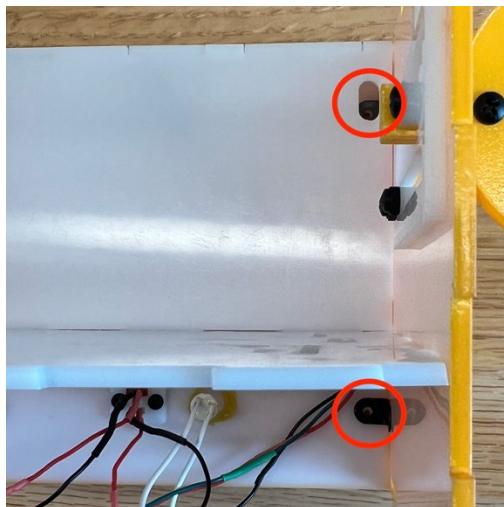
7. Ensure that the wire to the right-side wall potentiometer is seated in the notch on the false bottom.



8. Put the front of the box onto the assembly.



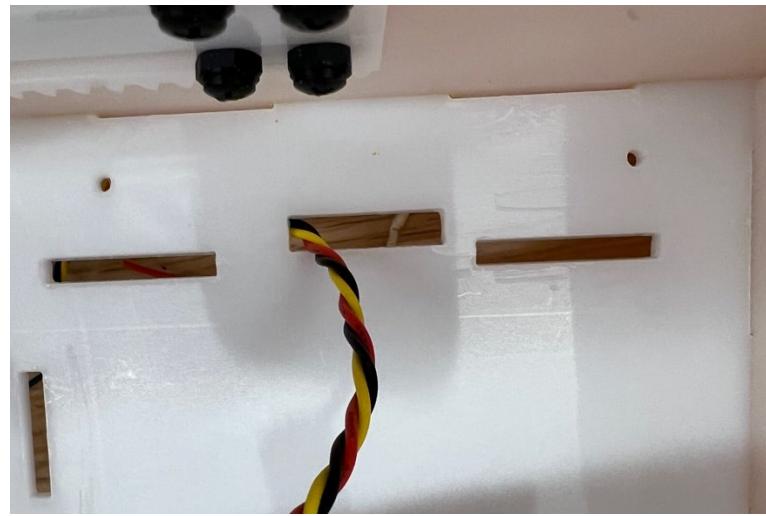
9. Align the angle brackets with the holes. Put screws in and snug up corner. Trim screws on that corner when done.



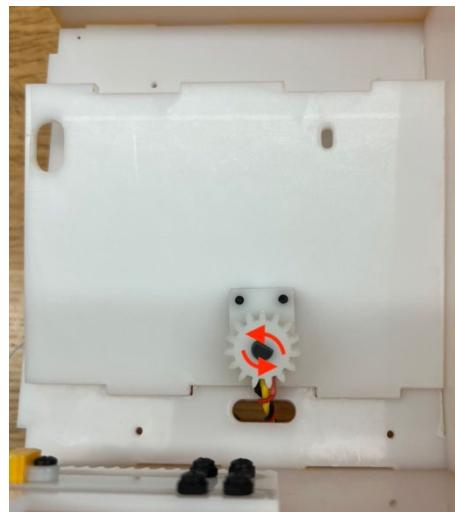
10. Attach the left side wall into the box. Snug up screws so that the edges of the box are aligned.



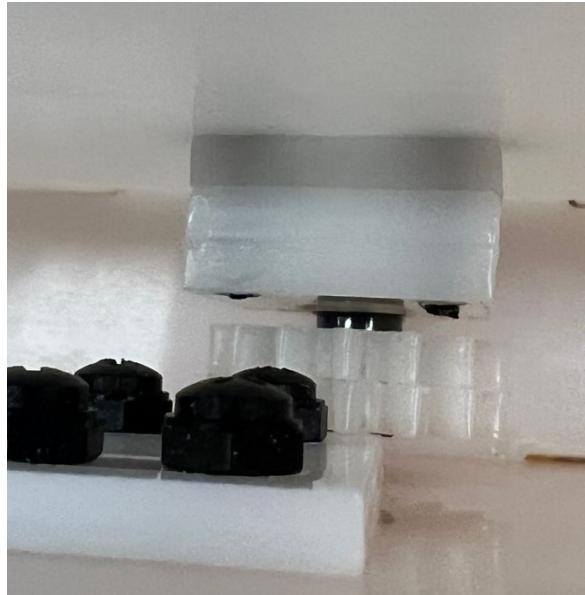
11. Feed the wires of the front partition into the false bottom.



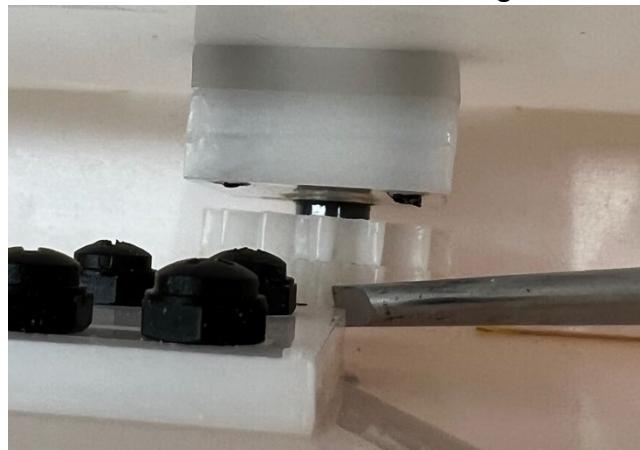
12. Spin the gears on the potentiometer counterclockwise until they stop.



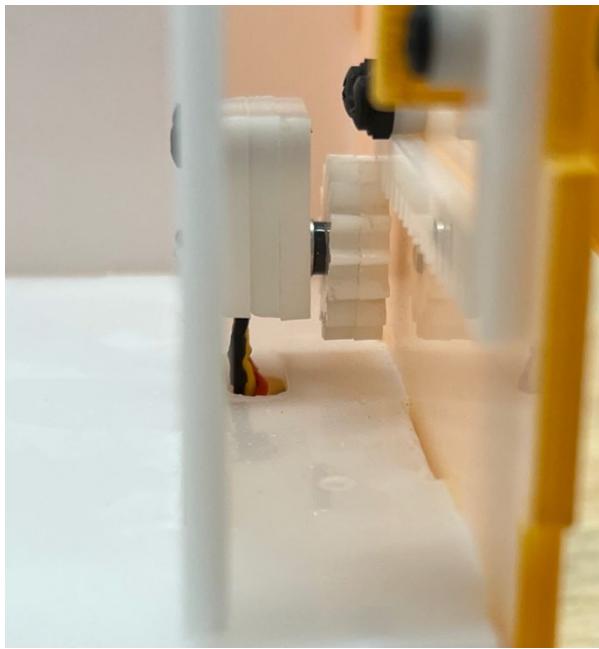
13. Slide the front slider all the way to the left. Stand the front partition upright. Note that the gear will not automatically mesh with the rack and pinion.



14. Using a long screwdriver or pick, push down on the gear closest to the rack and pinion. It might need to be moved side to side to mate the teeth together.



15. Once the gear and pinion have meshed, move the slider side to side and make sure gear is engaged properly.



16. Place the top of the front partition into the front wall and front partition.



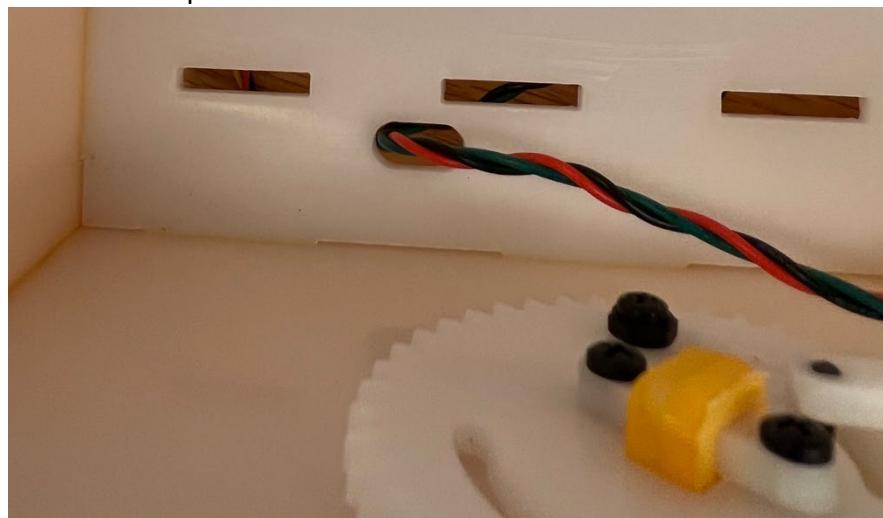
17. Put a screw into the small slot on the inside of the front partition. Screw front partition and front wall together.



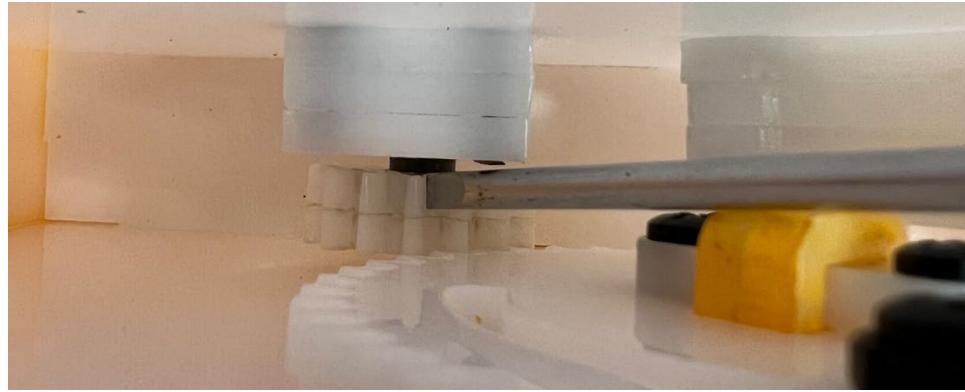
18. Put lever in the fully closed position by moving it towards the back wall of the box.



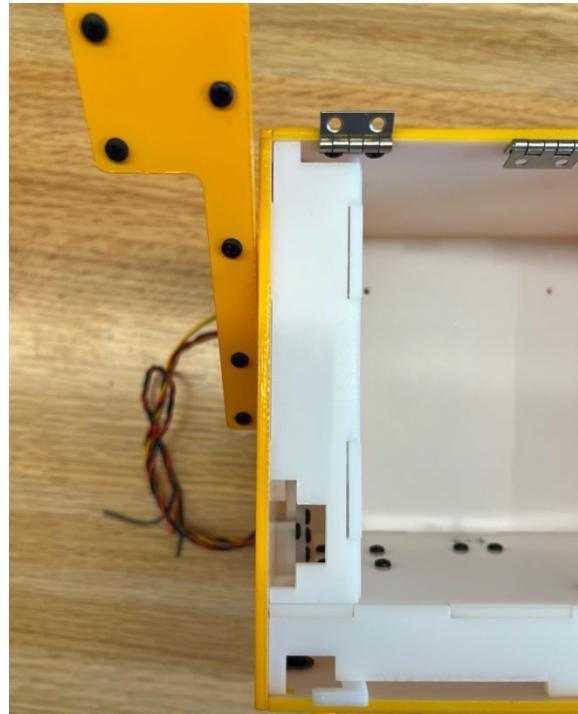
19. Feed wires for the lever partition into the slot in the false bottom.



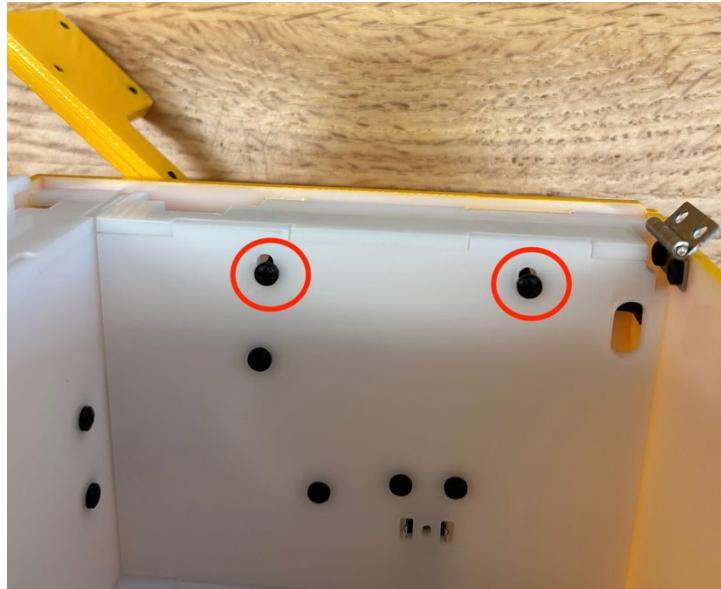
20. Spin the gear on the partition clockwise until they won't spin any further. Place the bottom of the side partition into the remaining rectangles on the false bottom. Using a screwdriver or pick mesh the gears together.



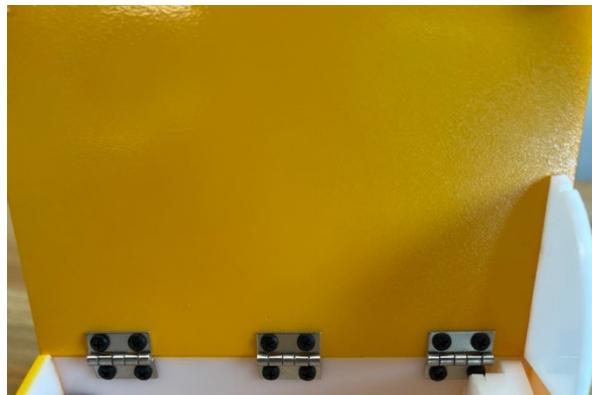
21. Put the top of the lever partition into the left side wall and push down to it is sitting in the lever partition.



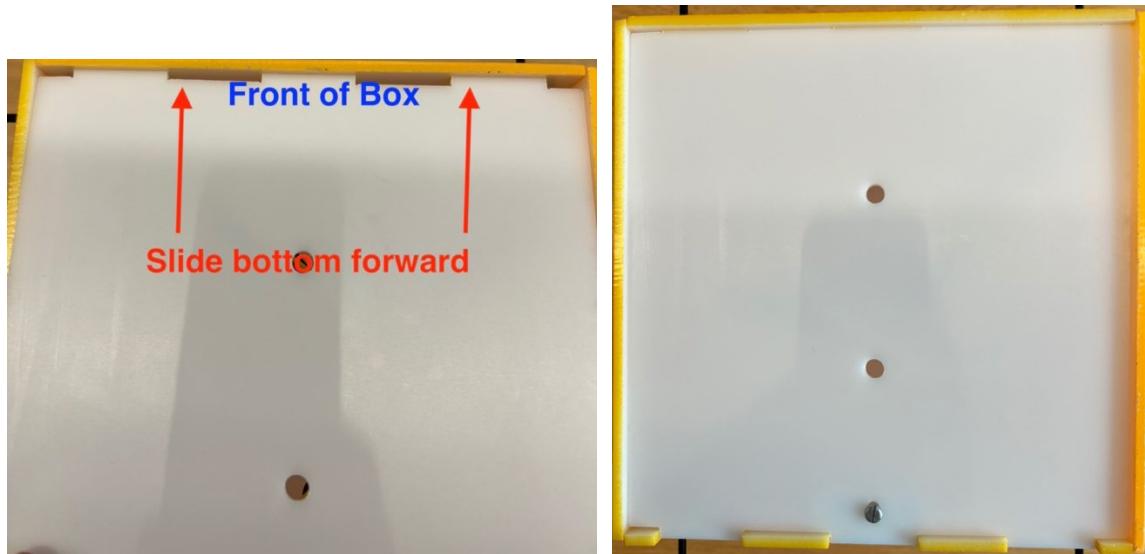
22. Put two screws into the two slots on the inside of the side partition. Screw them into the left side wall.



23. Screw the lid of the box into the hinges. Once all 6 screws are in, loosen them so the lid and move around a little bit. Hold the lid so it is open 90 degrees and tighten screws back down.



24. To install the bottom of the box, slide the protruding pieces on the opposite of the small slot into the inside of the front wall. Once in, push down on the small slot. This is very similar how the battery compartment door works on a TV remote. Using a metal 4-40 screw the bottom into the box using the small slot.



25. This box is now complete.



## Electronics Insert

The basic structure for the electronic insert is the same for all boxes, although the number of potentiometers, and therefore the number of wires routed to the Arduino varies with box design. The insert is also made of laser cut Delrin contoured to house the electronic components and to fit snugly in the 5inx5inx5in box.



Referring to the Electrical Part Index below, the component is a stack of five layers of Delrin, three of 1/8in thick sheets labeled “thick” and two layer 3/23in thick labeled “thin”. The Digital Resource folder contains SolidWorks EDRW files for each thickness that may be directly printed to a laser cutter.

The wiring diagram of the insert is shown below; but we did not provide detailed assembly instructions due to time constraints. However, we consider these neither complicated nor novel, any physical wiring configuration that implements the circuit diagram is suitable. As shown in the parts list, the most expensive components are the Arduino IoT and the linear instrumentation potentiometer. Spreadsheet image is included below, while a full spreadsheet containing links to vendor sites is included in the Digital Resource folder.

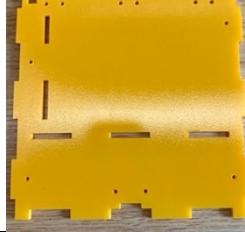
In our implementation we purchased pre-made 12-conductor ribbon cable assemblies then stripped the wires to gain access to the signals. This implemented a modular connection between the box and the insert permitting transferral between boxes. For connection to the Arduino we purchased Arduino IoTs without pins and soldered the block connector shown here.



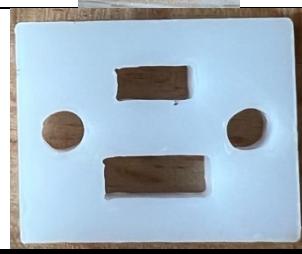
The microSD reader is purchased through the link shown below and wired as per the unit's instructions. However, as the Arduino IoT does not provide a 5V output we powered the reader directly with the 9V battery. Because this voltage is above specification we have found that the SD card can be damaged if inserted or removed with unit power on. We have witnessed no damage to the SD cards if box power is off when removing or inserting the SD card.

While we consider our hand-made electronic insert adequate for the current purposes, we acknowledge that a PCB implementation would have many advantages over ours including reduced size and greater reliability. Providing proper voltage regulation to the SD Reader card should also be implemented in future implementations.

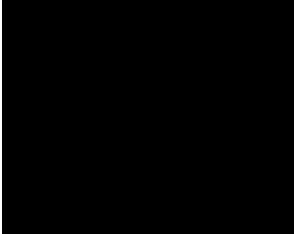
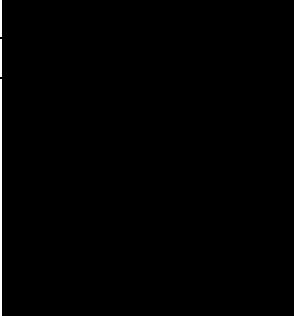
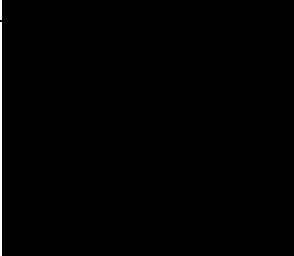
### Mechanical Part Index

	Lid Only Box	Slider Box	Lever – Slider Box
15 Tooth Gear			
45 Tooth Gear			
Bottom Mount			
Box Back			
Box Bottom			

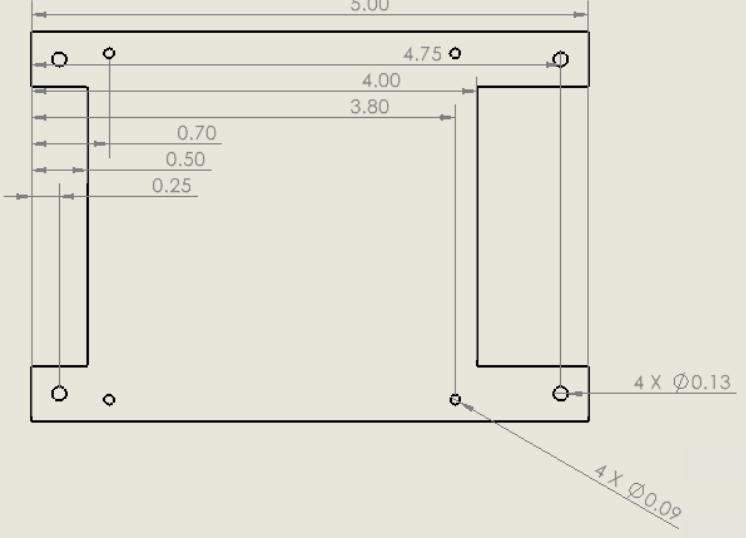
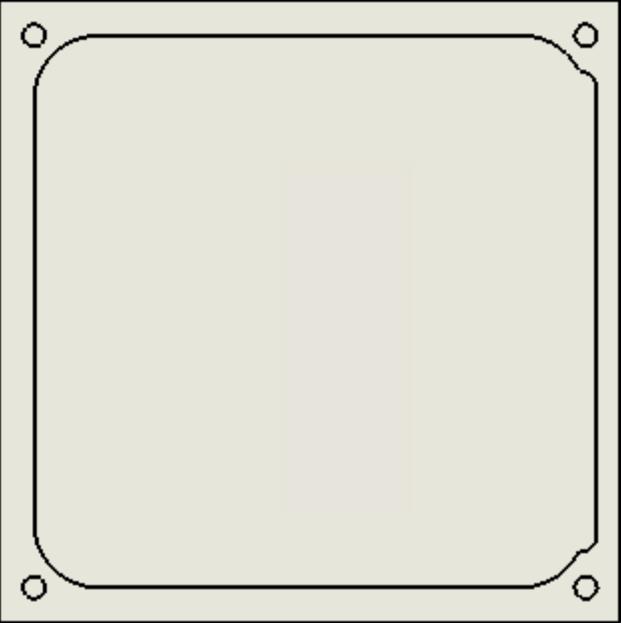
Box False Bottom			
Box Front			
Box Left Side			
Box Right Side			
Box Top/Lid			
Cam			
Front Partition			
Front Partition Top			

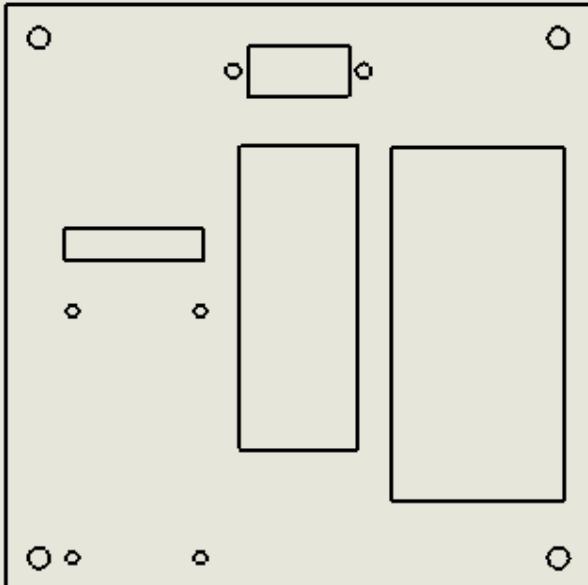
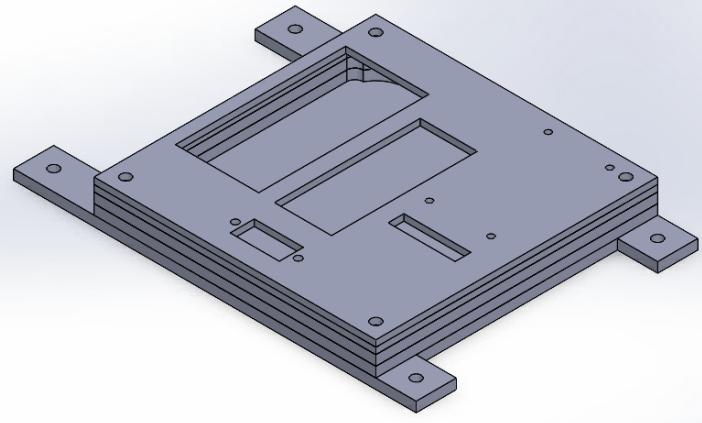
Handle Holder			
Handle Sides			
LED Insert			
Lever Arms			
Lever Arm Pin			
Lever Centering Plate			
Lever Connecting Rod			
Lever Connecting Rod Holder			

Lever Lock Prong		
Lever Lock Prong Anti-bender		
Lever Lock Prong Spacer		
Lever Partition		
Lever Partition Top		
Rotary Potentiometer Holder		

Rotary Potentiometer Spacer			
Side Partition			
Side Partition Top			
Slider Lock			
Slider Lock Latch			
Slider Tab			
Slider Tab Pin			Has a flat spot on short edge
Slot Spacer			No flat stop, also slightly shorter than Slider Tab Pin

## Electrical Part Index

<p><b>Base</b></p>	<p><b>Thick Insert.EDRW</b></p>	 <p>Technical drawing of the base component. The overall width is 5.00. There are two vertical slots on the left side with widths of 0.70 and 0.50 respectively, and a gap of 0.25 between them. On the right side, there is a slot with a width of 3.80. Four holes are located at the corners of the base, with a note indicating <math>4 \times \emptyset 0.13</math>. A dimension of 4.00 is also shown.</p>
<p><b>Wire layer:</b> 2 in 1/8in Delrin and one in 3/31in Delrin</p>	<p>Two from Thick Insert.EDRW One from Thin Insert.EDRW</p>	 <p>Technical drawing of the wire layer. It consists of a rectangular outline with four circular corner features, one at each corner.</p>

Top Layer	Thin Insert.EDRW	
Completed Assembly		

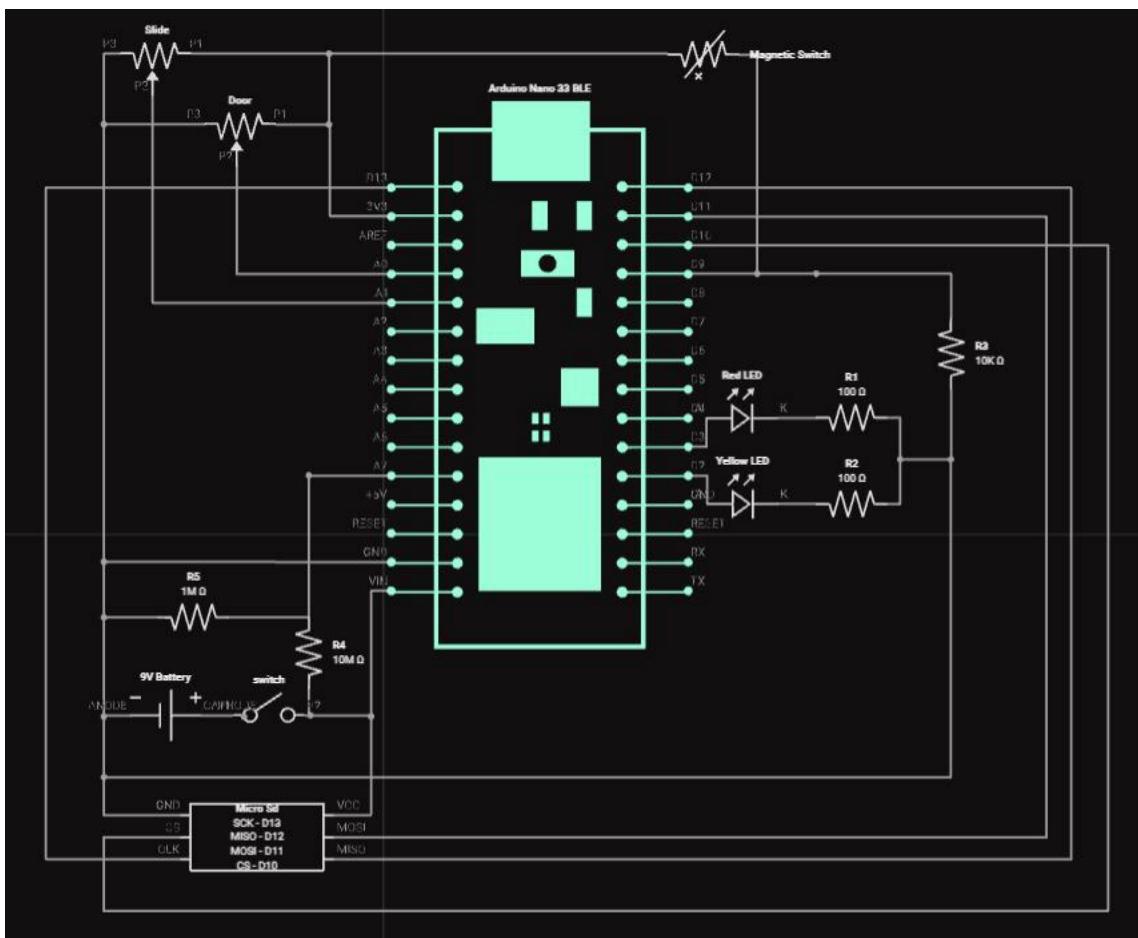


Figure 2 Electronic Insert Circuit Diagram

Part	Quantity	Each	Total	Link
Arduino Nano IoT 33	1	30.00	30.00	<a href="https://store-usa.arduino.cc/products/arduino-nano-33-iot?selectedStore=us">https://store-usa.arduino.cc/products/arduino-nano-33-iot?selectedStore=us</a> <a href="https://www.digikey.com/en/products/detail/lt-electronics-bi/404R1KL1-0/2408604?qs=N4lgTCBcDaICwAY4CUCMBpAMggdAkAugL5A">https://www.digikey.com/en/products/detail/lt-electronics-bi/404R1KL1-0/2408604?qs=N4lgTCBcDaICwAY4CUCMBpAMggdAkAugL5A</a>
Lineaar Potentiometer	1	25.66	25.66	<a href="https://www.digikey.com/en/products/detail/cui-devices/PT01-D120D-B104/15903928?utm_adgroup=General&amp;utm_source=google&amp;utm_medium=cpc&amp;utm_campaign=PMax%20Shopping_Product_Zombie%20SKU&amp;utm_term=&amp;utm_content=General&amp;qclid=Cj0KCQjwyLGIBhDKARlsAFRNqW8NZ4iDaCA2ZC4tUTGZx7CC6g5kJQfcZsLhus9MvBRBb9SSj9vQ">https://www.digikey.com/en/products/detail/cui-devices/PT01-D120D-B104/15903928?utm_adgroup=General&amp;utm_source=google&amp;utm_medium=cpc&amp;utm_campaign=PMax%20Shopping_Product_Zombie%20SKU&amp;utm_term=&amp;utm_content=General&amp;qclid=Cj0KCQjwyLGIBhDKARlsAFRNqW8NZ4iDaCA2ZC4tUTGZx7CC6g5kJQfcZsLhus9MvBRBb9SSj9vQ</a>
Rotary Potentiometer	1	1.02	1.02	<a href="https://www.digikey.com/en/products/detail/digilent-inc/410-380/9445906?utm_adgroup=Evaluation%20Boards%20-%20Expansion%20Boards%20%20Daughter%20Cards&amp;utm_source=google&amp;utm_medium=cp&amp;utm_campaign=Shopping_Product_Development%20Boards%20Kits%20Programmers&amp;utm_term=&amp;utm_content=Evaluation%20Boards%20-%20Expansion%20Boards%20%20Daughter%20Cards&amp;qclid=Cj0KCQjwyLGIBhDKARlsAFRNqWXYqXfRmYnwVfa07zQGDzlpV0Nr7Bu0NzBku3Uhyv7NU-tqMaAnnNEALw_wcB">https://www.digikey.com/en/products/detail/digilent-inc/410-380/9445906?utm_adgroup=Evaluation%20Boards%20-%20Expansion%20Boards%20%20Daughter%20Cards&amp;utm_source=google&amp;utm_medium=cp&amp;utm_campaign=Shopping_Product_Development%20Boards%20Kits%20Programmers&amp;utm_term=&amp;utm_content=Evaluation%20Boards%20-%20Expansion%20Boards%20%20Daughter%20Cards&amp;qclid=Cj0KCQjwyLGIBhDKARlsAFRNqWXYqXfRmYnwVfa07zQGDzlpV0Nr7Bu0NzBku3Uhyv7NU-tqMaAnnNEALw_wcB</a>
Micro SD Adapter	1	7.55	7.55	<a href="https://www.digikey.com/en/products/detail/american-opto-plus-gw/LYqXfRmYnwVfa07zQGDzlpV0Nr7Bu0NzBku3Uhyv7NU-tqMaAnnNEALw_wcB">https://www.digikey.com/en/products/detail/american-opto-plus-gw/LYqXfRmYnwVfa07zQGDzlpV0Nr7Bu0NzBku3Uhyv7NU-tqMaAnnNEALw_wcB</a>
Magnet Sensor	1	4.33	4.33	<a href="https://www.amazon.com/uxcell-SS12F32-G7-Position-Switch-Solder/dp/B007QAJWYWW/ref=sr_1_4?qid=1060ZVMJHTN70&amp;keywords=slide+switch&amp;qid=1684854519&amp;prefix=slide+switch%2Caps%2C83&amp;sr=8-4">https://www.amazon.com/uxcell-SS12F32-G7-Position-Switch-Solder/dp/B007QAJWYWW/ref=sr_1_4?qid=1060ZVMJHTN70&amp;keywords=slide+switch&amp;qid=1684854519&amp;prefix=slide+switch%2Caps%2C83&amp;sr=8-4</a>
Switch	1	0.35	0.35	<a href="https://www.digikey.com/en/products/detail/american-opto-plus-led/L423SRD/13556906?qs=N4lgTCBcDaIDBYwGYDKAIAlAugXyA">https://www.digikey.com/en/products/detail/american-opto-plus-led/L423SRD/13556906?qs=N4lgTCBcDaIDBYwGYDKAIAlAugXyA</a>
Red LED	1	0.80	0.80	<a href="https://www.digikey.com/en/products/detail/american-opto-plus-led/L403YD/13556905?qs=N4lgTCBcDaIDBYwAMBmAmeFRAXQLSA">https://www.digikey.com/en/products/detail/american-opto-plus-led/L403YD/13556905?qs=N4lgTCBcDaIDBYwAMBmAmeFRAXQLSA</a>
Yellow LED	1	0.35	0.35	<a href="https://www.digikey.com/en/products/detail/stackpole-electronics-inc/CF12JT100R/1741020">https://www.digikey.com/en/products/detail/stackpole-electronics-inc/CF12JT100R/1741020</a>
100 Ohm Resistor	2	0.10	0.20	<a href="https://www.digikey.com/en/products/detail/stackpole-electronics-inc/CF14JT1M0/1741316">https://www.digikey.com/en/products/detail/stackpole-electronics-inc/CF14JT1M0/1741316</a>
1M Ohm Resistor	1	0.10	0.10	<a href="https://www.digikey.com/en/products/detail/stackpole-electronics-inc/CF18JT10M0/1741568">https://www.digikey.com/en/products/detail/stackpole-electronics-inc/CF18JT10M0/1741568</a>
12 Pin Connector w/ Ribbon Cab	1	11.51	11.51	<a href="https://www.digikey.com/en/products/detail/samtec-inc/FFSD-06-S-12-00-01-N/7172197">https://www.digikey.com/en/products/detail/samtec-inc/FFSD-06-S-12-00-01-N/7172197</a>
12 Pin Adapter	1	2.37	2.37	<a href="https://www.digikey.com/en/products/detail/molex/0702461201/760167">https://www.digikey.com/en/products/detail/molex/0702461201/760167</a>
Female Crimp Pin	6	0.05	0.30	<a href="https://www.amazon.com/Cermant-400Pcs-2-54mm-Connector-Terminal/dp/B095BQDH6F/ref=asc_df_B095BQDH6F/taq=hvprod-20&amp;linkCode=df0&amp;hvadid=563688069599&amp;hvpos=&amp;hvnetw=q&amp;hvrand=15805257996927957557&amp;hvone=&amp;hvptwo=&amp;hvqmt=&amp;hvdev=c&amp;hvdvcmdl=&amp;hvlocint=&amp;hvlocphy=9002217&amp;hvtagid=pla-157078497476&amp;psc=1&amp;qclid=CjwKCAjw67ajBhAVEiwA2g_iEH6Uu3HMFadJWMhL7pvBtErK">https://www.amazon.com/Cermant-400Pcs-2-54mm-Connector-Terminal/dp/B095BQDH6F/ref=asc_df_B095BQDH6F/taq=hvprod-20&amp;linkCode=df0&amp;hvadid=563688069599&amp;hvpos=&amp;hvnetw=q&amp;hvrand=15805257996927957557&amp;hvone=&amp;hvptwo=&amp;hvqmt=&amp;hvdev=c&amp;hvdvcmdl=&amp;hvlocint=&amp;hvlocphy=9002217&amp;hvtagid=pla-157078497476&amp;psc=1&amp;qclid=CjwKCAjw67ajBhAVEiwA2g_iEH6Uu3HMFadJWMhL7pvBtErK</a>
Empty 6 Pin Adapter	1	0.05	0.05	<a href="https://www.digikey.com/en/products/detail/duracell-industrial-operations-inc/PC1604/16344168">https://www.digikey.com/en/products/detail/duracell-industrial-operations-inc/PC1604/16344168</a>
9V Battery	1	3.04	3.04	<a href="https://www.digikey.com/en/products/detail/keystone-electronics/235/303806">https://www.digikey.com/en/products/detail/keystone-electronics/235/303806</a>
9V Battery Connector	1	0.56	0.56	<a href="https://www.digikey.com/en/products/detail/on-shore-technology-inc/OSTVN02A150/1588862">https://www.digikey.com/en/products/detail/on-shore-technology-inc/OSTVN02A150/1588862</a>
<b>Total Cost =</b>		<b>94.73</b>		

Figure 3 Electrical Parts list with cost and source

Part	Quantity	Individual Cost	Absolute Cost	Link
Hinges	1	\$4.99	\$4.99	<a href="https://www.amazon.com/National-Hardware-N211-012-Hinges-Nickel/dp/B00R10RU4">https://www.amazon.com/National-Hardware-N211-012-Hinges-Nickel/dp/B00R10RU4</a>
1/8th Delrin	2	\$40.06	\$80.12	<a href="https://www.mcmaster.com/catalog/129/4072/8573K3">https://www.mcmaster.com/catalog/129/4072/8573K3</a>
Behr Spray Paint	1	\$5.98	\$5.98	<a href="https://www.homedepot.com/p/BEHR-PREMIUM-12-oz-P250-7-Blazing-Bonfire-Gloss-Interior-Exterior-Spray-Paint-and-Primer-in-One-Aerosol-B000644/310275448">https://www.homedepot.com/p/BEHR-PREMIUM-12-oz-P250-7-Blazing-Bonfire-Gloss-Interior-Exterior-Spray-Paint-and-Primer-in-One-Aerosol-B000644/310275448</a>
4-40 Plastic Screws (100 ct)	1	\$8.92	\$8.92	<a href="https://www.mcmaster.com/catalog/129/396/94735AT725?qs=plastic+screws">https://www.mcmaster.com/catalog/129/396/94735AT725?qs=plastic+screws</a>
4-40 Plastic Nuts (100 ct)	1	\$3.69	\$3.69	<a href="https://www.mcmaster.com/catalog/129/358/98886A819?qs=plastic+screws">https://www.mcmaster.com/catalog/129/358/98886A819?qs=plastic+screws</a>
3-48 Screws (100 ct)*	1	\$6.07	\$6.07	<a href="https://www.amazon.com/Machine-Finish-B18-6-3-Slotted-Threaded/dp/B00F35VVV4/ref=sr_1_2?qs=ts&amp;content_id=amzn1.sym.918a99dd-4826-4c0a-be33-a6705d694cf%3Aamzn1.sym.918a99dd-4826-4c0a-be33-a6705d694cf&amp;keywords=Screws&amp;pd_rd_i=cfdeeb99-1e2c-4a61-b77b-608b9a8e1eb2&amp;pd_rd_w=b7paO&amp;pd_rd_wg=SvpCV&amp;pf_rd_p=918a99dd-4826-4c0a-be33-a6705d694cf&amp;pf_rd_r=2S77ZVWMRCXBHKVQ7QT&amp;pid=zKR10D&amp;qid=1685569745&amp;refinements=p_n_feature_fourteen_browse-bin%3A11433953011%2Cp_n_feature_twenty-eight_browse-bin%3A19043640011%7C19043642011&amp;s=industrial&amp;r=1-2&amp;t_id=16403531">https://www.amazon.com/Machine-Finish-B18-6-3-Slotted-Threaded/dp/B00F35VVV4/ref=sr_1_2?qs=ts&amp;content_id=amzn1.sym.918a99dd-4826-4c0a-be33-a6705d694cf%3Aamzn1.sym.918a99dd-4826-4c0a-be33-a6705d694cf&amp;keywords=Screws&amp;pd_rd_i=cfdeeb99-1e2c-4a61-b77b-608b9a8e1eb2&amp;pd_rd_w=b7paO&amp;pd_rd_wg=SvpCV&amp;pf_rd_p=918a99dd-4826-4c0a-be33-a6705d694cf&amp;pf_rd_r=2S77ZVWMRCXBHKVQ7QT&amp;pid=zKR10D&amp;qid=1685569745&amp;refinements=p_n_feature_fourteen_browse-bin%3A11433953011%2Cp_n_feature_twenty-eight_browse-bin%3A19043640011%7C19043642011&amp;s=industrial&amp;r=1-2&amp;t_id=16403531</a>
Wood Screws(100 ct)*	1	\$5.70	\$5.70	<a href="https://www.amazon.com/Steel-Finish-Phillips-Thread-Length/dp/B00GI8BB6U/ref=sr_1_2?content_id=amzn1.sym.918a99dd-4826-4c0a-be33-a6705d694cf%3Aamzn1.sym.918a99dd-4826-4c0a-be33-a6705d694cf&amp;keywords=Screws&amp;pd_rd_i=026a840d-3e00-4fe7-b77f-675e6a156279&amp;pd_rd_w=wQAT&amp;pd_rd_wg=adRc&amp;pf_rd_p=918a99dd-4826-4c0a-be33-a6705d694cf&amp;pf_rd_r=82FG5DPDXZB4H076CC8X&amp;pid=7EXcCiF&amp;qid=1685561232&amp;refinements=p_n_feature_twenty-eight_browse-bin%3A19043661011%2Cp_n_feature_five_browse-bin%3A3177285011%2Cp_n_feature_thirteen_browse-bin%3A15245615011&amp;s=industrial&amp;r=1-2">https://www.amazon.com/Steel-Finish-Phillips-Thread-Length/dp/B00GI8BB6U/ref=sr_1_2?content_id=amzn1.sym.918a99dd-4826-4c0a-be33-a6705d694cf%3Aamzn1.sym.918a99dd-4826-4c0a-be33-a6705d694cf&amp;keywords=Screws&amp;pd_rd_i=026a840d-3e00-4fe7-b77f-675e6a156279&amp;pd_rd_w=wQAT&amp;pd_rd_wg=adRc&amp;pf_rd_p=918a99dd-4826-4c0a-be33-a6705d694cf&amp;pf_rd_r=82FG5DPDXZB4H076CC8X&amp;pid=7EXcCiF&amp;qid=1685561232&amp;refinements=p_n_feature_twenty-eight_browse-bin%3A19043661011%2Cp_n_feature_five_browse-bin%3A3177285011%2Cp_n_feature_thirteen_browse-bin%3A15245615011&amp;s=industrial&amp;r=1-2</a>

\*could buy at local hardware store for much cheaper as only a few are needed

Total Cost = \$115.47

Total Cost w/o unnecessary items = \$100.01

Figure 4 Mechanical Parts list with source and cost