Advanced Computer Applications: Major Project Report

Leapster 2 Reverse Design
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Figure 1: Leapster 2 top shell rendering. Source: Author

Introduction

The part that was chosen to be reverse designed was a Leapster 2. Leapster 2 consoles are made by the company Leapfrog, and peaked in popularity in the early 2000's. They are handheld educational gaming consoles, designed specifically for young children. They have an overall rectangular shape with large curves and radii across all edges. The body of the device is thick, which improves its durability for the targeted user, and allows all the internal components to fit. There is over-molded rubbery plastic on either side of the console to enhance the user's grip. The square screen lies inset in the centre of the device. The top surface on the body flows down to the screen level with an angled surface. On either side of the display there are control buttons, as well as on the bottom of the device. The console also includes a pen, speaker, game cartridge slot, and battery compartment. The overall design allows for an ergonomic, fun learning device for children (see figure 2).

Figure 2: Leapster 2 product orthographic views. Source: Author

Part Measurements

Measuring Process:

The part was measured using a 3D scanner, which provided a scaled surface body that I could use to reference the part's features. While the basic shape was derived from the surface geometry of the 3D scan, the overall dimensions were carefully measured with calipers to ensure greater precision.

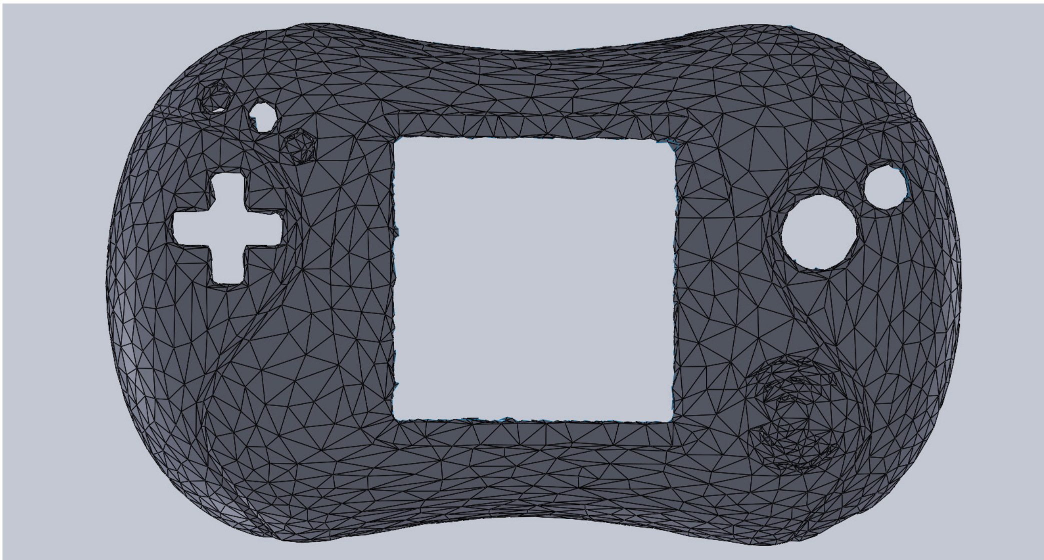


Figure 3: 3D scan front view of the Leapster 2. Source: Author

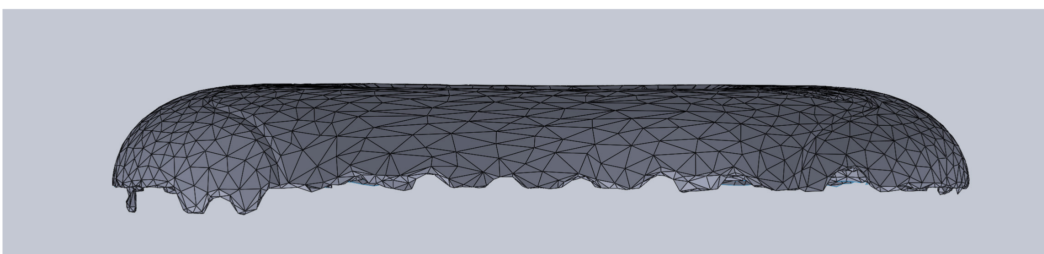


Figure 4: 3D scan bottom view of the Leapster 2. Source: Author

Challenges with the Measuring Process:

The shadows and depth of the back of the part made it difficult for the scanner to pick up on the details (see figure 5). The ribs that were sticking up created difficult to scan areas. This is because not all three of the cameras could pick up on the same spot at once. I was able to simplify the ribs and bosses for the scope of this project, however if I were to model them in their entirety, it would have required a secondary method of measurement. The features on the back that were included in the model were measured using calipers and the position was referenced from other modelled features.

Another challenge of the scanner was the general imperfections throughout the whole surface body. The scanner was not perfect, and the Solidworks software could only handle a lower resolution file. Therefore, to work around these imperfections it required many details to be measured with calipers.

In addition, a challenge that was discovered during the modelling process was the fact that the part is not symmetrical about both axes. When I purchased the part I thought I would be modeling one corner and mirroring it twice, however the scan of the part demonstrated that one side was slightly larger. This concluded that half the part had to be modeled.

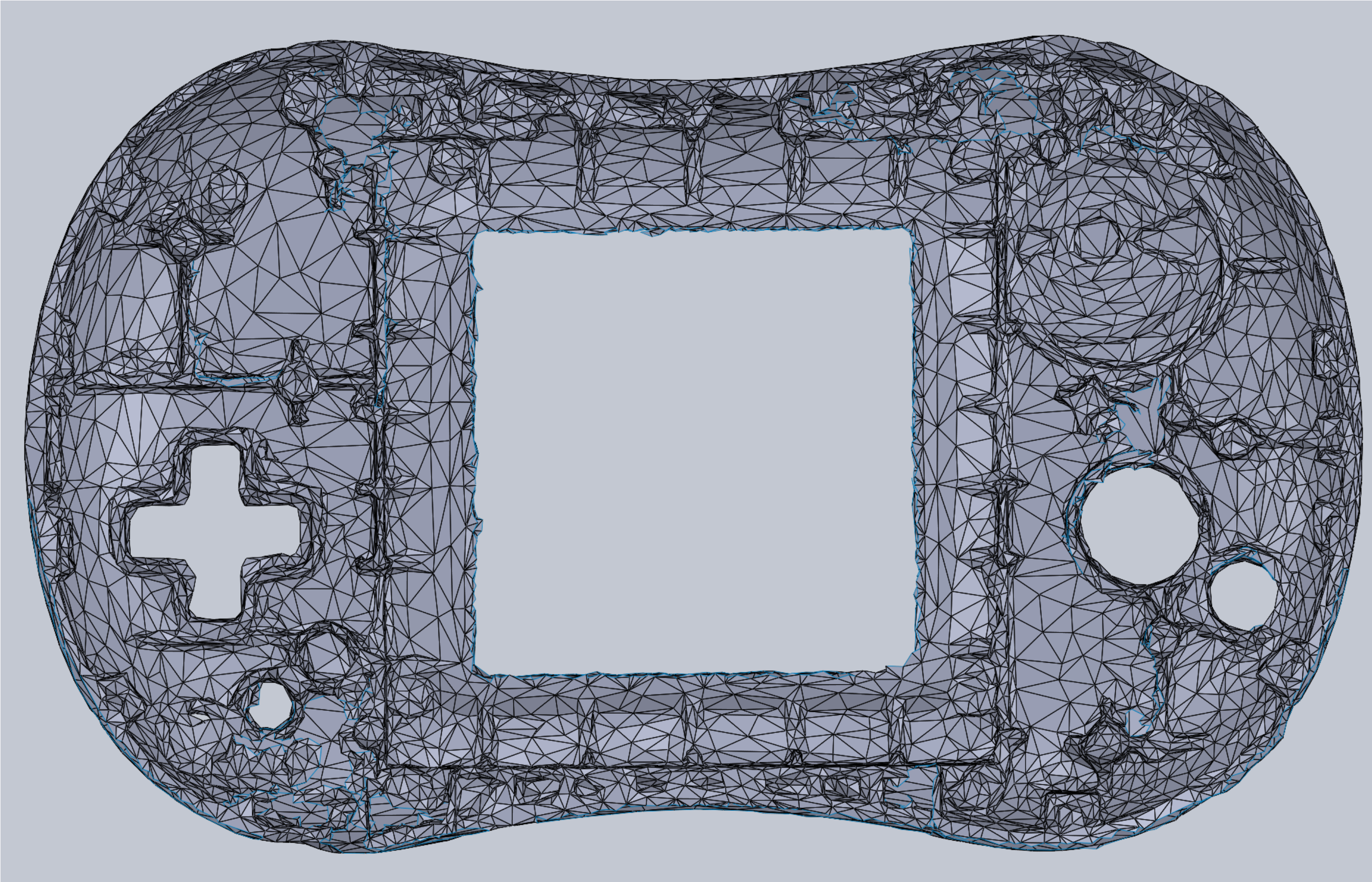
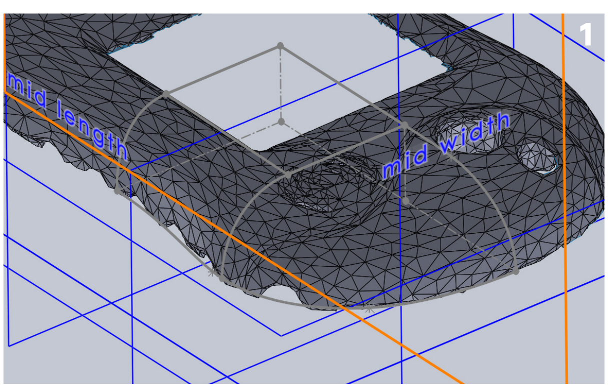


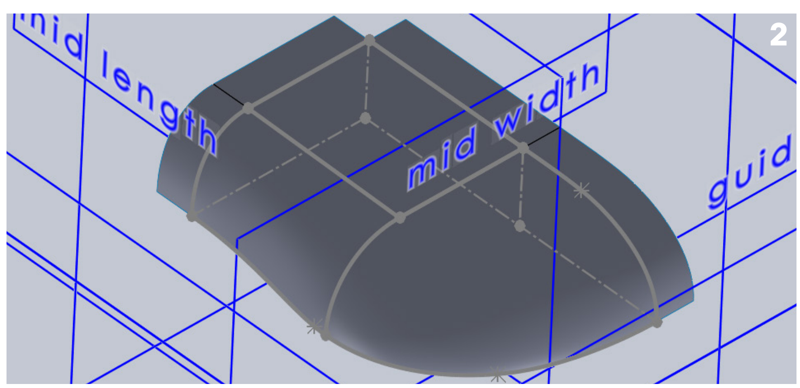
Figure 5: 3D scan back view of the Leapster 2, rib details are imprecise. Source: Author

Did the Measuring Plan Change Since the Initial Report?
To measure the part most efficiently I shifted from making a point cloud on the mill, to 3D scanning the part. I diverged from using the mill after speaking to Paul. He recommended the 3D scanner over the mill due to its simplicity, and accuracy. I wanted to choose the most efficient way to measure the part so I could have more time on the modeling stage. Therefore to ensure the best results, I diverged to using the 3D scanning technique.

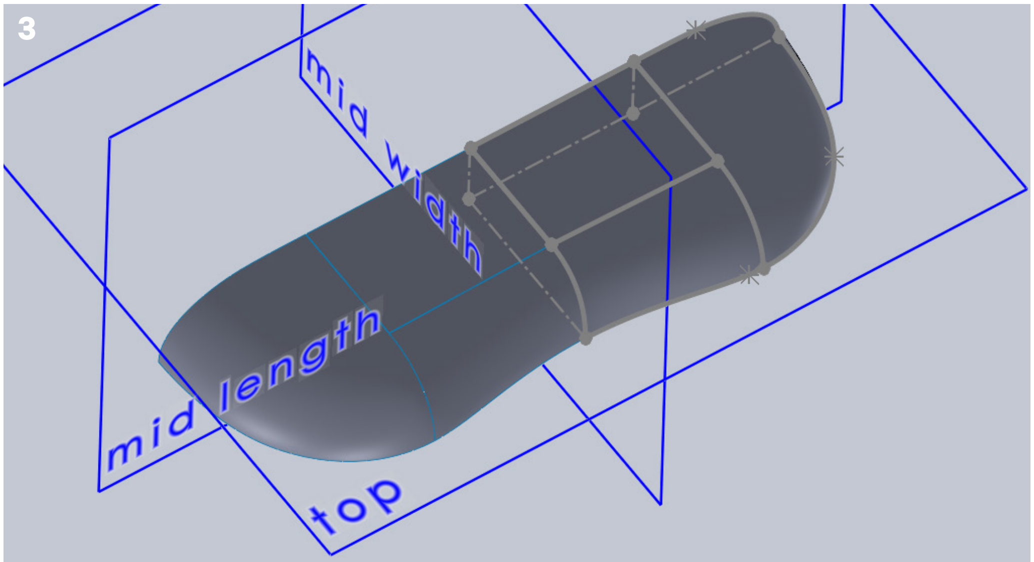
SolidWorks Part Design



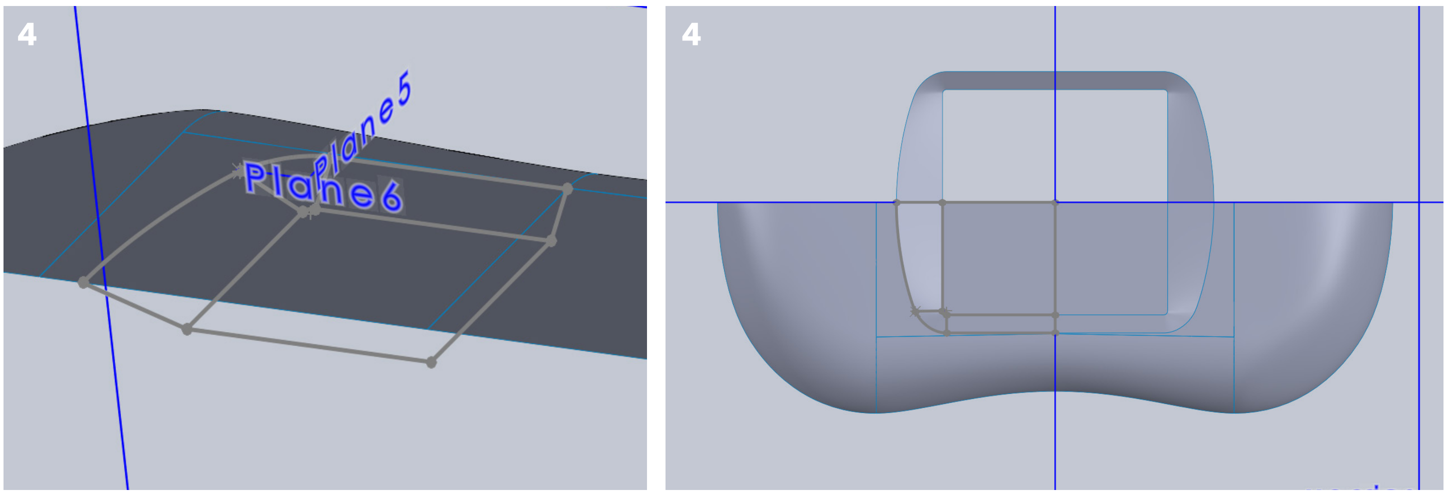
1. Laying out the guide curves on one corner of the part. There was a guide curve for the bottom profile, both middle profiles, and one parallel to the midwidth, at the widest point of the part.



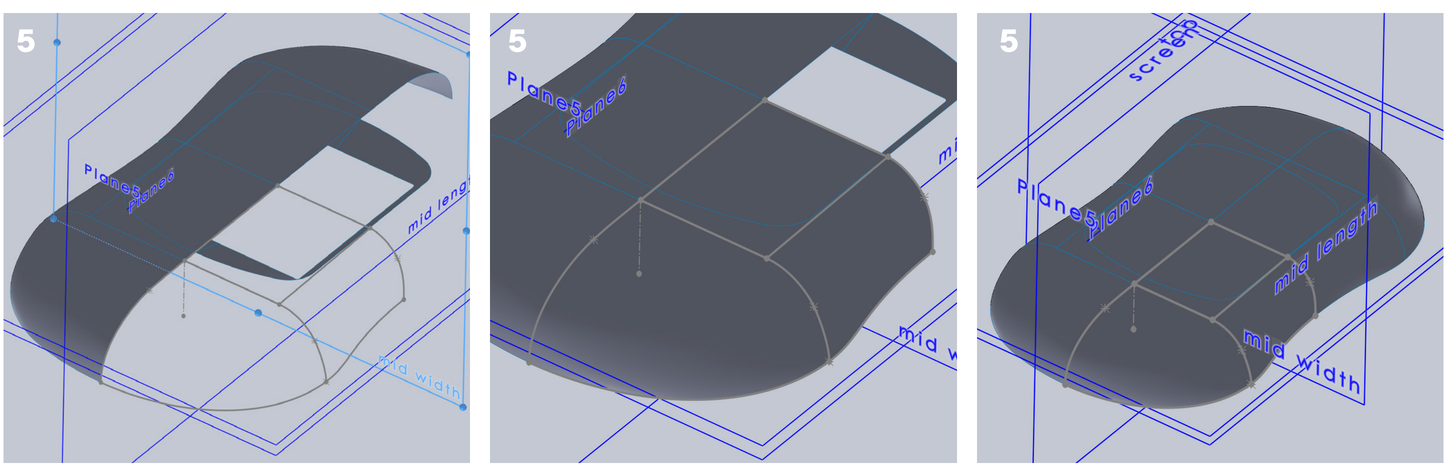
2. A planar surface was made on the top of the product. Two boundary surfaces were made, one from the mid-width plane sketch to the guide plane sketch, and one to define the corner of the model. Shown are the extruded surfaces used to create proper continuity.



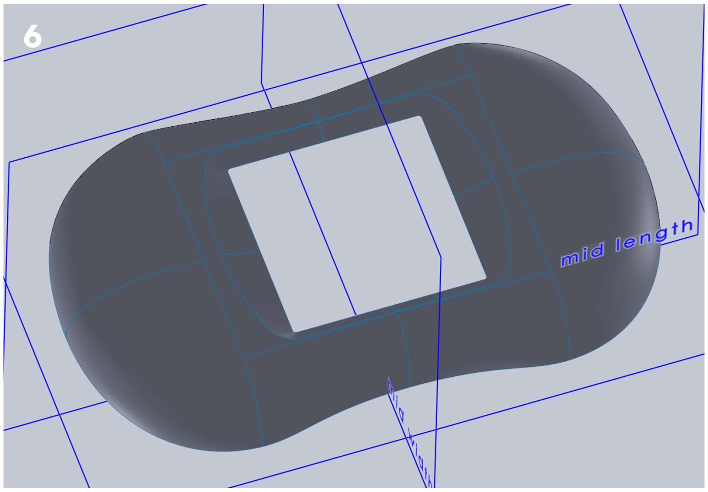
3. This surface body was then mirrored across the mid-width plane.



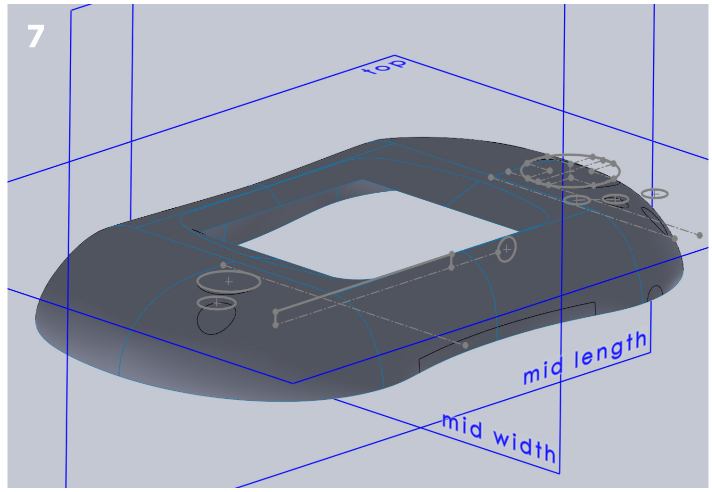
4. Next, guide planes and sketches were created for the screen. Planes were needed to define the corner, using sketches. And profiles were made at both heights of the ledge. This was then lofted and mirrored across both middle planes.



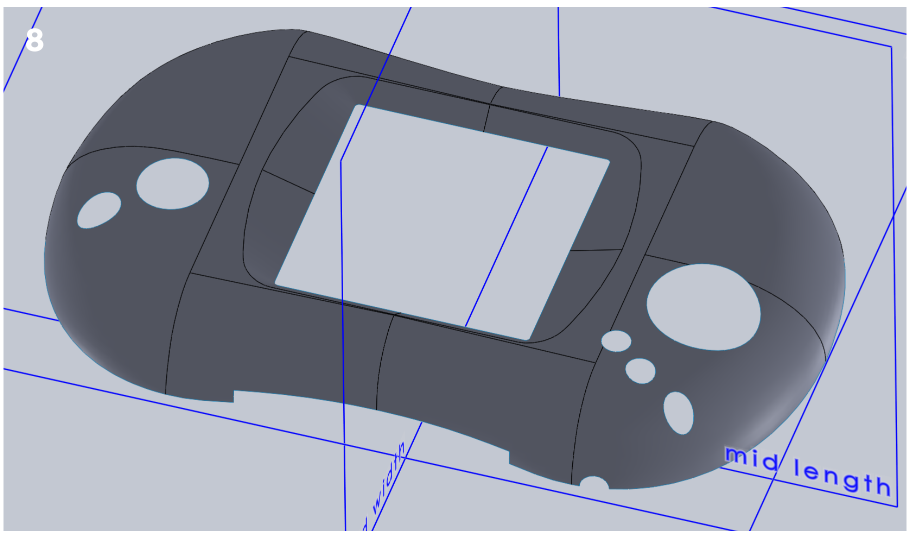
5. The guide curves for the second half of the model were drawn very similarly to the first side. The drawings were mirrored from the first side and adjusted to be slightly longer, accounting for the slightly wider geometry. The sketches were made into surfaces using the planar and boundary surface tools. This was then mirrored across the mid-width plane.



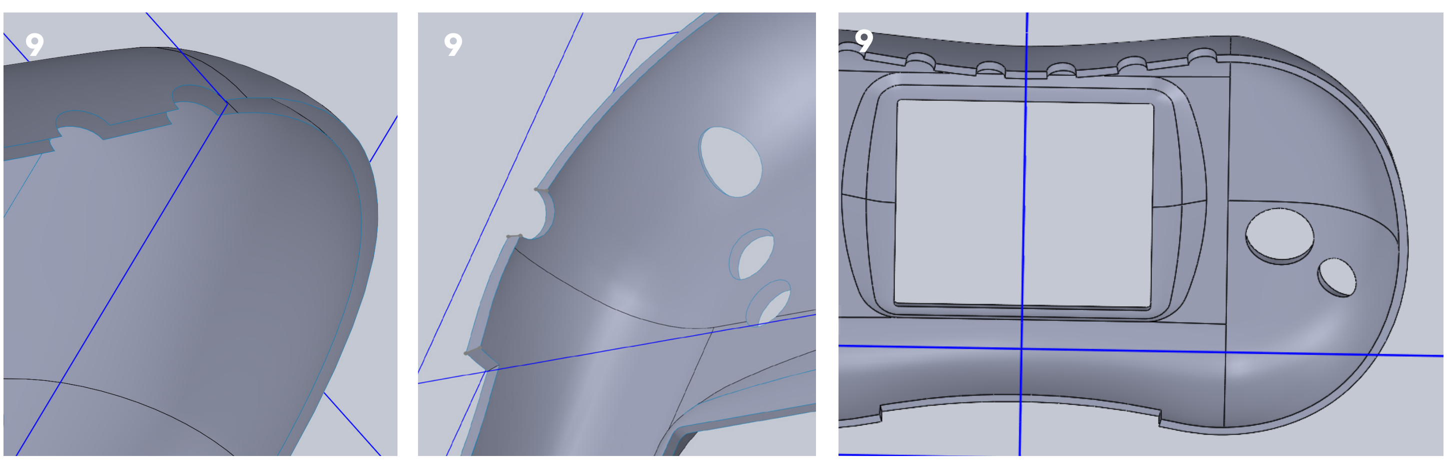
6. A mutual surface trim was used to achieve the transition from the body to the screen.



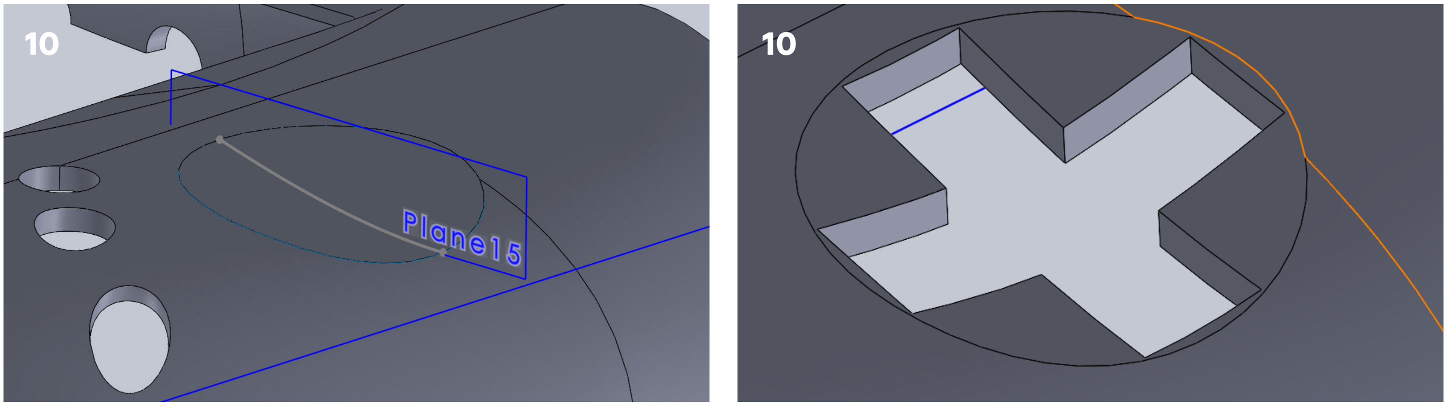
7. Using calipers and the 3D scan for reference, the cut out features were sketched on the mid length and mid width planes. Using the split feature, the sketches were cut onto the surface.



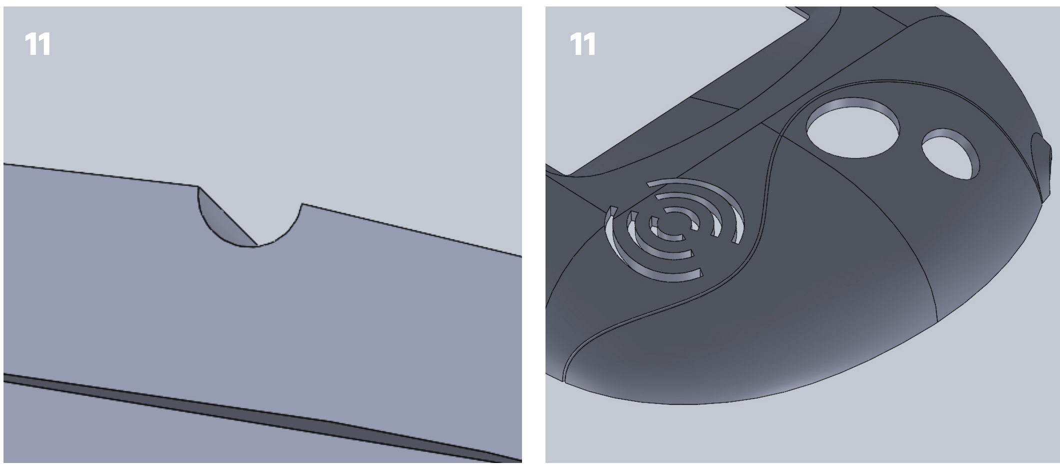
8. Delete face was used to remove the cut outs from the previous step, and the surfaces were knit together to form a single surface body.



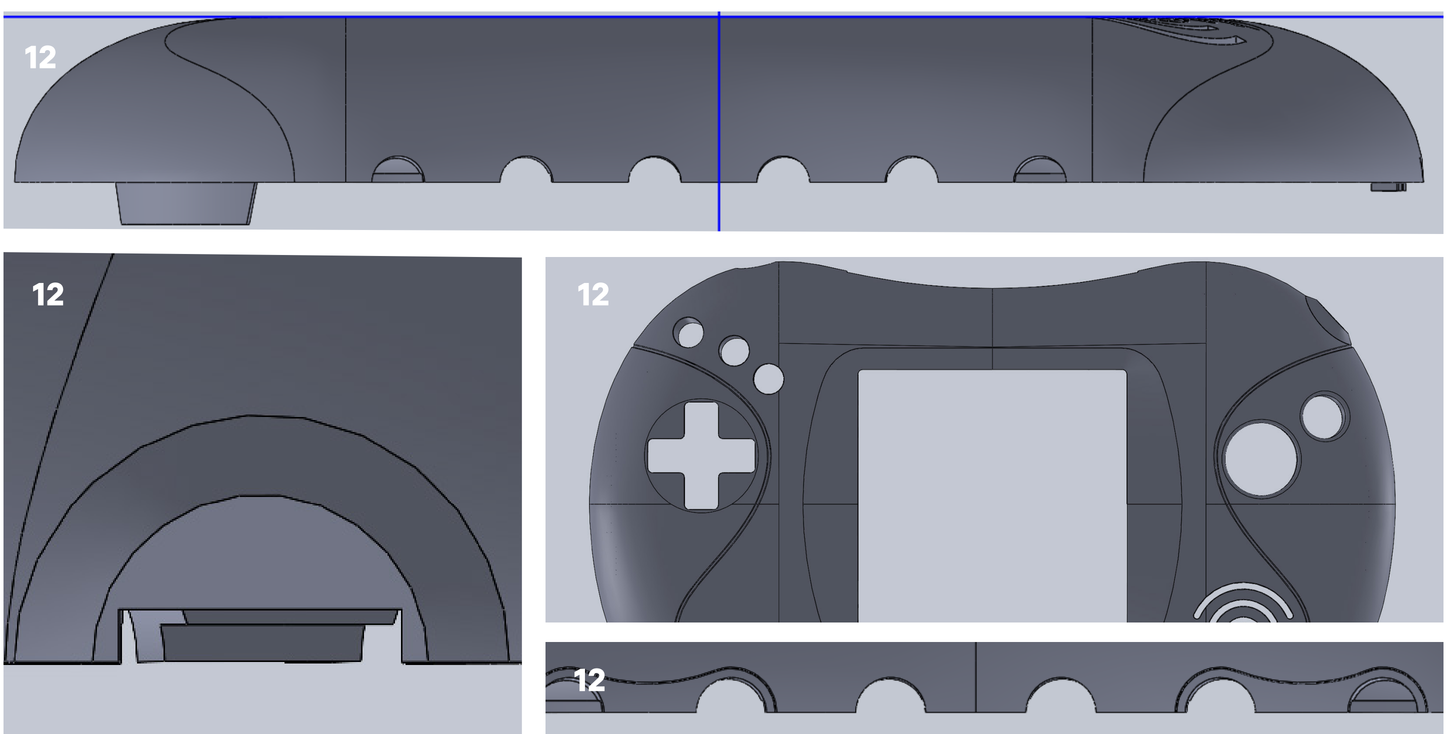
9. The thicken feature did not work, likely due to tight radii. Therefore a work around was created to turn the part into a solid. First, a surface offset was completed to the desired thickness. After, a lofted surface around the edge was used to fill the gap. Once this airtight surface body was created, they were knitted together and converted into a solid.



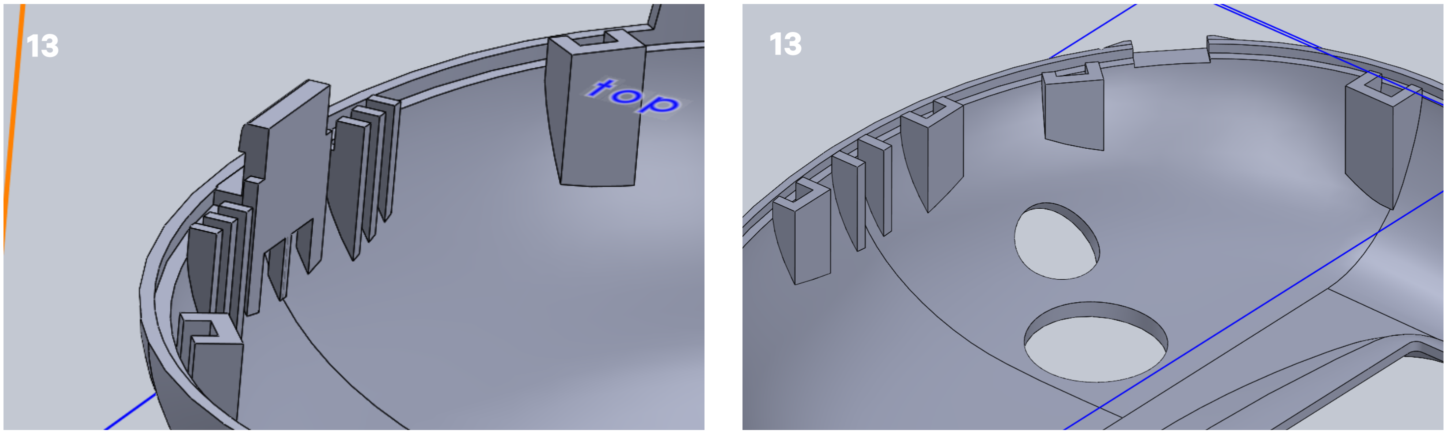
10. To create the inset surface where the button lies, a guide curve was used to create a surface fill. This was then thickened to match the rest of the part. Lastly a boss extrude was used to cut the cross button shape.



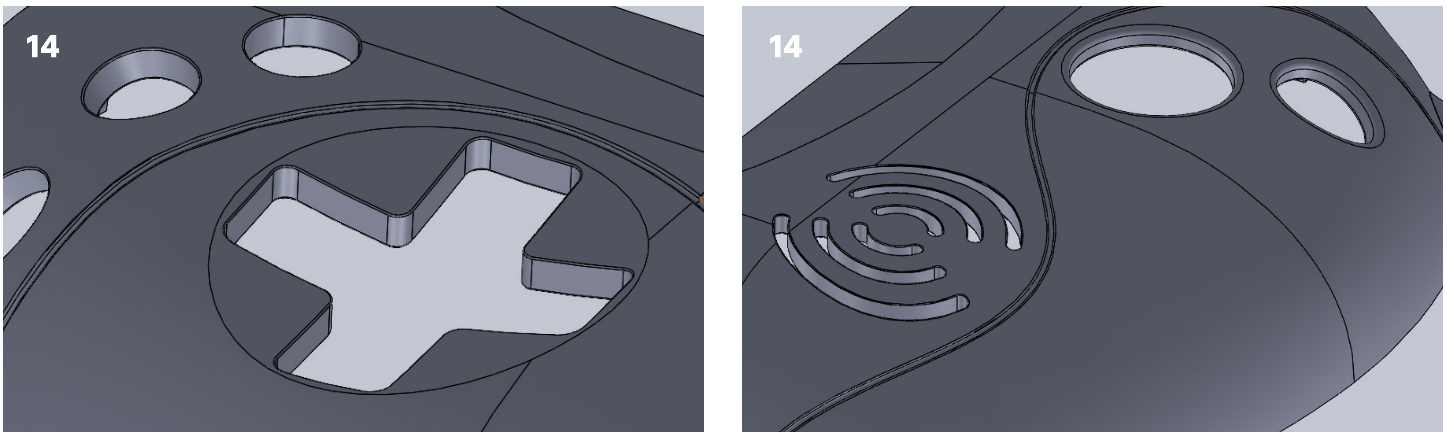
11. The indent of the over-molded feature was created using a swept cut along a 3D sketch.



12. Summary - The other A-Surface features were created using a variety of different tools; boss extrudes, extrude cuts, lofts and split lines.



13. Summary - The ribs, bosses, and other internal features were created using boss extrudes and extrude cuts.



14. The finishing details consisted of fillets along each edge and chamfers where necessary.

Analysis and Iterations:

Figure 6: Two initial 3D printed parts. Source: Author

The first print completed used white filament, pictured on the right (see figure 6). This print finished with bad A-surface quality, so it was reprinted in a different orientation, angled upwards at a 45 degree angle. In addition, the plastic was switched to a shimmery filament, which creates the illusion that there are no print layers. This print orientation allowed me to achieve an improved surface quality all over (see figure 6).

Analyzing Initial Model: Overall, the outer dimensions fit very nicely together, the edges lined up in most areas, and the curvature was continuous from the bottom of the part to the top (see figure 7 and 8).

Figure 7: Side view of initial 3D print. Source: Author

Figure 8: Top view of initial 3D print. Source: Author

One of the incorrect measurements, were the areas with holes that did not quite match up. This can be seen on the rectangular cartridge slot that is slightly offset to the left (see figure 9). This needed to be adjusted in the final model.

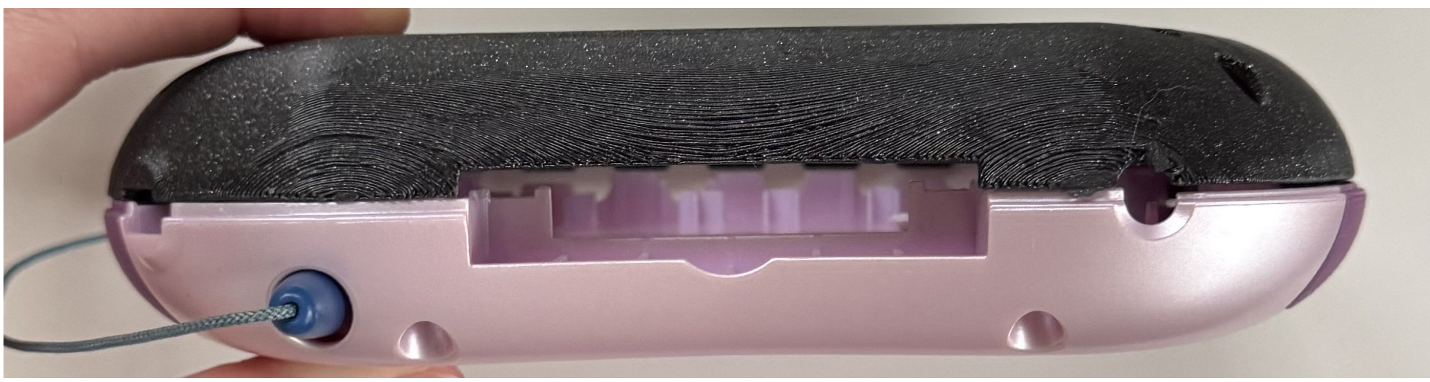


Figure 9: Top view of initial 3D print, cartridge slot does now line up. Source: Author

The hole that lines up with the pen rope slot was overlooked in the modeling process, therefore this side of the part did not sit flush (see figure 10). This cutout had to be made before printing the final model. The buttons that sit in a line across the bottom were slightly offset to the left (on the left side), and to the right (on the right side). These needed to be adjusted accordingly on the final model (see figure 11).

Figure 10: Side view of initial 3D print, hole cut out is missing. Source: Author

Figure 11: Bottom view of initial 3D print, button holes are not matching up in some instances. Source: Author

Analyzing Final Model: The outer dimensions fit very nicely, similar to the initial models. The outer edges lined-up throughout the whole model (see figure 12). Despite being printed in the same orientation, the surface quality of the edges did not turn out as cleanly as the initial print. The outer shell turned out very smooth and the curvature looked continuous from the bottom shell to the printed shell.

Figure 12: Front view of final 3D print, fits well on bottom housing. Source: Author

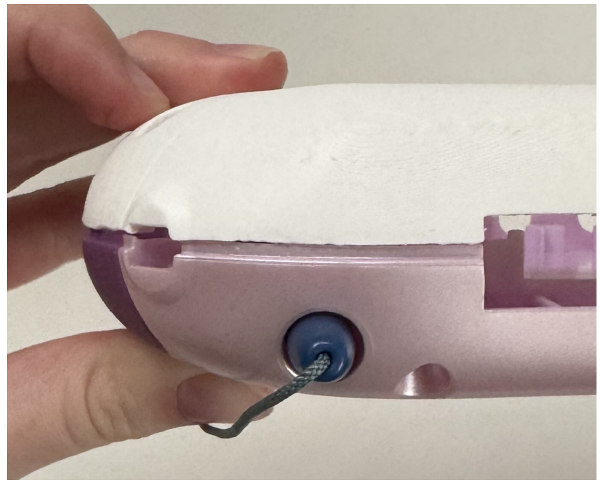


Figure 13: Top view of final 3D print, gap created by inner rib fit. Source: Author

The side of the part shown in figure 13 lined up fairly well, however the rib thickness was slightly too large causing it to knock up against the rib on the other side of the part. This created a slight gap between the parts. The other sides fit very well to the bottom housing (see figure 14 and 15). Offsetting the rectangular cartridge cut-out worked nicely to create a better line up (see figure 14).

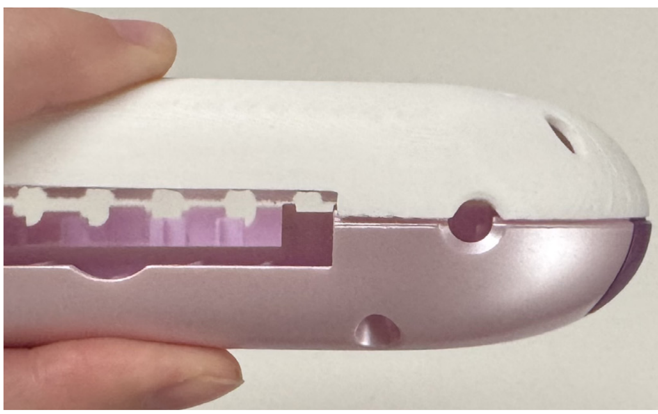


Figure 14: Top view of final 3D print, nice line up on the cartridge slot. Source: Author

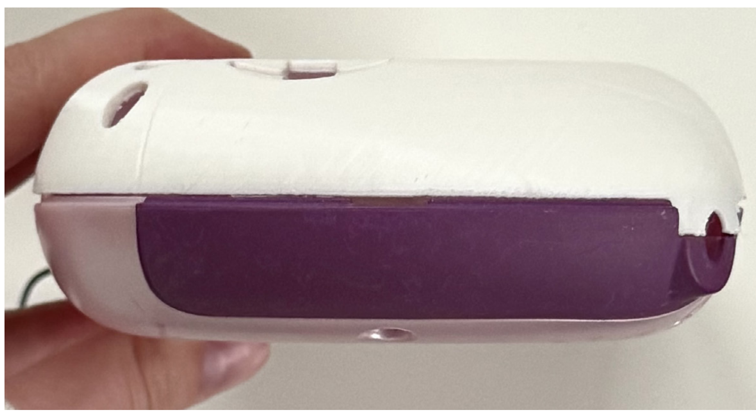


Figure 15: Side view of final 3D print, good fit and seamless curvature. Source: Author

The added hole cut out in the final model allowed for a much better overall fit. Additionally, adjusting the button holes was successful, as seen in figure 16.

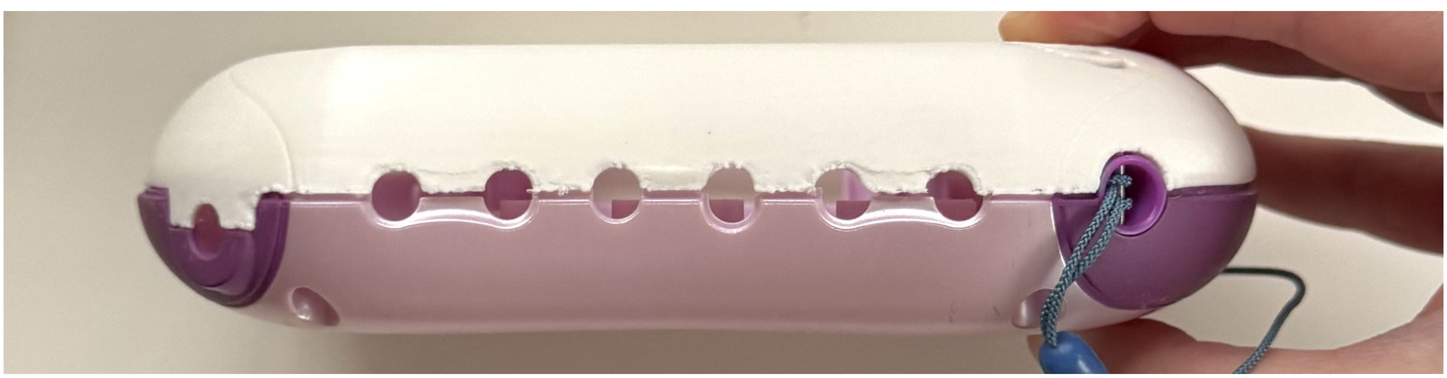


Figure 16: Bottom view of final 3D print, improved button hole line up. Source: Author

Findings:

Figure 17: Iterations photographed side-by-side. Source: Author

An unexpected challenge I faced was the initial placement of the surface scan in the SolidWorks file. I realized too late that the measurements were not aligning correctly because the surface was slightly tilted, rather than flat. By this point, I had already created the entire outer surface, so I lost significant progress. Unfortunately, there wasn't a simple workaround, as I hadn't constrained anything to the scan file. This meant I had to restart the file and properly adjust the scan. Once the scan surface was correctly positioned, I checked all the outer, and major feature dimensions to ensure that the alignment was accurate the second time around.

Another challenge that I faced, as mentioned previously, was thickening the part. Due to the geometry of the part, Solidworks did not allow me to thicken using the regular feature. Instead I had to use a workaround, by offsetting the surface and lofting around the edge. Next time, what I would have done differently is simplified the surface so the thicken feature could work. I believe the problematic zone was the screen feature due to tighter geometry. Next time I would make the base surface first, thicken the housing, and then model the screen.

Something I would change for next time is making the cutouts after the part is already solid. In this model, I created the cutouts in the surface body, which gave me less control when I thickened it. If I were to model this again, I would draw the button cutouts on the top plane and extrude them downwards through the solid body. This approach would allow the buttons to easily slide up through the openings.

Appendix:

Renderings: Keyshot renderings on the final model.

Figure 18: Keyshot rendering of part on white background. Source: Author

Figure 19: Keyshot rendering of part in context. Source: Author