3D Modeling Safety Glasses in SolidWorks

DSGN 321: Spring 2023

Hannah Huang

I. Base Images

Figure 1. Front view

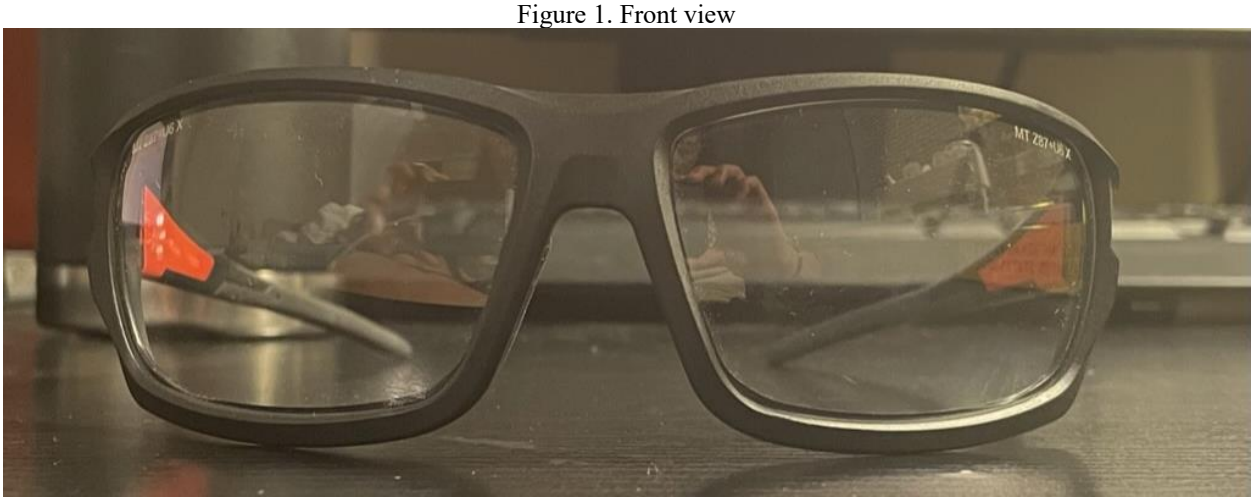


Figure 2. Side View

Figure 3. Top View

II. Terminology

The terminology used to reference the different parts of the glasses are shown in Figure 4.

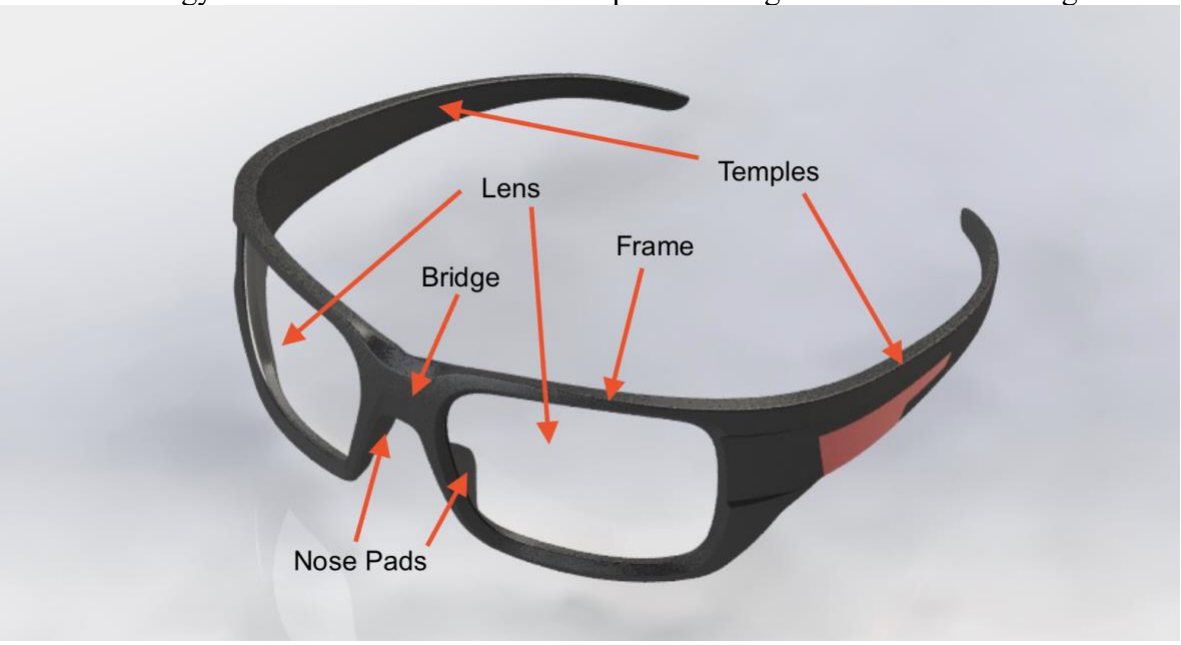


Figure 4. Glasses terminology.

III. Modeling Strategy

BASIC PLAN

1. Establish the origin at the top of the frame, in the middle of the bridge.
2. Model Base Surface as lofted silhouette of glasses.
3. Create many reference surfaces that are offset from the Base Surface, which can be used for later detailing.
    a. This includes an offset that lines up with the indent right in front of the lens, right behind the lens, under the front of the bridge, the indent on the side of the frame, as well as a copy of the Base Surface.
4. Cut out holes in Base Surface and thicken to make a solid.
5. Create the details on the frame.
    a. Sketch all the details of the indents in the frame, project these sketches as split lines onto respective faces, and then delete the faces.
    b. Project curves on the offset reference geometry and create surfaces between the projected curves and edges of the before deleted faces with boundary surfaces and surface fills.
    c. Make the nose pads by creating split lines, then using the Freeform tool to create the one of the nose pads.
    d. For surfaces around the lens and the nose pads, only create one set of surfaces on one side of the frame, then mirror across the Front Plane to get the surfaces on the other side.
6. Knit the surfaces into a solid body and then create a plane that splits the temples from the frame, resulting in 3 separate bodies.

7. Taper the temples by copying the inner and outer face of the temples, rotating both of the surfaces toward the inside of the temple, and replacing the inner and outer face of that temple with the rotated surfaces.
    a. To avoid having to do this for both sides, delete the non-tapered temple body and mirror the tapered temple body.
8. In order to smoothly create details on the side of the glasses that transition smoothly from the frame to the temple, recombine the bodies into a single solid body.
9. Sketch the side details by sketching the outlines on the Front Plane, and creating split lines along the sides of the glasses, and project curves on the reference offset surface created earlier.
    a. Similar to the front of the glasses, delete faces and use surface fill to create surfaces between the edges and projected curves. Again, mirror surfaces to the other side so that these operations do not need to be repeated twice.
    b. Knit the surfaces into a solid body.
10. Create the lens by creating a sketch of one the lens, trimming the surface that was a copy of the Base Surface, and thickening it to create a solid. Then, mirror this lens to the other side.
    a. The body of the lens should slightly intersect the main body. Using the indent feature, delete material from the main body based on the intersection with the lens, resulting in a groove in the main body surrounding the lens.
11. Fillet all rounded edges.
12. Once again, split the bodies at the plane created in step 7 to result in 3 different bodies.
13. Add red detail on the temples, right at the split of the bodies, by creating split lines on the outer faces and coloring them red. Color the rest of the glasses black, and give the lens a clear glass appearance.

ORIGIN PLACEMENT

The origin has been placed at the top of the frame and at the center of the bridge (see Figure 5). This is advantageous because the Front Plane splits the model along its plane of symmetry, allowing me to easily mirror features and bodies.

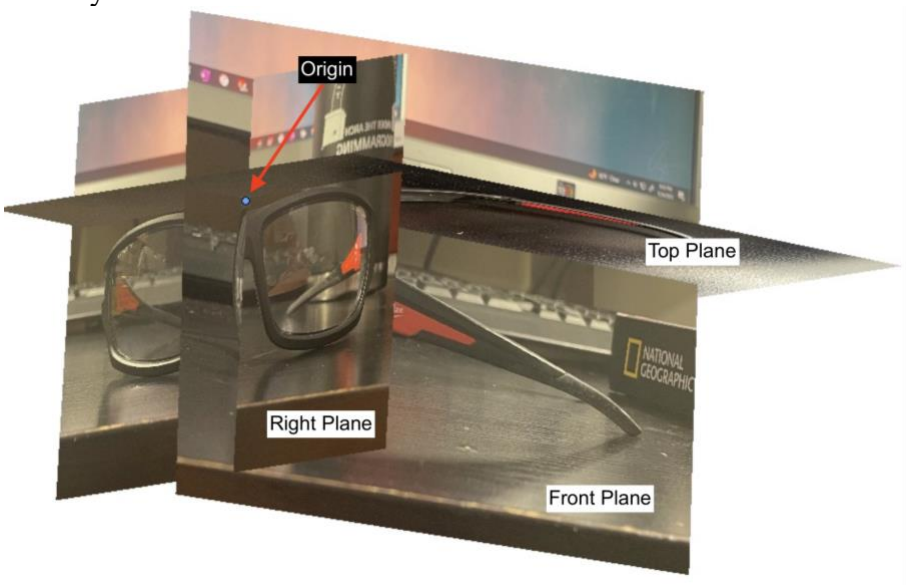
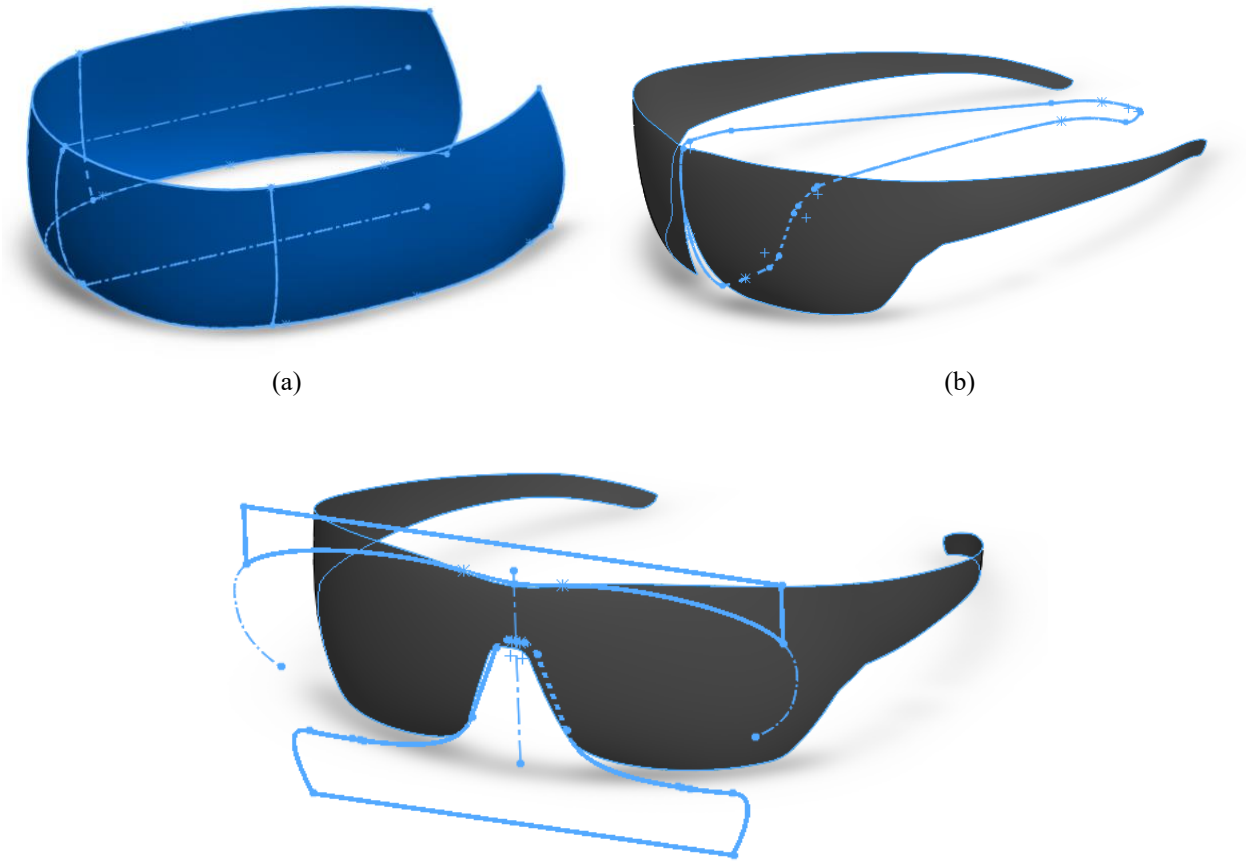


Figure 5. Origin and plane placement.

BASE GEOMETRY

Unlike typical glasses, in which the frame and temples lie on three distinct planes, these safety glasses follow a very organic curve. Thus, I decided to model all the components of the glasses in a single part file and split the bodies later, as opposed to modeling three separate components in an Assembly file, in which capturing a continuous curve would be more difficult. I started with a single lofted surface sketched from the top view picture, and then make cuts based on the outline in the Front Plane and Right Plane.



(a) (b)

(c)

Figure 6. Progression of base geometry from (a) lofted surface, to (b) temple cutout, to (c) frame cutouts.

REFERENCE GEOMETRY

The glasses feature a lot of geometric, recessed geometry. Thus, several reference surfaces were created that were offsets from the base surface. These include:

- Front of Lens Offset
- Back of Lens Offset
- Bottom of Bridge Offset
- Side Feature Offset
- Base Surface Copy

Figure 7 shows the edges of the glasses to which these surfaces are coincident.

Figure 7. The edges to which the reference offset surfaces are coincident are marked in red, including the (a) Front of Lens Offset, (b) Back of Lens Offset, (c) Bottom of Bridge Offset, and (d) Side Feature Offset.

For the Front of Lens Offset and Back of Lens Offset, global variables were established based on the desired thickness of the lens (“lens_thick” = 0.02”), as well as a clearance from the edge of the lens to the beginning of the indented surface (“lens_clearance” = 0.005”). Thus, the offset distance for both the Front and Back of Lens Offset surfaces were

“lens_thick”/2 + “lens_clearance” = 0.02”

This is clarified in Figure 8. Global variables and equations were used so that quick adjustments could be made later if I wanted to change the thickness of the lens, or if the clearance didn’t look like it was enough.

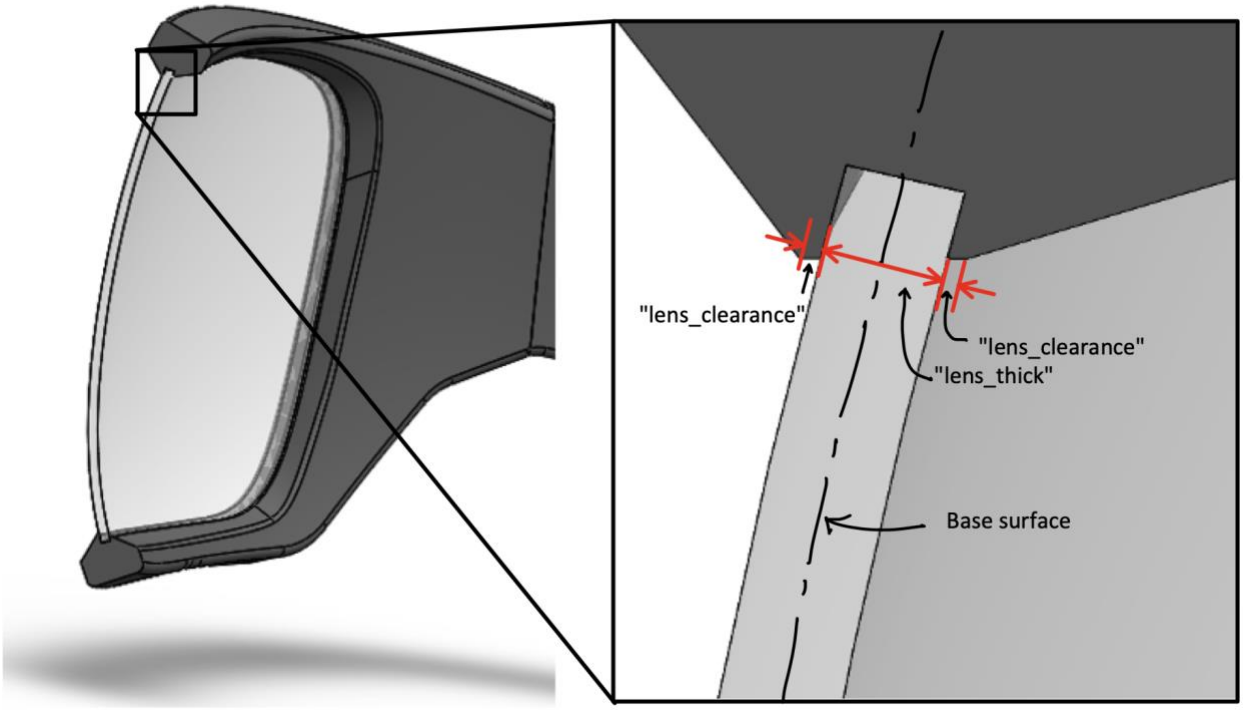
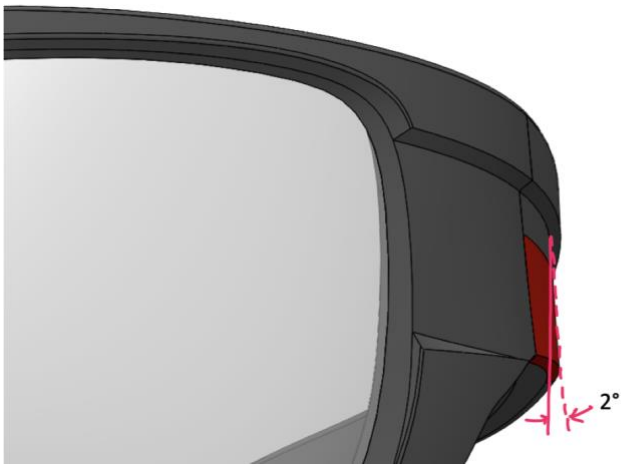
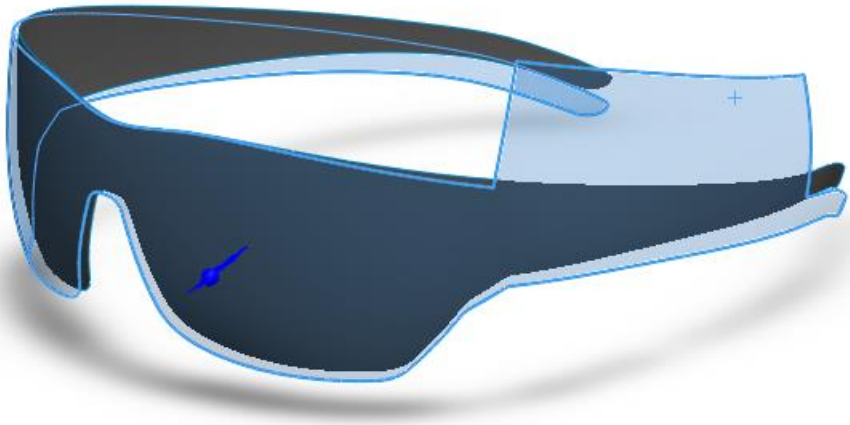


Figure 8. Cross section view showing the global variables used to offset the Front and Back of Lens Surface.

To get the Side Feature Offset, I made an offset plane of 0.05”, then I rotated the frame 2° downwards about the top, center of the frame. This rotation is necessary later because this allows the side indent to gradually slope into the main body. The result of this rotation is shown in Figure 9. I also extended the top edge a little so that I could project a curve onto it later, since rotating the surface makes the surface not completely behind the base surface when looking at it from the front view.



(a)



(b)

Figure 9. Side feature offset, (a) depicting how the rotated surface geometry affects the side feature later, and (b) showing the final offset surface with a rotation and extension.

The Bottom of Bridge Offset surface was offset at 0.08”. The Base Surface was copied as a reference for the indent above the bridge, as well as to later create the lens of the glasses.

FRAME

First, outlines of the indents surrounding the lens were sketched. Note that the left lens were sketched, then mirrored across the Front Plane to get the right lens sketch. Then, the sketch was projected onto the Front of Lens Offset as shown in Figure 10. I then used the surface trim tool and made cuts out of the Base Surface based on outside of the indent details of the projected curve. I similarly projected the lens detail sketch onto the Back of Lens Offset. The base surface was then thickened by 0.9375” on both sides of the Mid Plane, demonstrated in Figure 11.

- NOTE: I was unable to directly use the curve to make these cuts and future geometry, as a projected curve is recognized as a single entity, and I cannot select individual lines within a curve feature. Thus, every time I created a projected curve, I made a 3D sketch and converted the entities of the projected curve into my sketch.

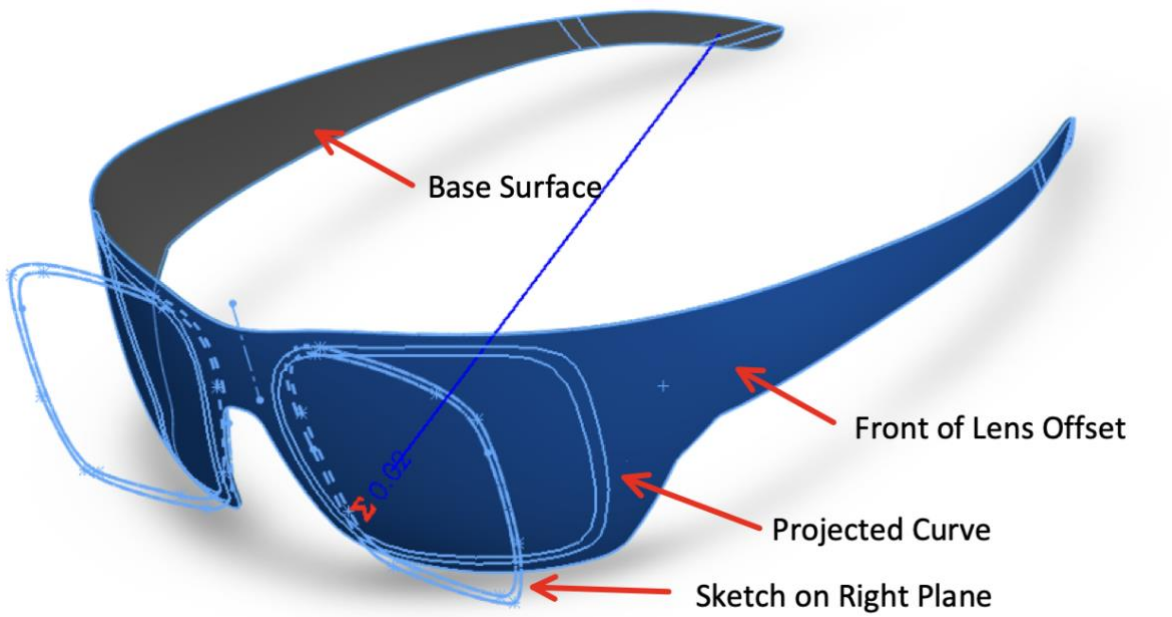
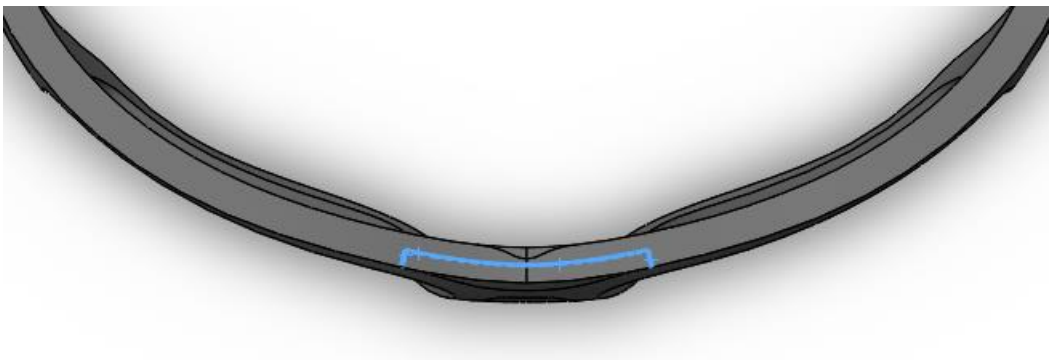


Figure 10. Sketch of lens projected onto the Front of Lens Offset.

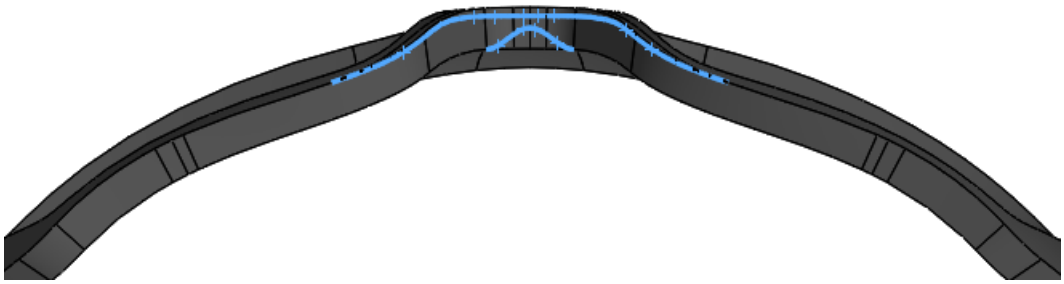
Figure 11. Lens cutout in Base Surface, then thickened.

Next, several split lines are sketched on the Right Plane and Top Plane, then projected onto their respective faces (see Figure 12). Each sketch utilizes sketch mirroring across the Front Plane.

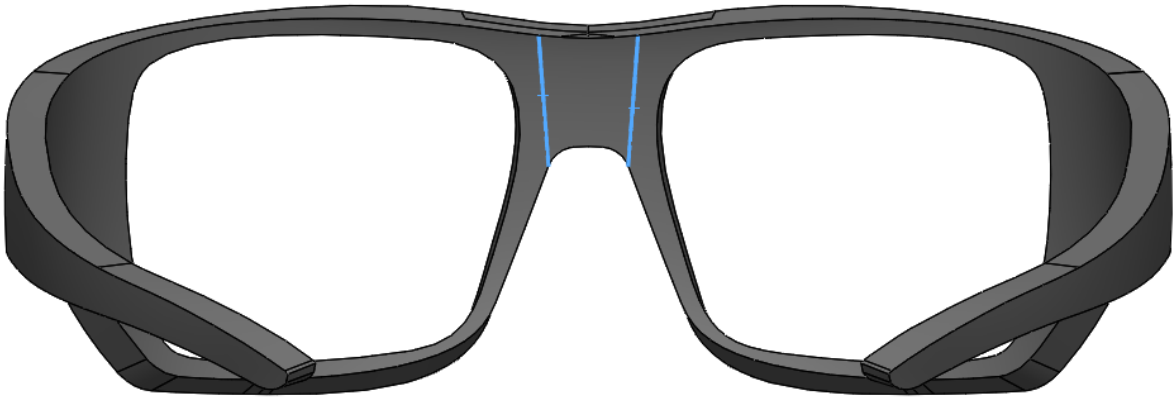


(a)

(b)



(c)



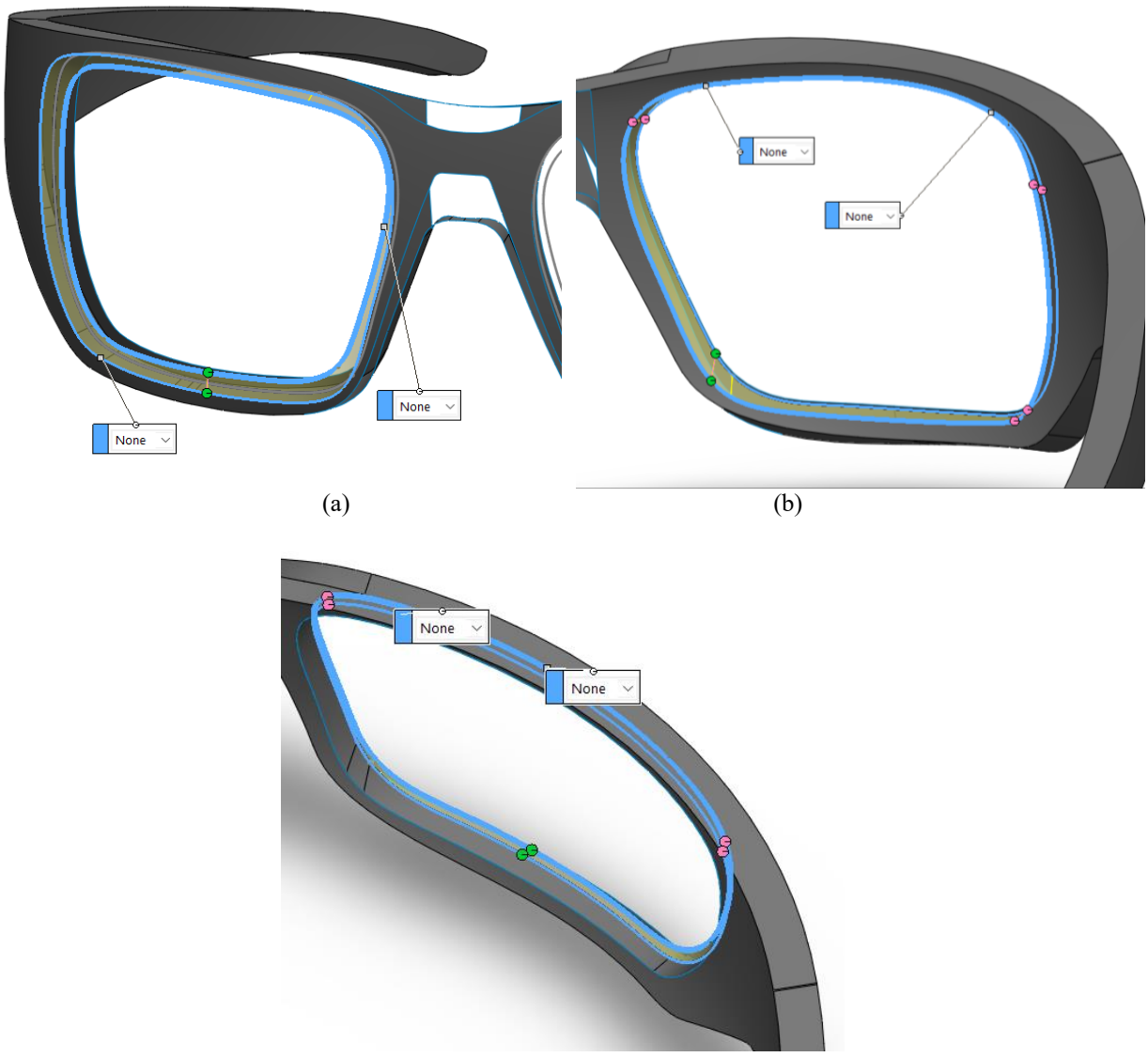
(d)

Figure 12. The split lines created by projecting sketches onto the (a) top of the frame, (b) front of the frame, (c) bottom of the frame, (d) and back of the frame.

Then, faces were deleted where the indents would go. Figure 13 highlights all the faces that were deleted. I had to manually delete all the faces highlighted, including ones that are mirrored across the Front Plane because the delete face feature cannot be mirrored.

Figure 13. Faces that were deleted are highlighted in red.

For the area around the lens, I used two boundary surfaces that connect the deleted edge to the curves projected to the Front of Lens Offset and Back of Lens Offset (see Figure 14a and 14b). I also used a boundary surface between the edges of both boundary surfaces the close the gap in the middle, where the lens would sit. This could also have been done with a lofted surface; however, I was having random rebuild errors with a lofted surface and found the boundary surface to be much more stable.

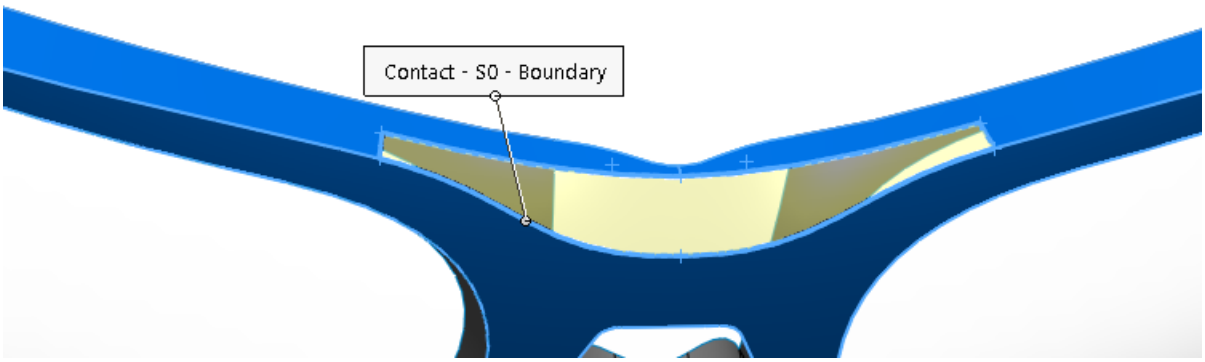


(a) (b)

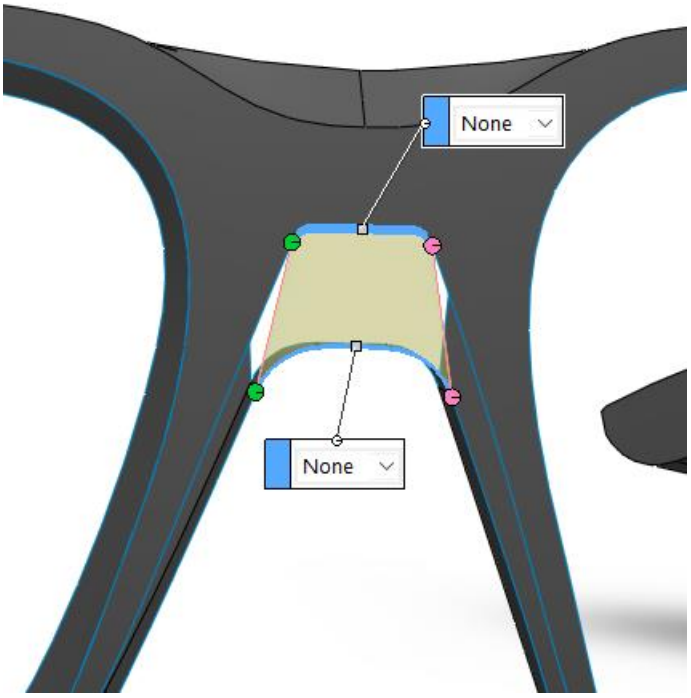
(c)

Figure 14. Creating boundary surfaces for the (a) front of the lens indent, (b) back of the lens indent, (c) and connecting the two boundary surfaces in the middle.

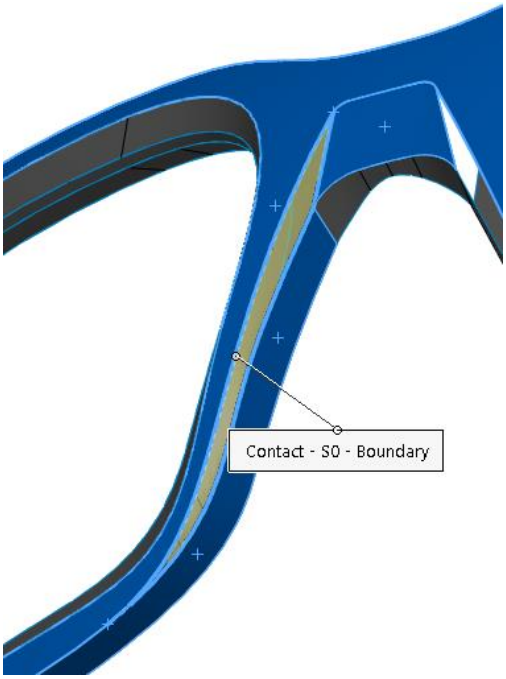
Next, the edges of the bridge's deleted faces were filled with surface fills as shown in Figure 15. I could have done the surface fills shown in Figure 15b and 15c as a single surface fill, but I split them into two features to capture the somewhat sharp edge on the actual glasses.



(a)



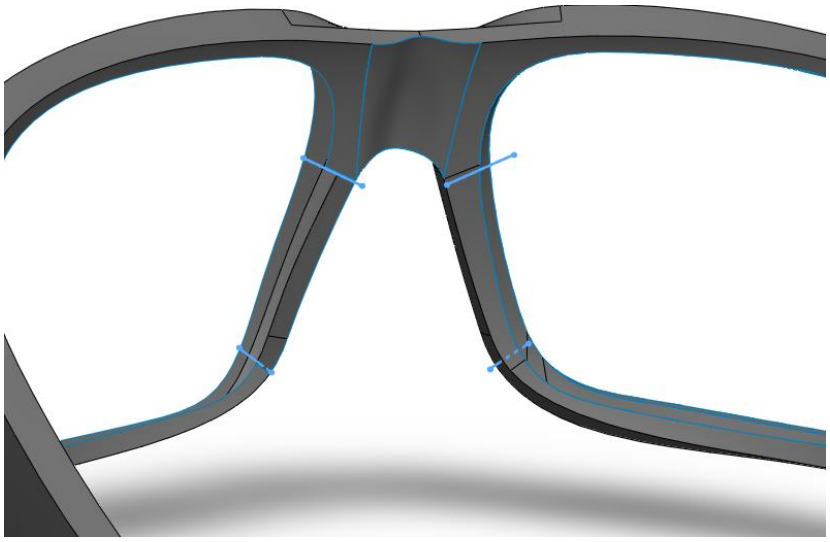
(b)



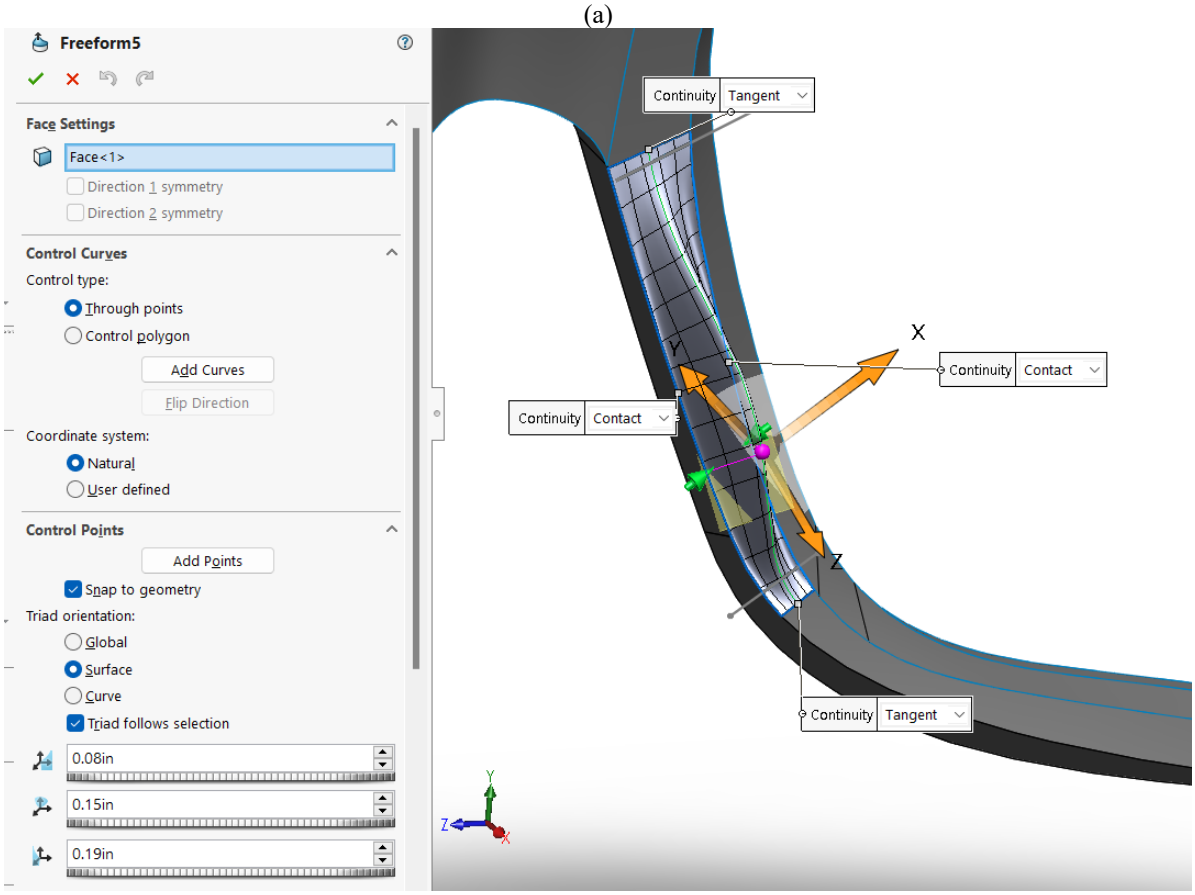
(c)

Figure 15. Surface fills for (a) top of bridge, (b) bottom-center of bridge, and (c) bottom-side of bridge.

The nose pads were created by making split lines on the back of the frame and then deleting only one of the faces. On the face that wasn't deleted, the surface is freeform manipulated, and a point is dragged out until the protrusion looks reasonable. It helps to choose the triad orientation based on the Surface, and then only drag the triad in the Z direction, which is normal to the surface. These steps are clarified in Figure 16.



(a)



(b)

Figure 16. The (a) creation of split lines and the (b) settings for the freeform tool.

Because this creates a protrusion in a surface (instead of a separate surface body), it cannot be easily mirrored. After many different attempts, I settled on copying the freeformed face using the surface offset tool (setting the offset to 0”), then mirroring the copied surface across the Front Plane and hiding the copied surface of the original face. In this mirror feature, I also mirror all the surfaces around the lens, shown in Figure 14. Finally, I knitted all the parts as one solid.

TEMPLES AND SIDE DETAILS

First, I noticed in the Top View orthographic view of the glasses (see Figure 3) that the thickness of the temples tapers inwards, instead of maintaining a constant thickness like the frame. When initially thickening the base surface, there was no way to create a "variable thickness." Thus, I used a combination of solid modeling and surface modeling to achieve this outcome. First, I created a plane normal to the Front Plane that I used to split the temples from the frame, as seen in Figure 17.

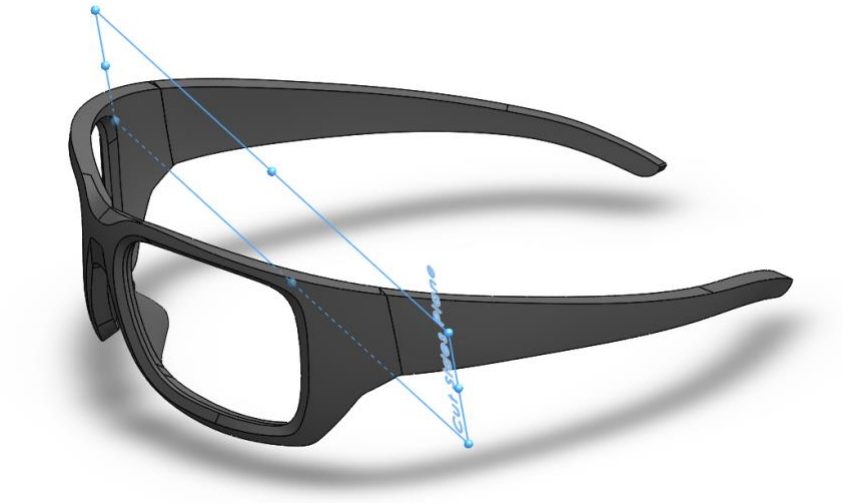
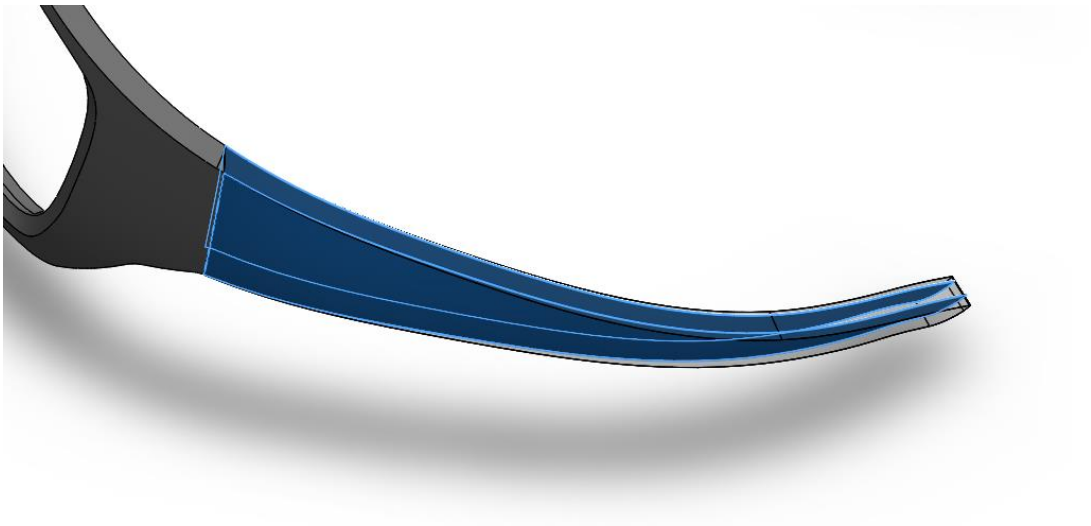
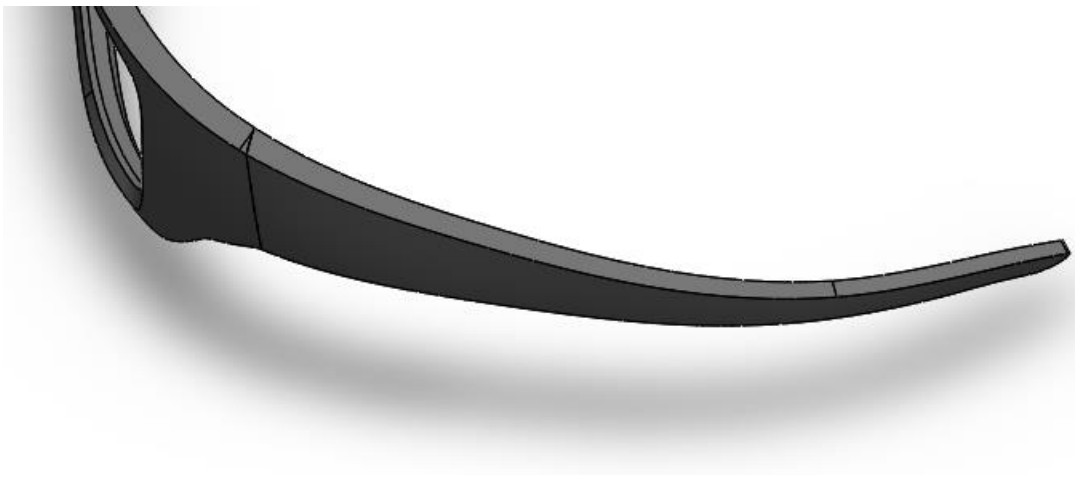


Figure 17. Splitting the temples from the frame.

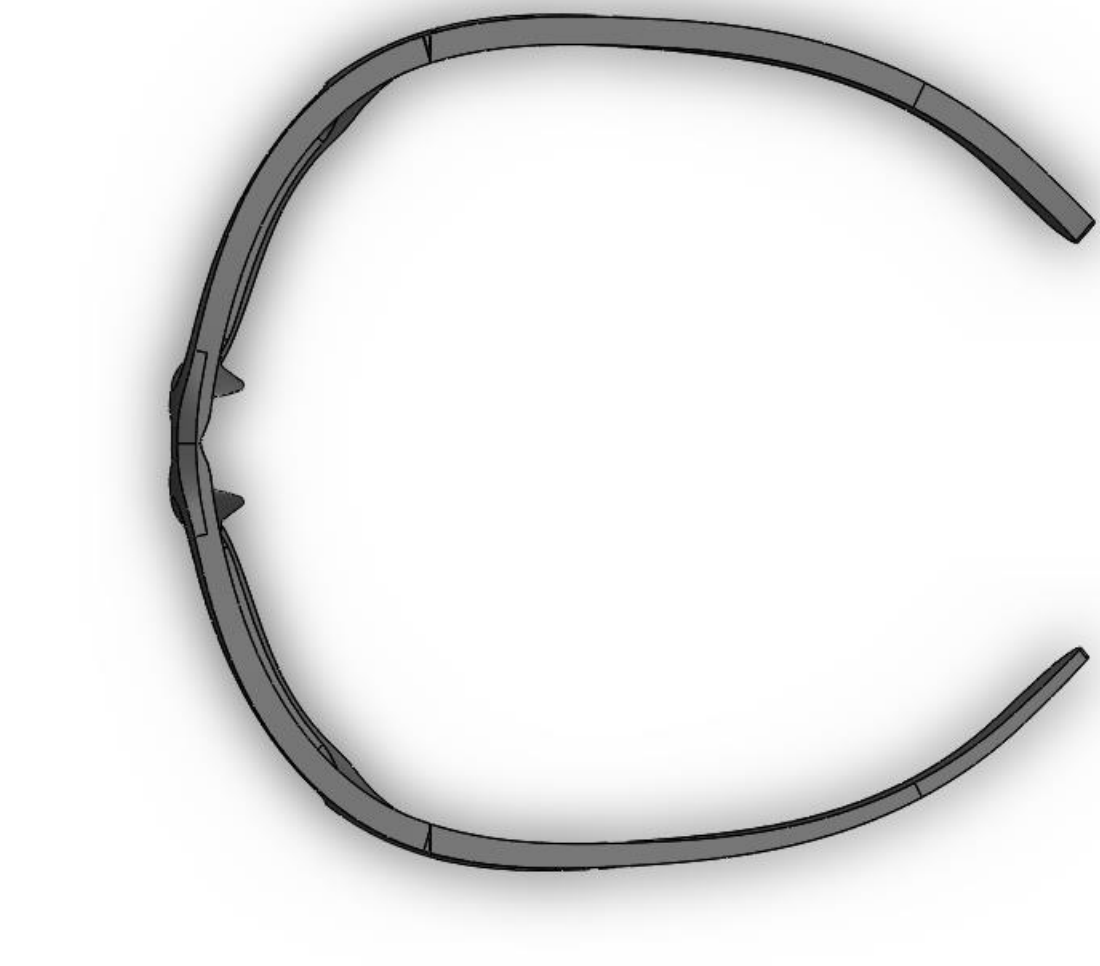
Then, I created a copied surface of both the inner and outer faces of the temple. I rotated the outer surface by 1° towards the center of the temple and the outer surface by 0.5° towards the center of the temple. Each is rotated about the line on that face that is coincident to the splitting plane (see Figure 18a). Then, the replace face feature is used to replace the inner and outer faces of the temples with the rotated surfaces (see Figure 18b). Figure 18c compares the tapered and non-tapered temples.



(a)



(b)



(c)

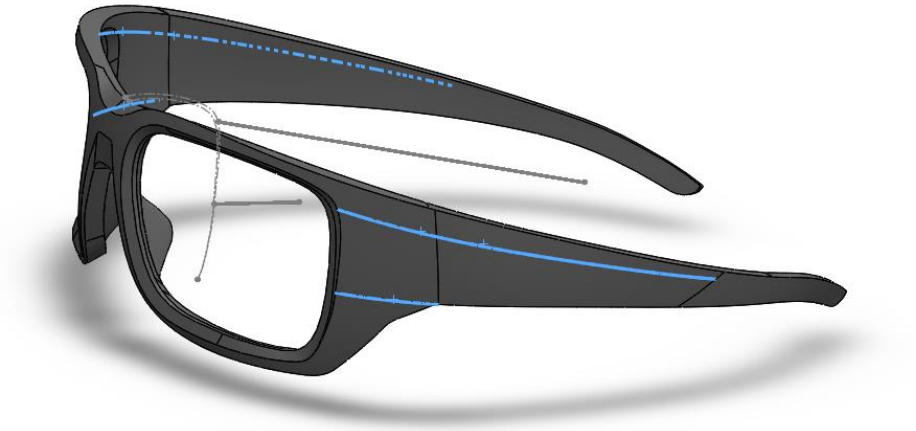
Figure 18. Steps for tapering the temple including the (a) copied, rotated surfaces of the inner and outer face of the temples, the (b) faces of the temples replaced with the surfaces, and then a (c) comparison between the tapered and non-tapered temples.

To avoid needing to do this twice for the other temple, the other temple body was simply deleted, and the tapered temple was mirrored across the Front Plane.

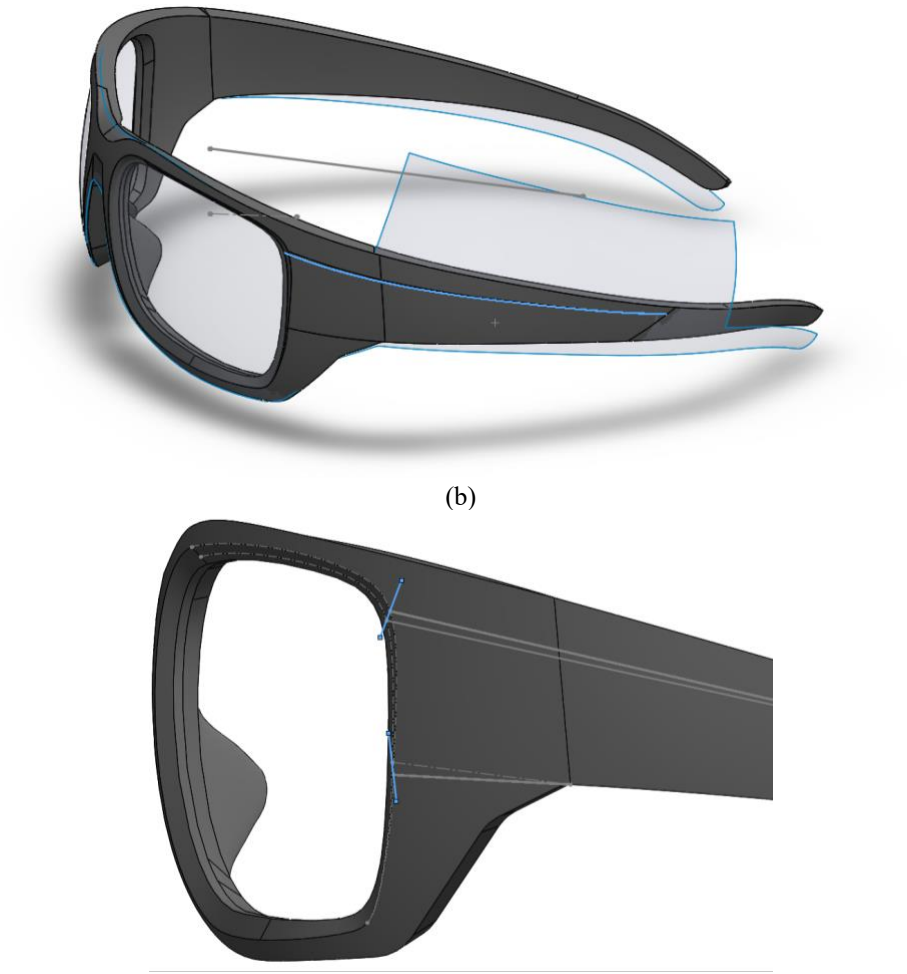
For the actual detailing of the sides, I had to recombine the bodies into a single body because features on the side flowed as a single curved indent from the frame to the temples. If I kept them as separate bodies, then deleting the outer face of the frame and temple would reveal two surfaces at the location where the two bodies were split. This would require more split lines and would be annoying to handle. Thus, recombining the bodies first, made it easier to create the features. I made a series of split lines. The first was a split line created by the intersection of the Side Feature Offset and of the outer temple faces, as well as the face on the outer indent around the lens. This is shown in Figure 19.

Figure 19. Split lines created at the intersection of the Side Feature Offset and faces of the glasses.

Then, several sketches were drawn on the Front Plane, outlining the indents on the side of the glasses. This process is shown in Figure 20, in which the outer outlines are projected as split curves onto the outer faces (see Figure 20a), the inner curve is projected as a curve onto the offset surface (see Figure 20b), and the lines connecting the two sketches is projected onto the face on the indent around the lens (see Figure 20c).



(a)



(b)

(c)

Figure 20. Sketch lines projected as a (a) split line on outer face of temple and lens, (b) projected curve on the Side Feature Offset, and as a (c) split line on the face of the indent around the lens.

Afterwards, the faces were deleted as shown in Figure 21. Note that had we not recombined the bodies before detailing the sides, we would see a surface (which would actually be 2 surfaces) at the location of the body split that we would have to manually cutout. Also note that these faces were deleted on both sides of the glasses.

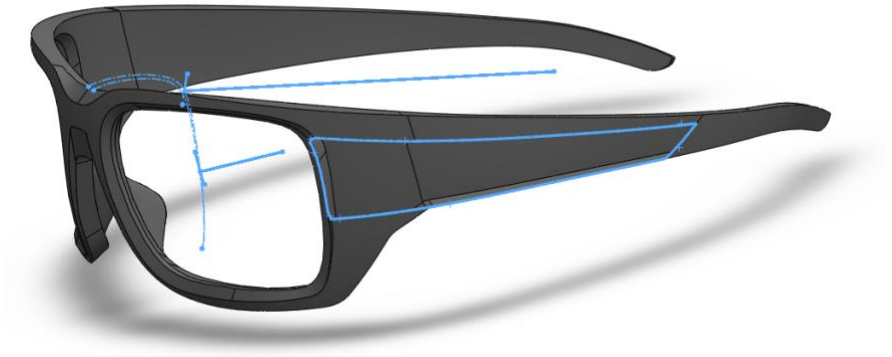
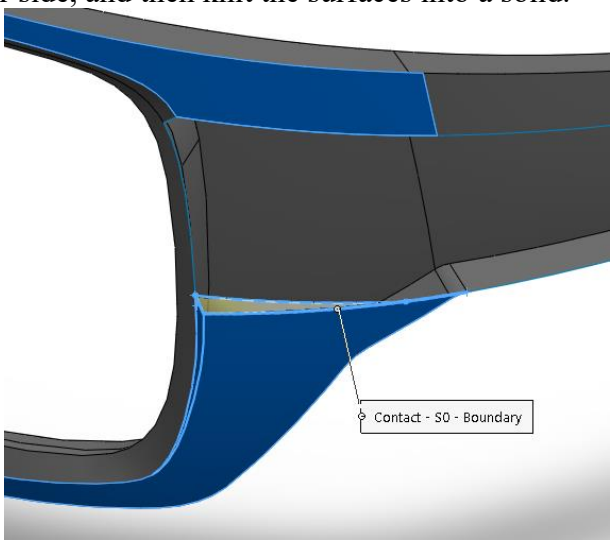
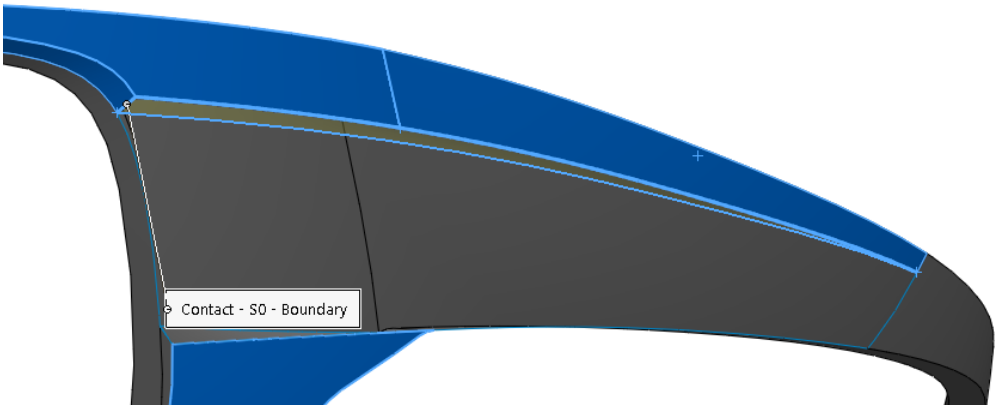


Figure 21. Deleted faces for side detailing. These faces are also deleted on the other side.

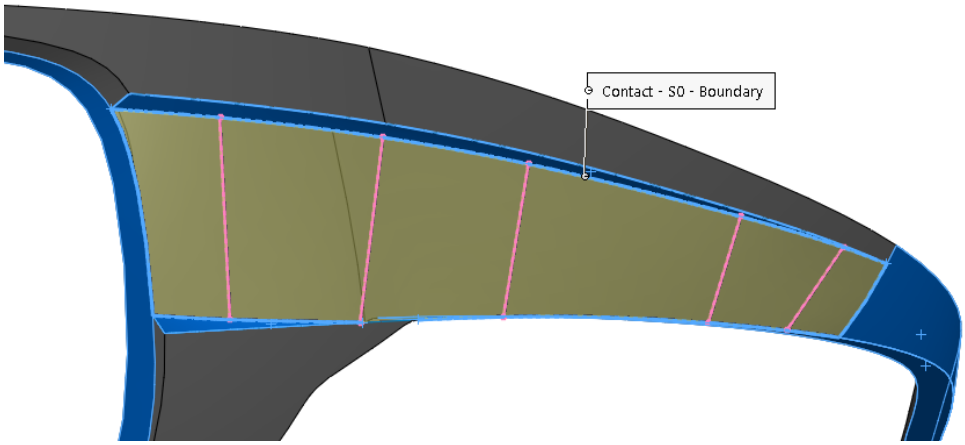
Then, I used surface fills to refill the space. These fills are shown in Figure 22. Notice that for the large fill in Figure 22c, I had to make straight constraint curves (done as a 3D sketch). Without them, the surface bulged outward, which is not the desired result. Finally, I mirrored all of these faces to the other side, and then knit the surfaces into a solid.



(a)



(b)



(c)

Figure 22. Surface fills for side detailing, including the (a) bottom undercut, (b) top undercut, and the (c) surface connecting the two undercuts.

LENS

Focusing only on the right lens (“right” with respect to someone who’s wearing the glasses), I made a sketch on the Right Plane in which I offset the curve surrounding the inside of the lens by 0.02” outside. Then, I trimmed the Base Surface Copy with this sketch, only keeping the part of the surface that makes up the lens (see Figure 23). Then, I thickened this sketch about the mid plane according to the “lens_thick” global variable defined earlier (such that the total thickness of the lens is equal to “lens_thick”). This body was mirrored about the Front Plane to make the left lens.

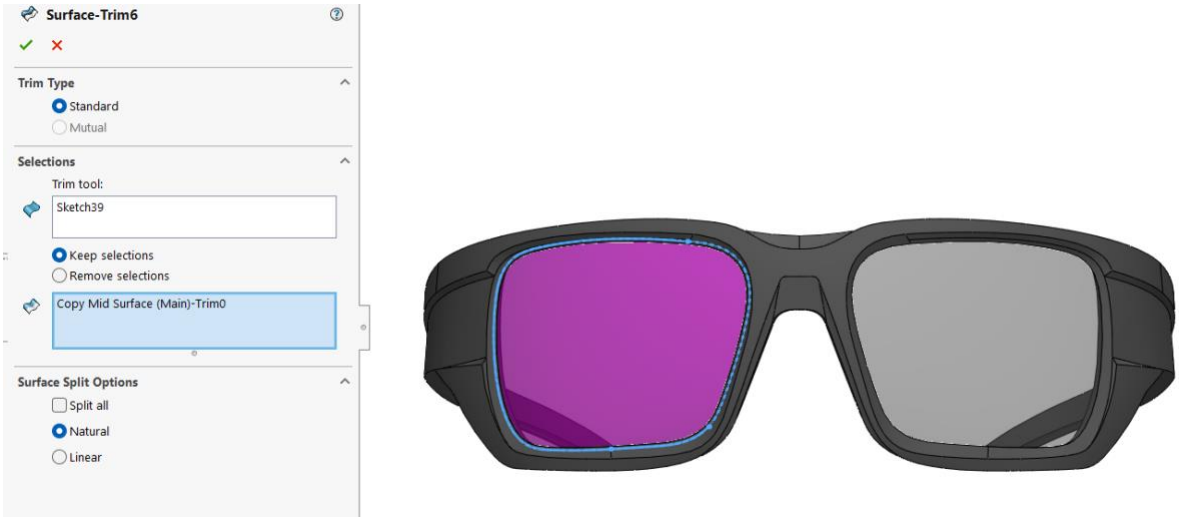
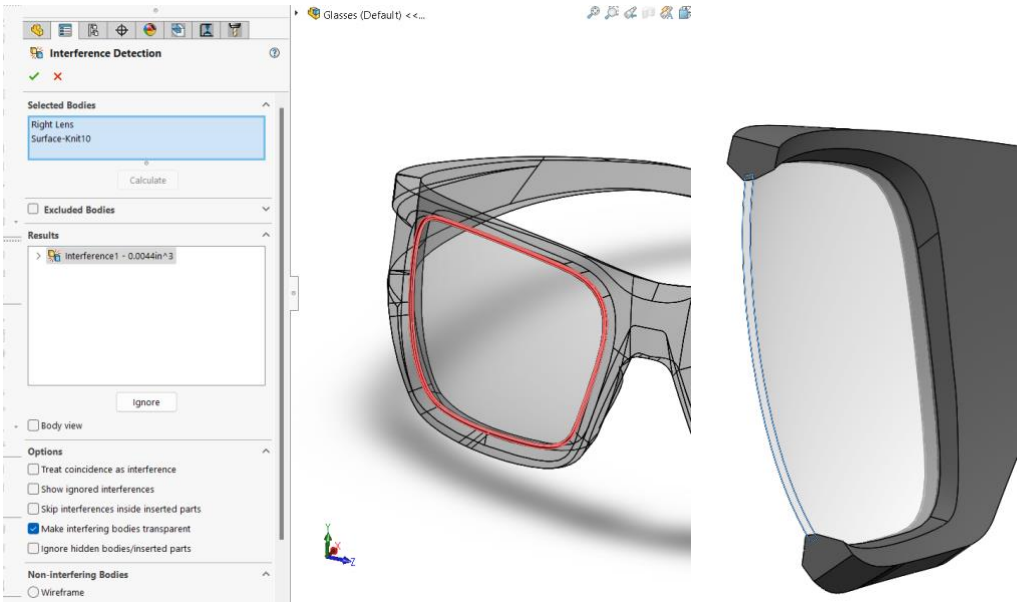


Figure 23. Cutting out lens surface from the Base Surface Copy.

If we perform a simple interference detection, we can see that the lens body interferes with the frame (Figure 24a). We want this interference zone to be inset in the frame, such that the lens sits in the pocket. A cross section view can show you this interference as well (see Figure 24b). This section can be “scooped” out of the frame in two ways. First, we can use the combine tool and choose the subtract option, which allows us to use the lens body as a direct cutting tool into the frame. However, this consumes the lens body and would require us to duplicate the bodies before performing this operation. The better tool to use is the indent tool, in which we can select the frame as a target body and the lens as the cutting body, then assign a clearance around the cutting body to cut out of the target body. This tool gives the option to keep or remove the cutting bodies. In my case, I kept the cutting bodies and assigned a clearance region of 0” (see Figure 25).



(a) (b)

Figure 24. Interference between lens and frame shown with (a) interference detection tool and a (b) cross-section view.

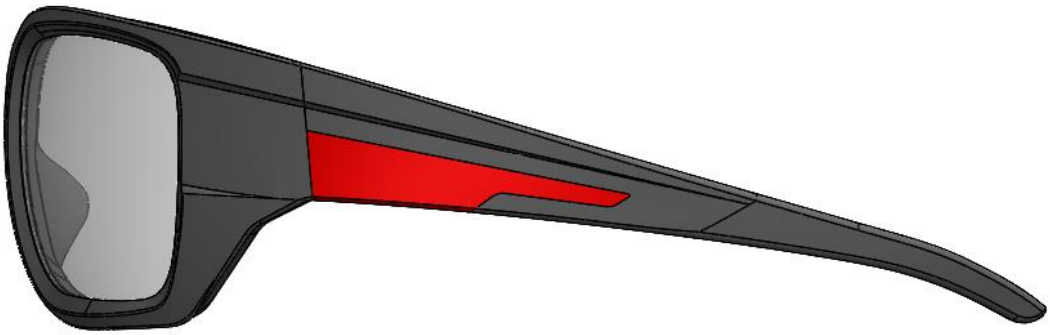
(a) (b)

Figure 25. (a) Using the indent tool to carve out the intersection zone, and (b) the resulting cross section.

FINISHING

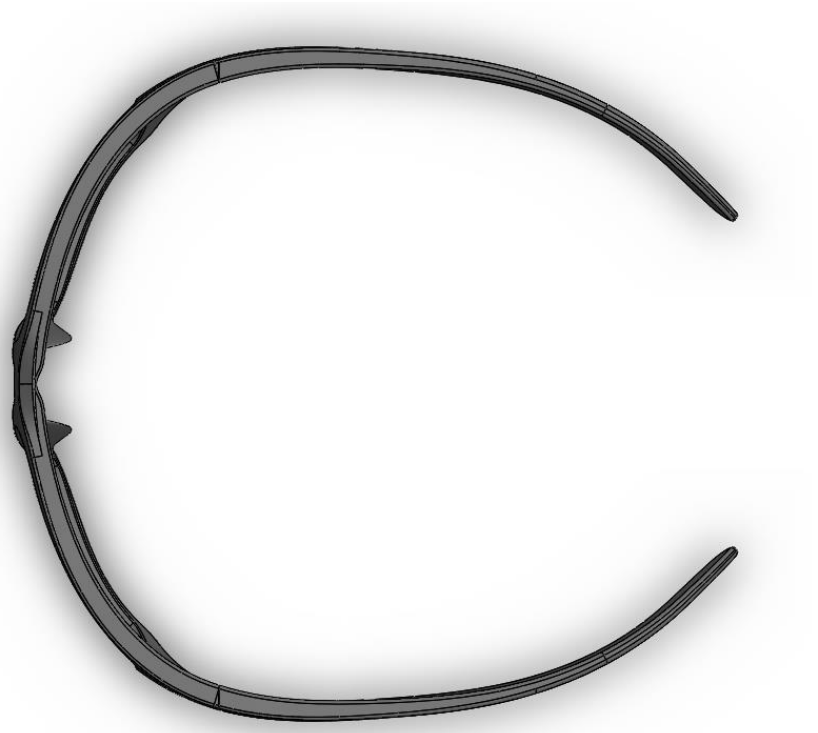
To finish, I filleted the frames, temples, and indents (see Figure 26). I then split the bodies again about the plane made earlier to separate the frame from the temples. Finally, I projected split lines on the outer face of the temples to allow me to color the small section red. The finish glasses are shown in Figure 27.

Figure 26. All the fillets added to the glasses.



(a)

(b)



(c)

(d)

Figure 27. Finished glasses in the (a) front view, (b) side view, (d) top view, and (d) isometric view.