

Type III Roadway Lens Design

Tutorial Overview

We will develop a smooth Type III Roadway Lens by lofting together multiple aimed lens profiles. The Type III application is a standard forward-throw (asymmetric) street requirement with the goal of reducing the house-side light while spreading the light up and down the roadway to maximize pole spacing.

Topics Covered

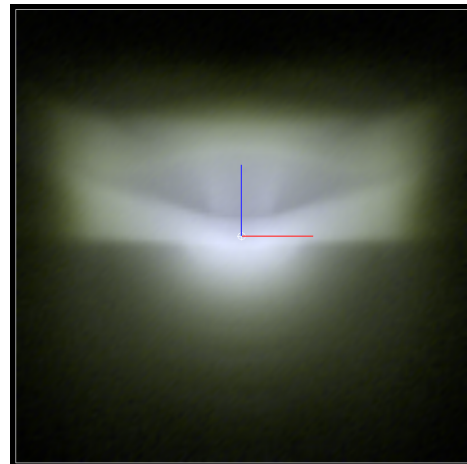
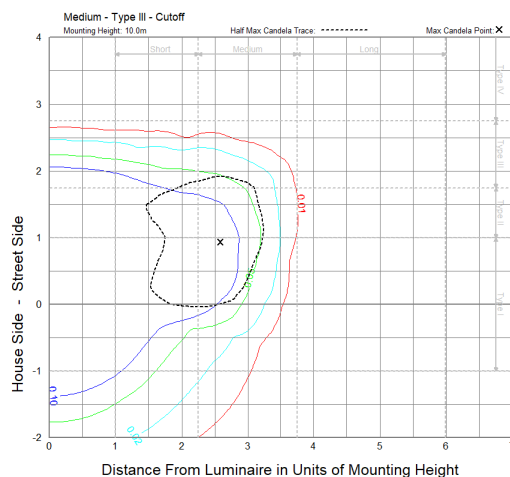
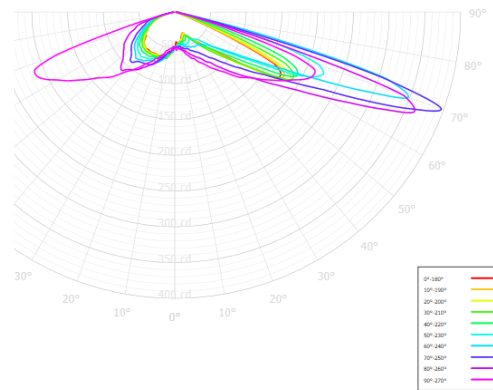
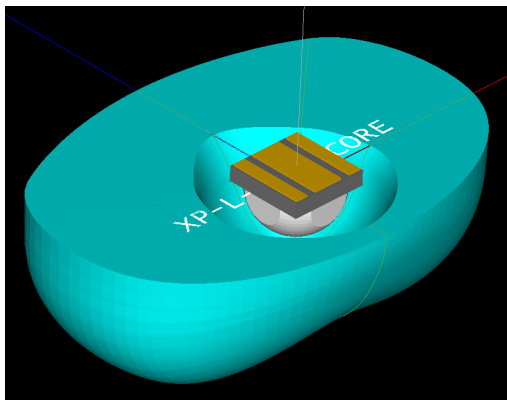
- Lens Design Tools
- Lofting
- Optical design processes

Skill Level - Advanced

Interface - Photopia

Units - Metric (mm)

Estimated Completion Time - 120 minutes



Model Setup

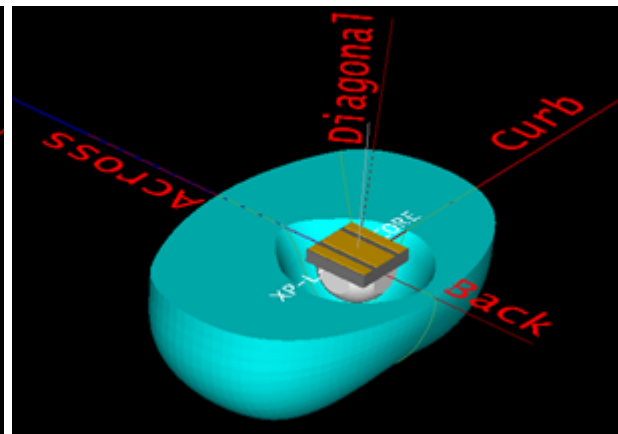
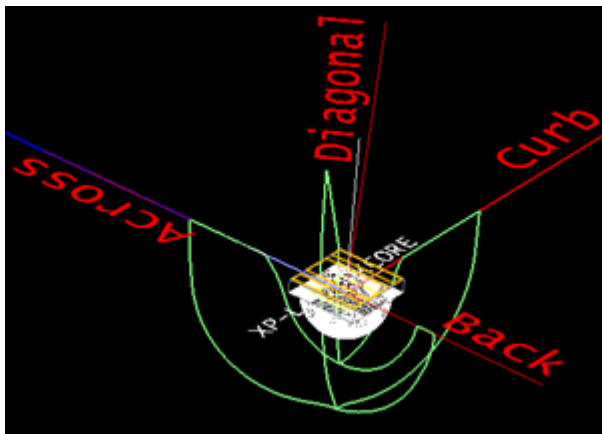
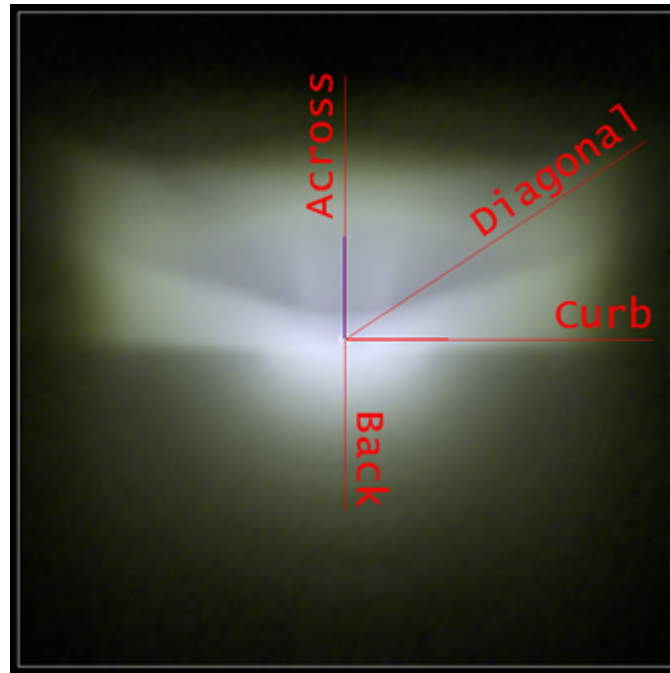
1. Open Photopia (the stand alone version) and go to File > New to begin a new project.
2. Change your model units to be in millimeters by going to Settings > Project Settings, and selecting "Millimeters" as the Length Units. Close the Project Settings window.
3. In this tutorial we will be working in the local construction planes (CPlanes) rather than the world coordinate system (WCS), at the bottom of the Photopia Window toggle the coordinate system button so it says "CPlane":



4. Save your project as "Type III Roadway Lens".
5. We will be designing the lens around the Cree XP-L, to add this LED to your model go to File > Import Lamp and select the "XL-L-5700K.LAMP" file. Insert it at the default insertion point of "0,0".
6. Create an Illuminance Plane that will be large enough so we can see the overall broad pattern we expect to create from our lens design. The plane will be 8m square, 1m below our optic. In the CAD View, go to Top view, go to Draw > Illuminance Plane (or type "ip" into the command line). In the Command line you will be prompted to select the lower left corner of the plane, type "-4000,-4000,-1000", hit enter. For the upper right corner type "4000,4000,-1000", enter. The plane description will be "8m x 8m, 1m below". Hit enter to accept the default cell extents and finish the illuminance plane.
7. Click the Zoom Extents button (or type "ze" into the command line) to zoom out and see your new illuminance plane. Toggle on the "Illum.Planes" button at the bottom of your screen.
8. Select one of the edges of your plane (it will turn pink) and in the properties window on the right, under the Display section, change Display Plot to be "True". In the CAD view hit the escape button to deselect your illuminance plane.
9. Go to Analysis > Specify Photometric Output, go to the Photometric Report tab. Change the Report Type from Indoor to Roadway, change the Horizontal angle set to be "0" and the Vertical angle set to be "0(2.5)90". We will start our roadway design by creating a revolved lens, so the horizontal angle set is symmetric. We increase the resolution in the vertical angles since we will be trying to create a strong batwing which will have a quickly changing intensity profile. Click "OK" to close the Photometric Output Specification window. Note - we will change these photometric settings later on in the design when we develop our asymmetric optic.
10. Go to Analysis > Specify Raytrace Settings. On the Raytracing tab change the number of Initial Source Rays from 2.5mil to 20mil. When we design our three primary lens profiles we will be trying to achieve a similar intensity profile around nadir and having more rays will give us a smoother intensity profile at those low angles where we don't have as much light aimed. Click "OK" to close the Raytrace Settings window.
11. Save the project.

Diagonal Lens Profile Design with Undercut

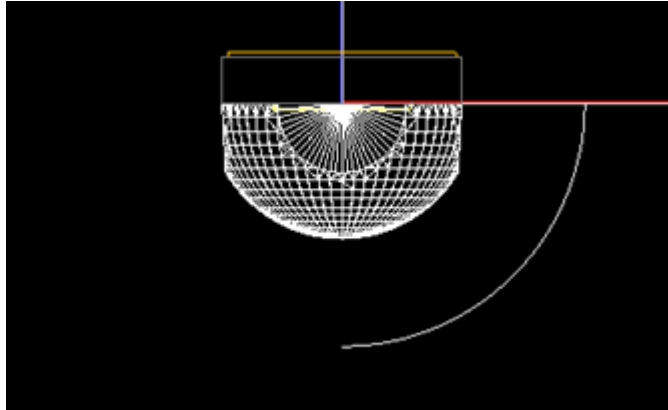
Note - The goal with this optic will be to achieve a Type III Medium distribution. This will require our peak intensity to occur around 70° vertically and 70° horizontally. Since we want to achieve a rectangular pattern the primary throw of our optic will be diagonally to the corner of the target area. Ultimately we will design four profiles which we will loft together to create a single smooth optic. In this tutorial these profiles will be called “Across”, “Diagonal”, “Curb”, and “Back” and will be oriented like this:



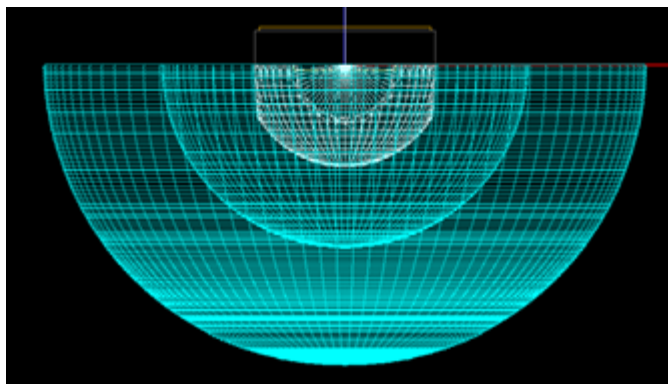
We will start with a revolved version of the “Diagonal” profile because it is the one that needs to achieve the widest throw. After completing the Diagonal lens design we will use that lens profile geometry as a foundation for our Across and Curb profiles.

12. In the CAD View, Toggle off your “Illum.Planes” button, go to the Right View, and Zoom Extents, you should only see the LED. Zoom out a few times to give yourself some working room to develop the lens profile.
13. The input face of our lens will be a hemisphere with a 3.5mm radius centered on the LED. The lens will have a minimum thickness of 2.0mm.

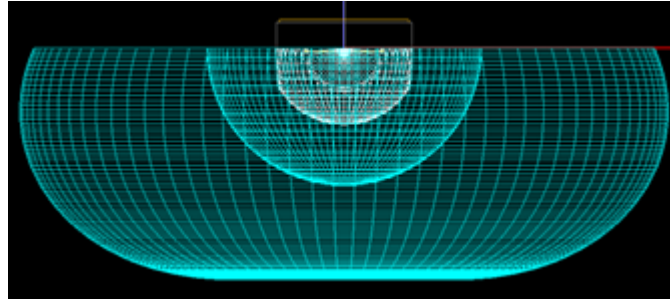
14. Go to Draw > Arc, type "c" for center, enter. Type "0,0", enter. The start point will be directly below the LED, type "0,-3.5", enter. The input face is a hemisphere, for the included angle type "90", enter.



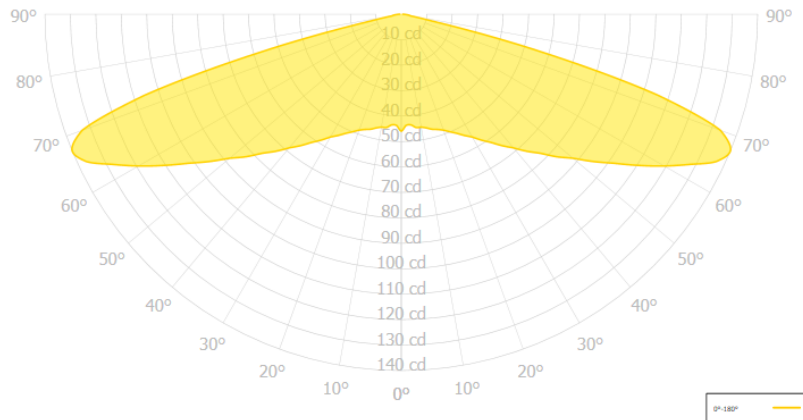
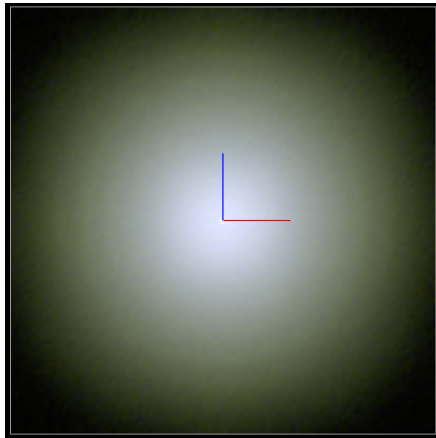
15. Go to Design > Lens > Revolved, the command line prompt will ask for the line type, type "S" to select a curve hit enter.
16. The LED was inserted at 0,0, for the lamp center hit enter for the default of 0,0 (or type in "0,0" and enter).
17. Select the arc, enter.
18. The number of prism steps/curve segments will be 100 so we have a clean and smooth lens profile. Type "100", enter.
19. The start aiming angle will be at nadir, straight below the luminaire. Type "0", enter.
20. The end aiming angle will be slightly beyond our goal of 70° so we can taper off the beam at the edge of our target area. Type "76", enter.
21. For the aiming angle increment we will work in 1 degree steps so we have a smoother beam. Type "1", enter.
22. The minimum thickness of our lens is 2.0mm. Type "2.0", enter.
23. The number of Revolve segments will be 90. Type "90", enter.
24. You have completed the parameters necessary for Photopia to generate your revolved lens profile. All of the parameters above can be changed at any time and the lens will rebuild based on the updated parameters. Your lens in the Right view should look like this:



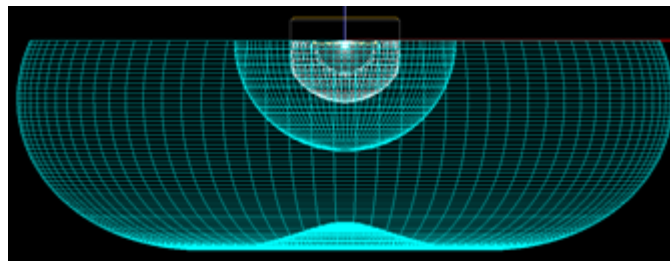
25. Select the lens (it will turn pink and the aiming lines will be displayed).
26. By default the lens profile type will be stepped, like what we would use for a Fresnel lens design. This optic will be smooth instead. In the Properties window under Optical Parameters change the Profile Type to be "Smooth".
27. Also by default, the inside and outside lens profiles will be closed at the start and end. For this lens we want the end to be closed (at the top of the lens), but not the start. In the Properties window under Optional Geometry change Close Start to be "No". Move the mouse back to the CAD space and hit escape to deselect the lens. The lens now looks like this:



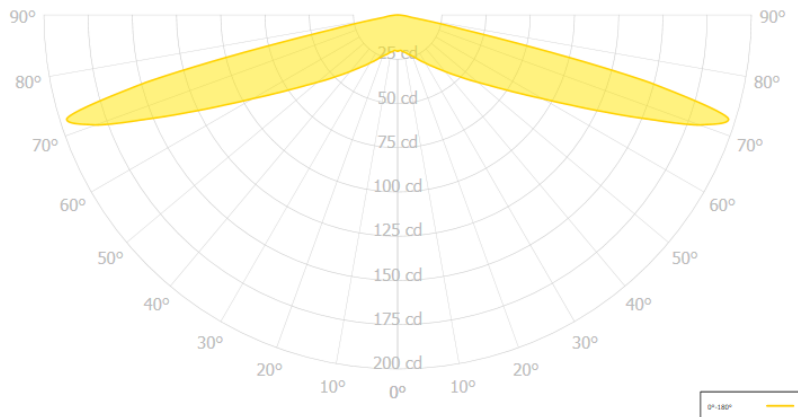
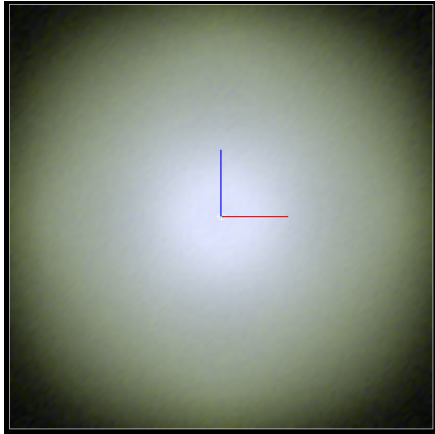
28. Assign a lens material by going to Edit > Design Properties, switch to the Refractive Tab, select the REFR-Main layer and click Assign Material. Scroll down to the Generic Manufacturer section and select the "ACRYLIC1" material and click OK. Click OK to close the Design Properties Window.
29. Save the project.
30. Begin the analysis by either clicking on the calculator button, going to Analysis > Begin Analysis, or hitting Ctrl+B. Your illuminance plane and polar plot will look like this:



31. While the pattern is smooth, we want a very wide batwing distribution to push light up and down the roadway to maximize our pole spacing. So we need to reduce the intensity at nadir and increase the intensity at 70° vertical. Toggle off the "Illum.Planes" button, go to Right view, and Zoom Extents.
32. Select the lens and in the Properties window in the Weight Section change the Weight Exponent to "1.55" this will place increase the percent of lens aimed towards the higher angles and decrease the amount aimed at the lower angles.
33. Your lens is now wider with a more defined dip in the center directly in front of the LED:



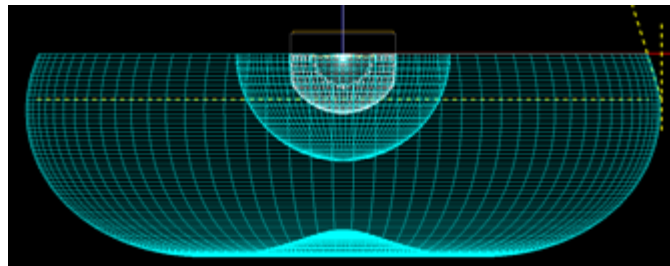
34. Save the project.
35. Begin the analysis and view your results:



The lens now produces a smooth, but much wider, beam with the peak occurring near 70°.

Diagonal Lens Profile Design without Undercut

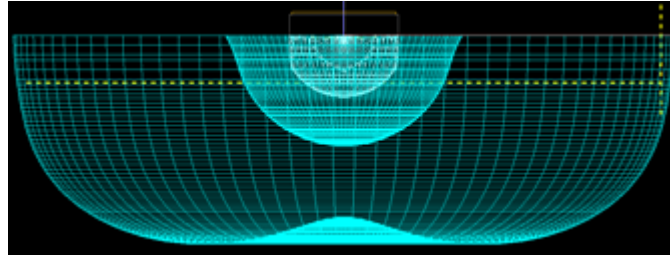
36. While the Diagonal lens design is producing a good quality beam, it has an undercut at the top of the outside face which would either need to be resolved in a secondary CAD step, or now during the design process. We will correct this now in order to maintain beam control of the high angle light that leaves the LED. Toggle off the "Illum.Planes" button, go to Right view, and Zoom Extents.
37. To better visualize this undercut use the following trick. Go to Settings > Layers, create a New Layer, rename it "Construction", make the color "Yellow", line type "DASH", and line width "3". Select the Construction layer and click "Set Current". Click OK to close the Layer Window.
38. Go to Draw > Line (or type "l" into the command line). The first point will be "-10,-1.5", enter. The second point will be "10,-1.5", enter. Enter to end. The dashed line represents a standard connecting flange thickness that would eventually connect the array of individual roadway optics so they can be molded as one part. As you see below, the lens has an undercut above the horizontal construction line. You can add multiple construction lines to help sketch the issue, since the Construction layer has a Non Optical layer type, these lines will not interact with the raytrace:



39. To remove the undercut we will remove optical control from the top of the outside profile and add optical control to the top of the inside hemisphere. Select the lens and go to View > Parametric Optical Design.
40. Scroll to the bottom of the Section Aiming Properties table and change the % of Control Inside for Section 77 to be "100", we will taper the % of Control Inside until we remove the undercut. For this lens this will be sections 70-77. Section 77 - 100%, 76 - 100, 75 - 75, 74 - 50, 73 - 35, 72 - 20, 71 - 10, 70 - 5:

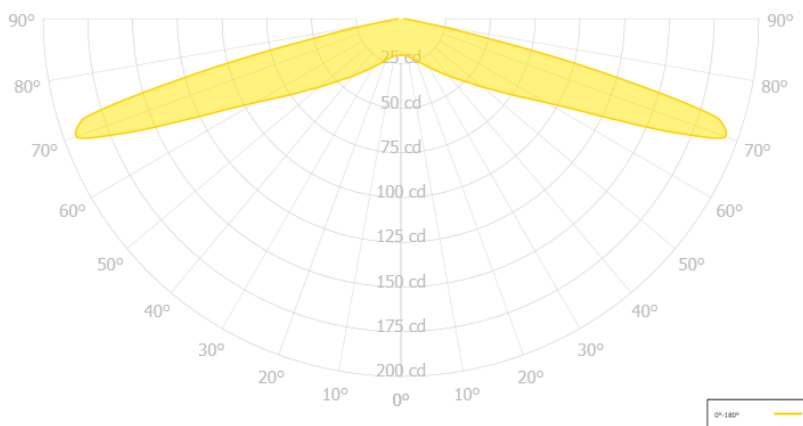
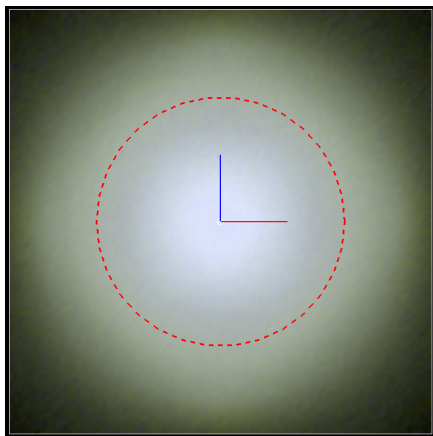
| | | | | | | | | | | | |
|----|--------|--------|--------|--------|----------|---------|----------|-----------|--------|--------|----------|
| 67 | 1.0000 | 3.5324 | 3.5324 | 2.6364 | By Angle | 66.0000 | 917.4698 | -410.1208 | 0.0000 | 0.0000 | 0.0000 |
| 68 | 1.0000 | 3.7913 | 3.7913 | 2.8297 | By Angle | 67.0000 | 924.5639 | -393.9482 | 0.0000 | 0.0000 | 0.0000 |
| 69 | 1.0000 | 4.0810 | 4.0810 | 3.0459 | By Angle | 68.0000 | 931.3824 | -377.6406 | 0.0000 | 0.0000 | 0.0000 |
| 70 | 1.0000 | 4.4067 | 4.4067 | 3.2890 | By Angle | 69.0000 | 937.9203 | -361.1984 | 0.0000 | 0.0000 | 5.0000 |
| 71 | 1.0000 | 4.7750 | 4.7750 | 3.5638 | By Angle | 70.0000 | 944.1713 | -344.6217 | 0.0000 | 0.0000 | 10.0000 |
| 72 | 1.0000 | 5.1938 | 5.1938 | 3.8765 | By Angle | 71.0000 | 950.1356 | -327.9150 | 0.0000 | 0.0000 | 20.0000 |
| 73 | 1.0000 | 5.6734 | 5.6734 | 4.2344 | By Angle | 72.0000 | 955.8084 | -311.0788 | 0.0000 | 0.0000 | 35.0000 |
| 74 | 1.0000 | 6.2267 | 6.2267 | 4.6473 | By Angle | 73.0000 | 961.1836 | -294.1132 | 0.0000 | 0.0000 | 50.0000 |
| 75 | 1.0000 | 6.8701 | 6.8701 | 5.1276 | By Angle | 74.0000 | 966.2544 | -277.0183 | 0.0000 | 0.0000 | 75.0000 |
| 76 | 1.0000 | 7.6256 | 7.6256 | 5.6915 | By Angle | 75.0000 | 971.0128 | -259.7937 | 0.0000 | 0.0000 | 100.0000 |
| 77 | 1.0000 | 8.5220 | 8.5220 | 6.3605 | By Angle | 76.0000 | 975.4492 | -242.4385 | 0.0000 | 0.0000 | 100.0000 |

41. The lens profile is updated with the new parameters and the undercut is removed:

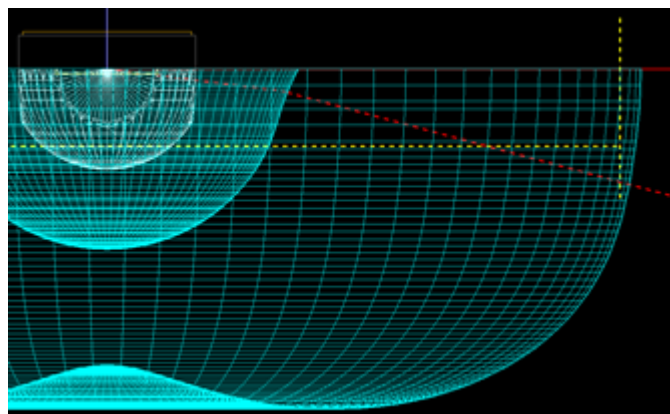


42. Save the project.

43. Begin the analysis and view your results. The beam has maintained the same general shape, however our pattern is not as smooth and we can see a step in the illuminance pattern, indicated with the red dashed circle below:



Note - The issue occurs because the light that is now controlled at the top of the inside surfaces refracts down sooner and misses the corresponding outside section. When those rays exit they refract in a slightly different direction than intended and the result is a striation in our pattern.

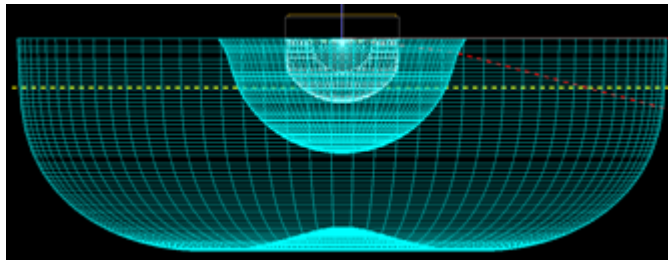


44. Toggle off the "Illum.Planes" button, go to Right view, and Zoom Extents.

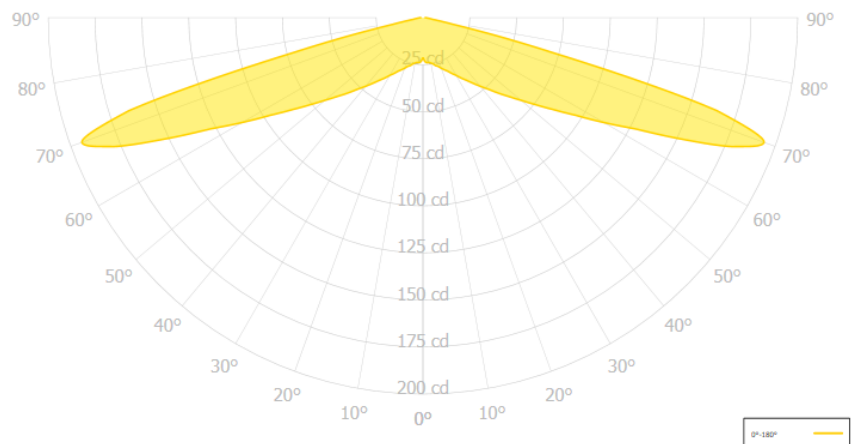
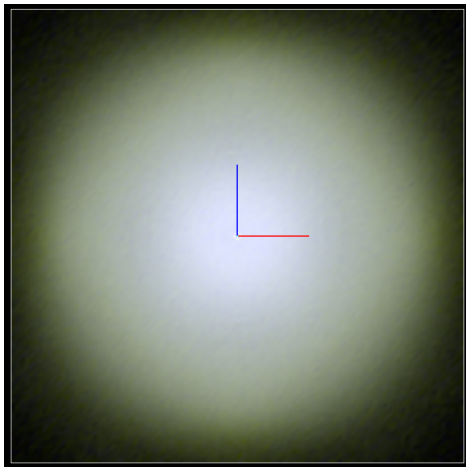
45. Select the lens and go to View > Parametric Optical Design.

46. At the bottom of the Section Aiming Properties table, change the Aim Angle for sections 75-77 to all be "73" degrees. By aiming each section towards the same angle, we will actually add spread to that light since it will be exiting out through non-corresponding section of the exit surface. So the rays for those sections enters the lens, is aimed towards 73°, hits the exit face and refracts to a range of angles below 73° since the exit face has a changing curvature.
47. With our lens aimed not as high vertically, we no longer need the last section, you can remove it by changing its weight to be "0":

| | | | | | | |
|----|--------|--------|--------|--------|----------|---------|
| 72 | 1.0000 | 5.1538 | 5.1538 | 4.2003 | By Angle | 71.0000 |
| 73 | 1.0000 | 5.6734 | 5.6734 | 4.5969 | By Angle | 72.0000 |
| 74 | 1.0000 | 6.2267 | 6.2267 | 5.0451 | By Angle | 73.0000 |
| 75 | 1.0000 | 6.2267 | 6.2267 | 5.0451 | By Angle | 73.0000 |
| 76 | 1.0000 | 6.2267 | 6.2267 | 5.0451 | By Angle | 73.0000 |
| 77 | 0.0000 | 6.2267 | 0.0000 | 0.0000 | By Angle | 73.0000 |



48. Save the project.
49. Begin the analysis and view your results:



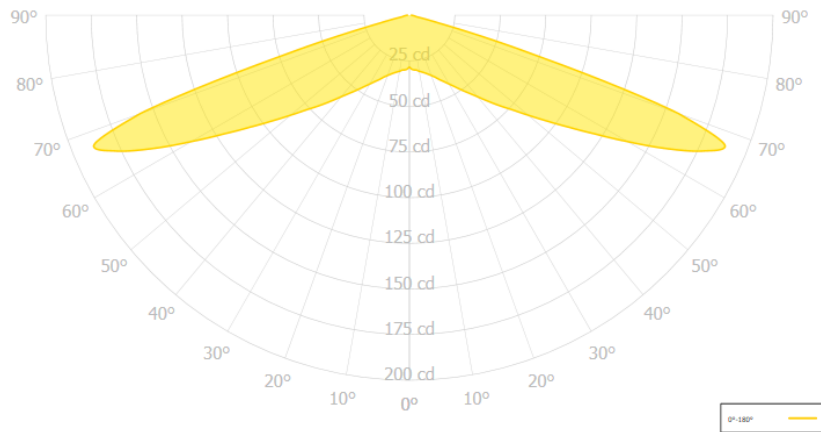
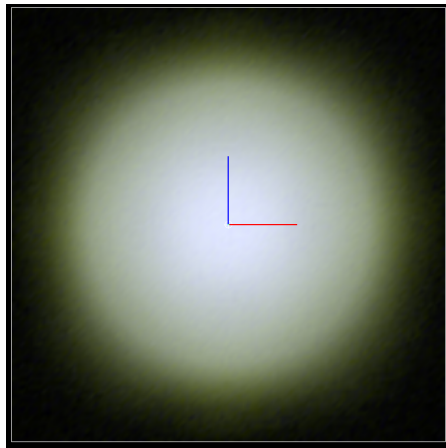
The beam is smoother and we have removed the undercut. The Diagonal profile of our lens design is complete and will serve as a foundation for the Across and Curb profiles. Note the intensity table at the low vertical angles since we will target these numbers in our following profile designs:

Candela Distribution

| | 0.00° |
|--------|-------|
| 0.00° | 25.80 |
| 2.50° | 26.44 |
| 5.00° | 27.01 |
| 7.50° | 28.07 |
| 10.00° | 27.97 |
| 12.50° | 28.89 |
| 15.00° | 29.96 |
| 17.50° | 30.55 |
| 20.00° | 31.22 |
| 22.50° | 32.11 |
| 25.00° | 33.19 |
| 27.50° | 34.44 |
| 30.00° | 35.65 |

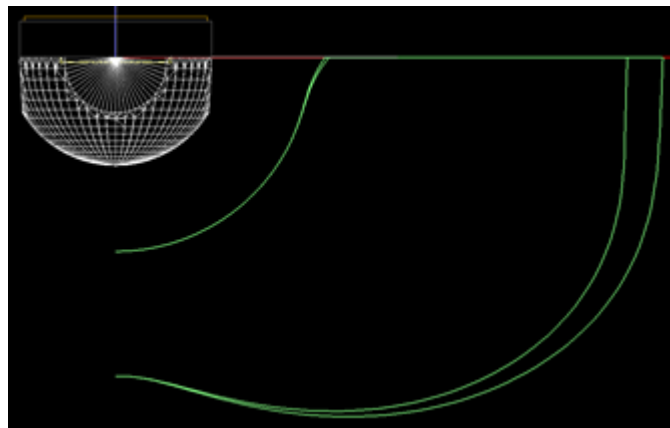
Curb Lens Profile Design

50. Toggle off the "Illum.Planes" button, go to Right view, and Zoom Extents.
51. Go to Settings > Layers, create a new layer named "REFR-Diagonal", change the color to be green. Click OK to close the Layers Window.
52. Select the lens, type "copy" into the command line, hit enter to copy in place.
53. Select only the original lens, in Properties under General, change the Layer to "REFR-Diagonal".
54. Go back to Settings > Layers, turn the "REFR-Diagonal" layer off, and close the Layers window. You should just see the original lens in cyan which we will now develop to be our Curb profile.
55. The lens profiles differ by being aimed to different vertical angles. The Diagonal profile must send the light the furthest distance to define our rectangular pattern, therefore it is aimed at the highest angle. The Curb profile will be aimed slightly lower at 67.5° vertically and will horizontally be pointed along the curb line. Select the lens and go to View > Parametric Optical Design.
56. In the Aiming of Sections change the end aiming angle from "76" to "73" and click "Update Aiming". This will remove the last three sections of our previous lens design.
57. Using our experience from the Diagonal Lens without Undercuts design process, we will use the same % of Control Inside numbers at the top of the inside surface and we will adjust the final three aiming angles to all be at 70.5°:
58. Save the project.
59. Begin the analysis and view your results:

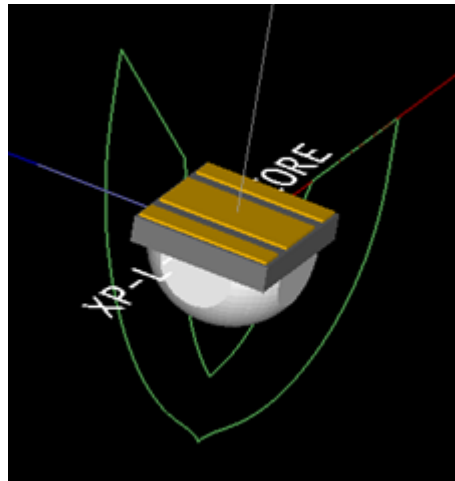


Square Lofted Lens

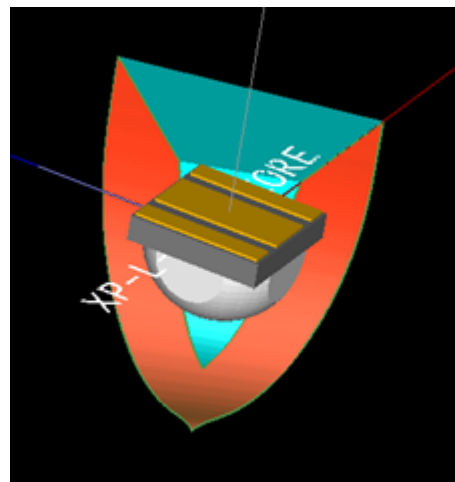
60. Besides aiming each profile at a different angle set to create a rectangular pattern, we want to ensure that our profiles will loft together smoothly to create a clean beam pattern. At this point we will create a lofted lens to create a square pattern (like you would use for Type V Square applications. Toggle off the "Illum.Planes" button, go to Right view, and Zoom Extents.
61. Go to Settings > Layers, create a new layer named "REFR-Curb", change the color to be blue. Turn on the "REFR-Diagonal" lens layer. Click OK to close the Layers Window.
62. Select the Diagonal (green) lens, go to Design > Lens > Extract 2D Lens Profile. Hit escape to deselect the new profile copy.
63. Select the Curb (blue) lens, go to Design > Lens > Extract 2D Lens Profile. Hit escape to deselect the new profile copy.
64. Go to Settings > Layers, turn off both the "REFR-Diagonal" and "REFR-Curb" layers. Note that you have two new layers for each of the profiles that you just extracted, keep those layers on. Turn off the "Construction" layer Click OK to close the Layers window.



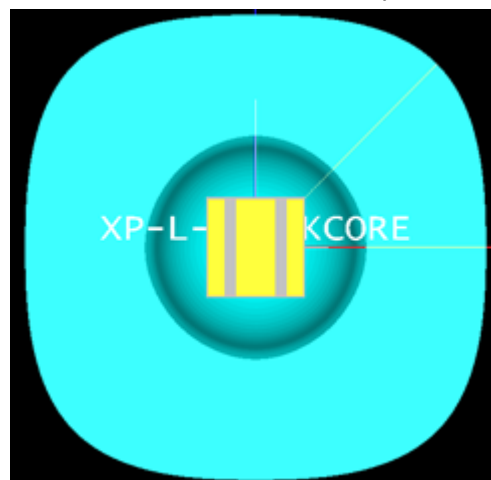
65. Select the Curb profile (inside and smaller). Go to Top view. Type rotate into the command line (or go to Modify > Rotate), the base point is "0,0" and the rotation angle will be "-90".
66. Select the remaining Diagonal profile (which in Top view will be oriented along the Y axis pointing straight up), Rotate about "0,0" and "-45" degrees.
67. Orbit in the CAD model so you can see your two lens profiles in relation to the LED:



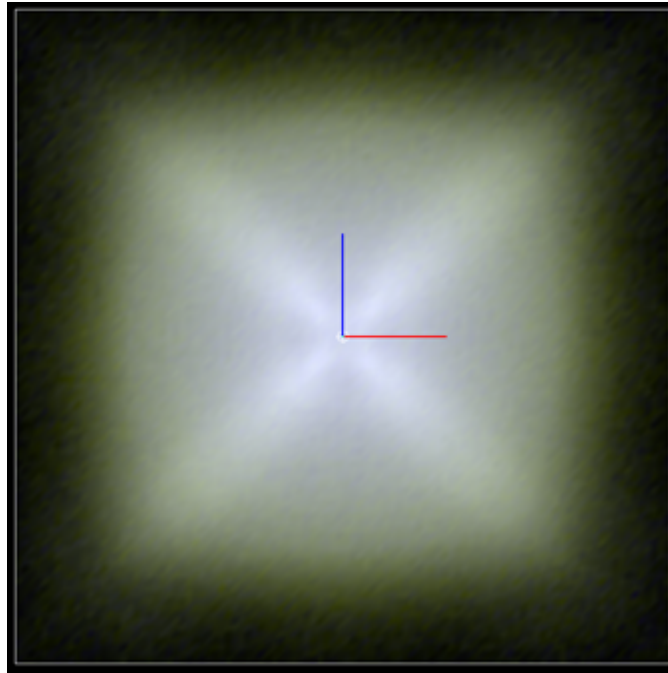
68. Design > Lens > Loft 2D Lens Profiles, first select the Curb profile (along the X axis) and will display the aiming lines when selected. Then select the Diagonal profile. Hit enter to end selection. In the CAD view you will now see a simple lofted shape between the two profiles:



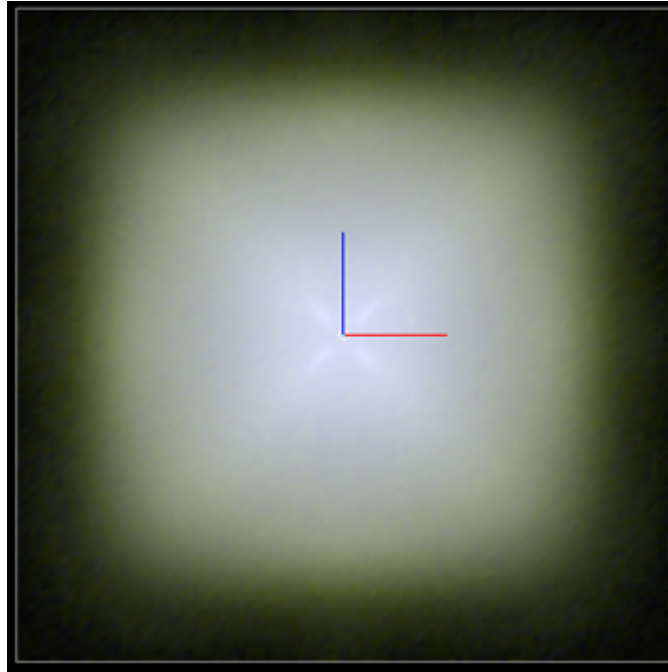
69. Go to Top view, select the loft . In Properties under the Loft section, change Profile Symmetry to be Octalateral which will mirror and complete the loft around the LED. Hit escape to deselect the lofted lens:



70. The lens is no longer symmetric but is quadrilaterally symmetric. Go to Analysis > Specify Photometric Output, on the Photometric Report tab change your horizontal angle set to be "0(15)90". Click OK to close the Photometric Output Specification window.
71. Toggle on the "Illum.Planes" button and zoom extents.
72. Save the project.
73. Begin the analysis and look at the new pattern on the illuminance plane:



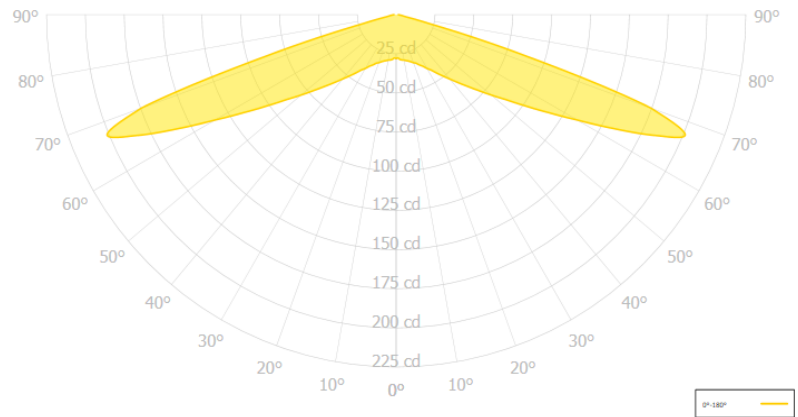
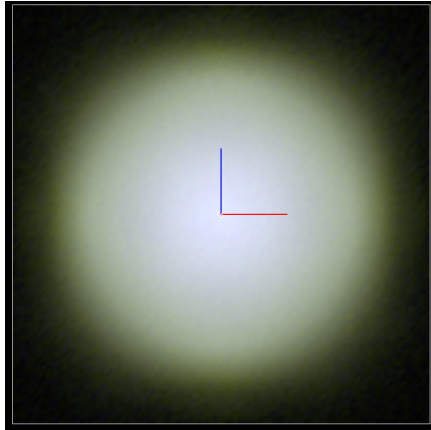
74. While the pattern is square in shape, we see a distinct "X" pattern which indicates that our loft is not as smooth as it needs to be. Toggle off the "Illum.Planes" button, go to Front view, and Zoom Extents.
75. Select the Curb lens profile, in Properties under the Weighting section change the Weight Exponent to be "1.675". The lofted lens will automatically update to account for the adjusted parameter.
76. Save the project.
77. Begin the analysis and look at the new pattern on the illuminance plane:



As can be seen, the adjusted Weight Exponent for the Curb profile smooths out the loft and therefore the pattern. A square shape is still maintained but the beam is much more smooth and uniform.

Curb Lens Profile Weight Adjustment

78. Toggle off the "Illum.Planes" button, Right view, Zoom Extents.
79. Go to Settings > Layers, create a new layer named "Square Loft" and turn the layer off. Turn on the "REFR-Curb" layer. Close the layers window.
80. Select the lofted lens and the two extracted profiles and in Properties under General change the Layer to "Square Loft". Those objects will disappear as they are now on a layer that is turned off. In the CAD view you should only see the Curb lens design (blue).
81. Select the Curb lens and in Properties under Weighting change the Weight Exponent to "1.675" which is the value we used to smooth out the square lofted lens pattern.
82. Under Edit > Design Properties, set the refractive "REFR-Curb" layer to be the Generic "ACRYLIC1" material. Close the Design Properties window.
83. Save the project.
84. Begin the analysis and view your results:



85. Open the Photometric Report and compare the candela distribution for the low angles to the Diagonal lens design from before:

| Diagonal Lens Profile Candela Distribution | Curb Lens Profile Candela Distribution | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|--|-------|-------|-------|-------|-------|-------|-------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|---|-------|--|-------|-------|-------|-------|-------|-------|-------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|
| <table> <tr><th colspan="2">0.00°</th></tr> <tr><td>0.00°</td><td>25.80</td></tr> <tr><td>2.50°</td><td>26.44</td></tr> <tr><td>5.00°</td><td>27.01</td></tr> <tr><td>7.50°</td><td>28.07</td></tr> <tr><td>10.00°</td><td>27.97</td></tr> <tr><td>12.50°</td><td>28.89</td></tr> <tr><td>15.00°</td><td>29.96</td></tr> <tr><td>17.50°</td><td>30.55</td></tr> <tr><td>20.00°</td><td>31.22</td></tr> <tr><td>22.50°</td><td>32.11</td></tr> <tr><td>25.00°</td><td>33.19</td></tr> <tr><td>27.50°</td><td>34.44</td></tr> <tr><td>30.00°</td><td>35.65</td></tr> </table> | 0.00° | | 0.00° | 25.80 | 2.50° | 26.44 | 5.00° | 27.01 | 7.50° | 28.07 | 10.00° | 27.97 | 12.50° | 28.89 | 15.00° | 29.96 | 17.50° | 30.55 | 20.00° | 31.22 | 22.50° | 32.11 | 25.00° | 33.19 | 27.50° | 34.44 | 30.00° | 35.65 | <table> <tr><th colspan="2">0.00°</th></tr> <tr><td>0.00°</td><td>28.45</td></tr> <tr><td>2.50°</td><td>26.84</td></tr> <tr><td>5.00°</td><td>27.42</td></tr> <tr><td>7.50°</td><td>28.20</td></tr> <tr><td>10.00°</td><td>28.16</td></tr> <tr><td>12.50°</td><td>29.52</td></tr> <tr><td>15.00°</td><td>30.00</td></tr> <tr><td>17.50°</td><td>30.43</td></tr> <tr><td>20.00°</td><td>31.59</td></tr> <tr><td>22.50°</td><td>32.60</td></tr> <tr><td>25.00°</td><td>34.35</td></tr> <tr><td>27.50°</td><td>36.16</td></tr> <tr><td>30.00°</td><td>38.46</td></tr> </table> | 0.00° | | 0.00° | 28.45 | 2.50° | 26.84 | 5.00° | 27.42 | 7.50° | 28.20 | 10.00° | 28.16 | 12.50° | 29.52 | 15.00° | 30.00 | 17.50° | 30.43 | 20.00° | 31.59 | 22.50° | 32.60 | 25.00° | 34.35 | 27.50° | 36.16 | 30.00° | 38.46 |
| 0.00° | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.00° | 25.80 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.50° | 26.44 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.00° | 27.01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.50° | 28.07 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10.00° | 27.97 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.50° | 28.89 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15.00° | 29.96 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17.50° | 30.55 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20.00° | 31.22 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22.50° | 32.11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25.00° | 33.19 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27.50° | 34.44 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30.00° | 35.65 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.00° | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.00° | 28.45 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.50° | 26.84 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.00° | 27.42 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.50° | 28.20 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10.00° | 28.16 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.50° | 29.52 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15.00° | 30.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17.50° | 30.43 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20.00° | 31.59 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22.50° | 32.60 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25.00° | 34.35 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27.50° | 36.16 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30.00° | 38.46 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

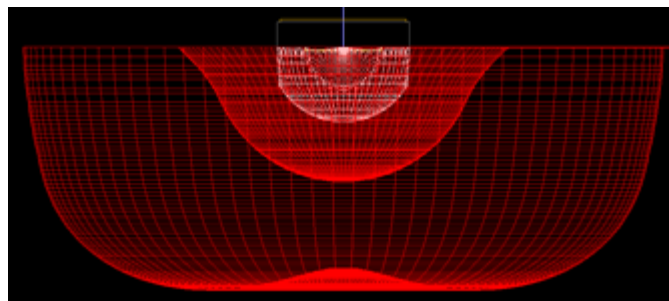
As can be seen the intensities are very similar across the low angles and this is what is required in order to produce a smoother loft and a smoother pattern. A similar intensity pattern will be the goal for the Across lens.

Across Lens Profile Design

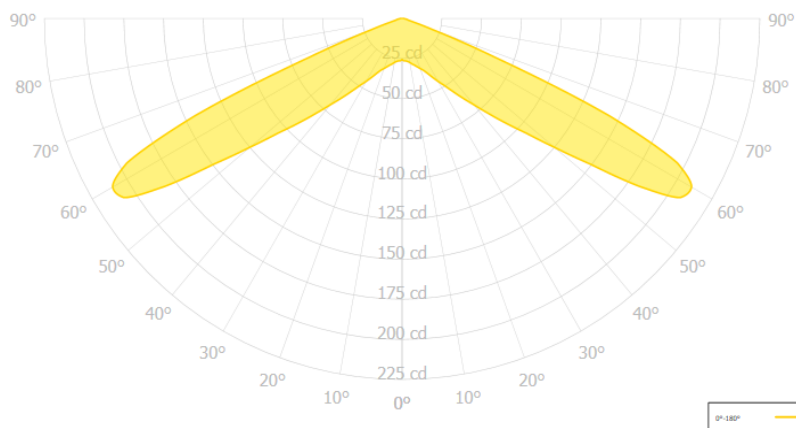
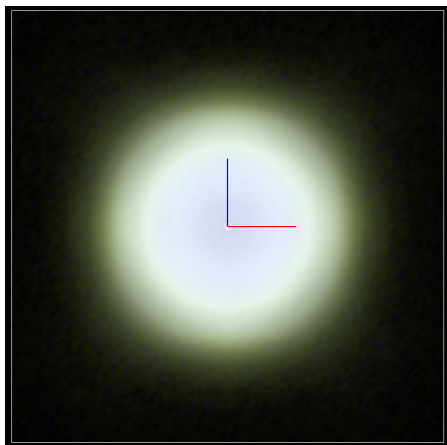
86. Toggle off the "Illum.Planes" button, go to Right view, and Zoom Extents.
87. Go to Settings > Layers, create a new layer named "REFR-Across", change the color to be red. Click OK to close the Layers Window.
88. Select the Curb lens (blue), type "copy" into the command line, hit enter to copy in place.
89. Select only one of the two Curb lenses, in Properties under General, change the Layer to "REFR-Across".
90. Go back to Settings > Layers, turn the "REFR-Curb" layer off, and close the Layers window. You should now see the Across lens in red.
91. As noted before, the lens profiles differ by being aimed to different vertical angles. The Diagonal profile must send the light the furthest distance to define our rectangular pattern, therefore it is aimed at the highest angle, 70°. The Curb profile is aimed slightly lower at 67.5° vertically and will horizontally be pointed along the curb line. The Across profile will be aimed even lower at 60° and will be pointed straight ahead (along the +Y axis). Select the lens and go to View > Parametric Optical Design.
92. In the Aiming of Sections change the end aiming angle to "66" and click "Update Aiming".
93. Using our experience from the Curb lens process, we will adjust the % of Control Inside numbers at the top of the inside surface and we will adjust the final three aiming angles to all be at "63.5" degrees. Additionally we will adjust the Weight Exponent to be "2.5":

| | | | | | | | | |
|----|--------|-----|---------|----------|-----------|--------|--------|----------|
| 58 | 1.0000 | ile | 57.0000 | 842.6041 | -548.0118 | 0.0000 | 0.0000 | 0.0000 |
| 59 | 1.0000 | ile | 58.0000 | 852.1437 | -533.0910 | 0.0000 | 0.0000 | 0.0000 |
| 60 | 1.0000 | ile | 59.0000 | 861.4267 | -517.9844 | 0.0000 | 0.0000 | 5.0000 |
| 61 | 1.0000 | ile | 60.0000 | 870.4493 | -502.6937 | 0.0000 | 0.0000 | 15.0000 |
| 62 | 1.0000 | ile | 61.0000 | 879.2054 | -487.2190 | 0.0000 | 0.0000 | 25.0000 |
| 63 | 1.0000 | ile | 62.0000 | 887.6882 | -471.5605 | 0.0000 | 0.0000 | 45.0000 |
| 64 | 1.0000 | ile | 63.0000 | 895.8900 | -455.7182 | 0.0000 | 0.0000 | 65.0000 |
| 65 | 1.0000 | ile | 63.5000 | 899.9423 | -447.5191 | 0.0000 | 0.0000 | 85.0000 |
| 66 | 1.0000 | ile | 63.5000 | 900.0372 | -447.0841 | 0.0000 | 0.0000 | 100.0000 |
| 67 | 1.0000 | ile | 63.5000 | 900.0955 | -446.6427 | 0.0000 | 0.0000 | 100.0000 |

| | |
|-----------------------|---------|
| Offset Direction | Outside |
| Weighting | |
| Auto Weighting | On |
| Weight Exponent | 2.5000 |
| Weight Minimum | |
| Weight Shift | 0.0000 |
| Optional Geometry | |
| Close Start | No |
| Close End | Yes |
| Sides that are Active | Both |
| Cap Ends | No |



94. Under Edit > Design Properties, set the refractive "REFR-Across" layer to be the Generic "ACRYLIC1" material. Close the Design Properties window.
95. Save the project.
96. Begin the analysis and view your results:



Candela Distribution

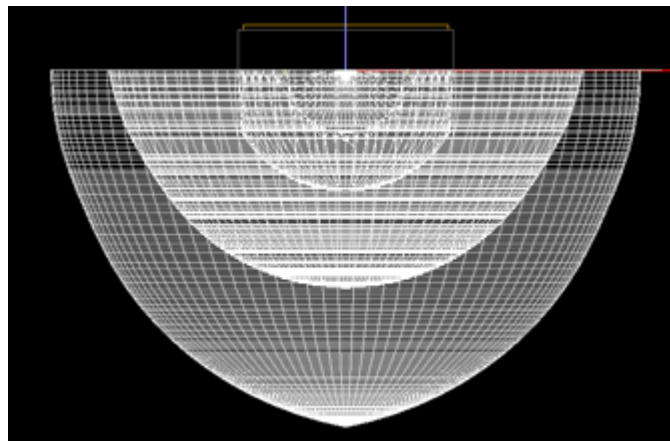
| | 0.00° |
|--------|-------|
| 0.00° | 25.03 |
| 2.50° | 25.02 |
| 5.00° | 25.41 |
| 7.50° | 26.03 |
| 10.00° | 26.51 |
| 12.50° | 27.79 |
| 15.00° | 29.30 |
| 17.50° | 29.95 |
| 20.00° | 32.06 |
| 22.50° | 33.78 |
| 25.00° | 36.68 |
| 27.50° | 39.83 |
| 30.00° | 44.12 |

Back Lens Profile Design

97. Toggle off the "Illum.Planes" button, go to Right view, and Zoom Extents.
98. Go to Settings > Layers, create a new layer named "REFR-Back", keep the color as white. Click OK to close the Layers Window.
99. Select the Across lens (red), type "copy" into the command line, hit enter to copy in place.
100. Select one of the two lenses, in Properties under General, change the Layer to "REFR-Back".
101. Go back to Settings > Layers, turn the "REFR-Across" layer off, and close the Layers window. You should just see the copied lens in white which we will now develop to be our Back profile.

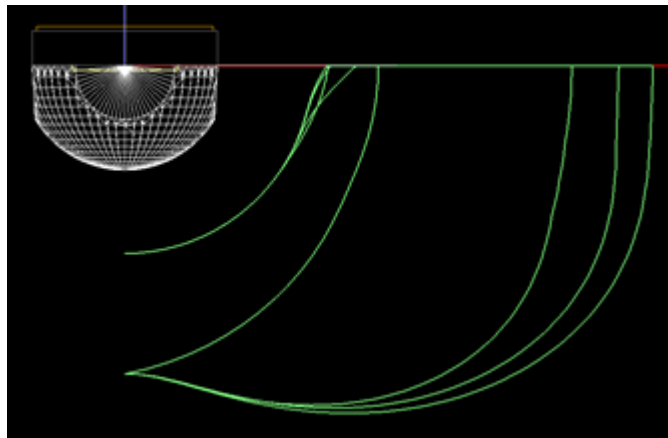
Note - The house side portion of a roadway lens can be done many ways, in this case we will create a simple arc style profile that will decrease the amount of house side light by aiming some light forward.

102. Select the lens and go to View > Parametric Optical Design.
103. In Properties under the Weighting section, change the Weight Exponent to be "0", in order to create a simple closed arc we will need to aim across a wider range of angles, but we don't want to put more light towards the higher angles with the increased weight factor.
104. In the Aiming of Sections change the start aiming angle to "-5" (so the light will be aimed slightly street side of the pole) and the end aiming angle to "85" and click "Update Aiming".
105. In the Section Aiming Properties table adjust the % of Control Inside so starting at section 54 (aimed at 48°) the % of Control Inside is 5%, then each subsequent line is 5% greater. Sections 73-91 will all be 100% control inside.
106. In Properties under Offset Profile change the Minimum Thickness to "0.9". Then change the Offset Distance to "2.0".
107. Save the project.

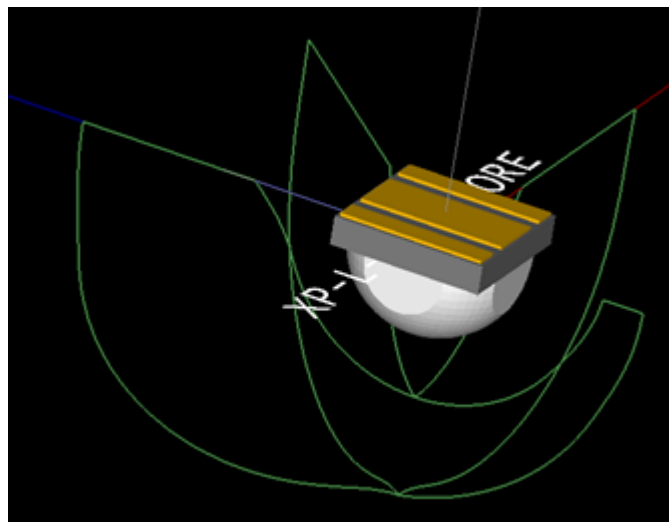


Asymmetric Lofted Lens

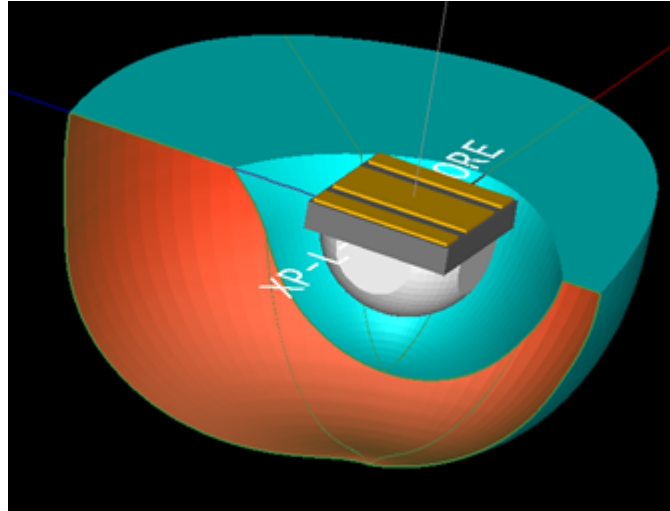
108. Go to Settings > Layers, turn on the three street side lens layers (REFR-Curb, REFR-Diagonal, and REFR-Across).
109. Select the Diagonal (green) lens, go to Design > Lens > Extract 2D Lens Profile. Hit escape to deselect the new profile copy. Go to Settings > Layers, turn off the "REFR-Diagonal" layer and close the Layers window.
110. Select the Curb (blue) lens, go to Design > Lens > Extract 2D Lens Profile. Hit escape to deselect the new profile copy. Go to Settings > Layers, turn off the "REFR-Curb" layer and close the Layers window.
111. Select the Across (red) lens, go to Design > Lens > Extract 2D Lens Profile. Hit escape to deselect the new profile copy. Go to Settings > Layers, turn off the "REFR-Across" layer and close the Layers window.
112. Select the Back (white) lens, go to Design > Lens > Extract 2D Lens Profile. Hit escape to deselect the new profile copy. Go to Settings > Layers, turn off the "REFR-Back" layer and close the Layers window.



113. Save the project.
114. Select the Back profile (the smallest). In Top view rotate around "0,0" by 180°.
115. In Right view select the Curb profile (the middle of the group of three profiles). In Top view rotate around "0,0" by -90°.
116. In Right view select the Diagonal profile (the largest of the group of two profiles). In top view rotate around "0,0" by -47.5°.
117. Orbit around in the CAD space and the four profiles and the LED should look like this:



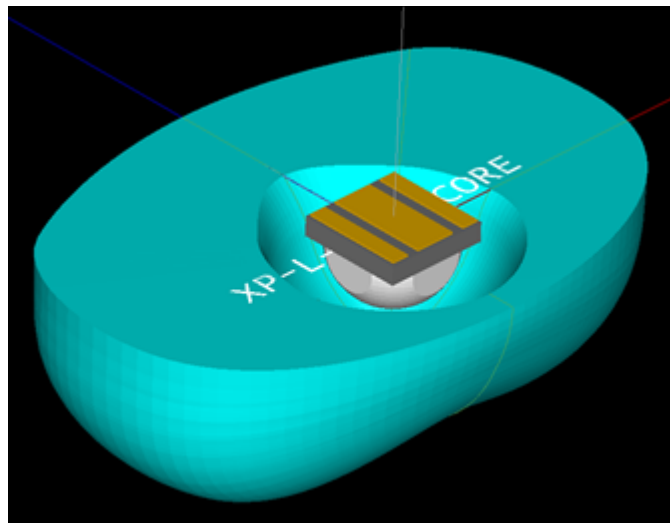
118. Go to Design > Lens > Loft 2D Lens Profiles, select first the Back profile, then Curb, Diagonal, and last the Across profile. Hit enter to end selection:



119. Go to Top view, select the lofted lens, in Properties under the Loft section, change Profile Symmetry to be "Bilateral Y" to mirror the loft.

120. To keep the loft from coming to a sharp crease on the back side, in Properties under the Loft section, change Close Loft to be "Yes".

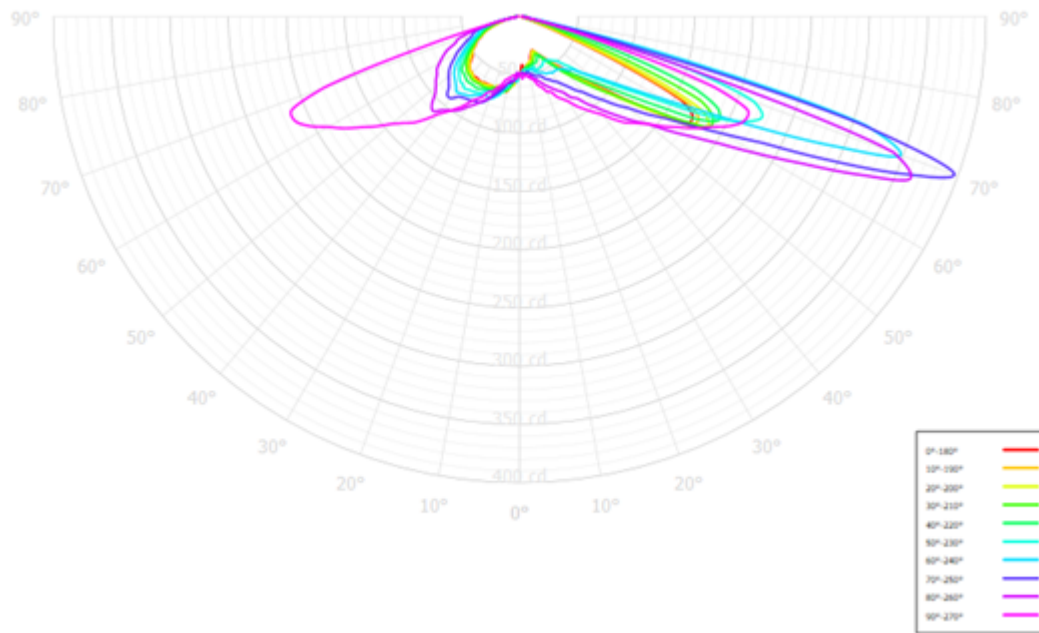
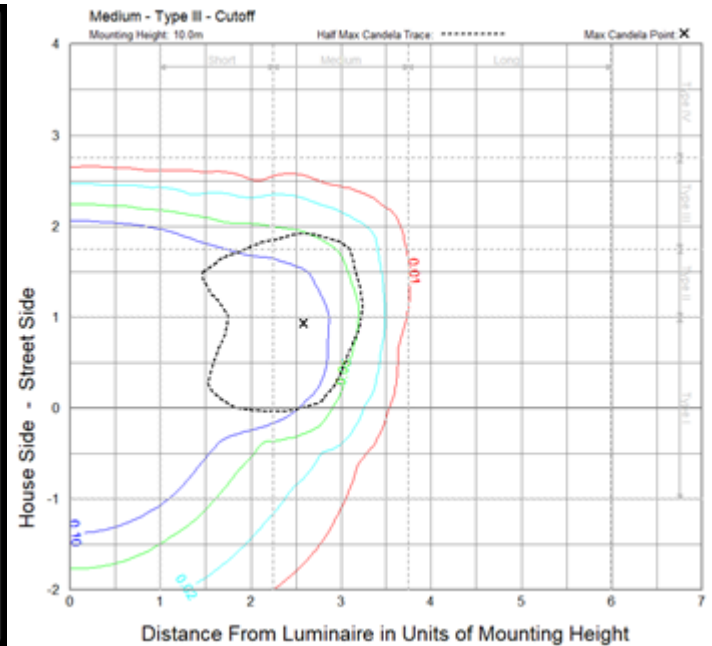
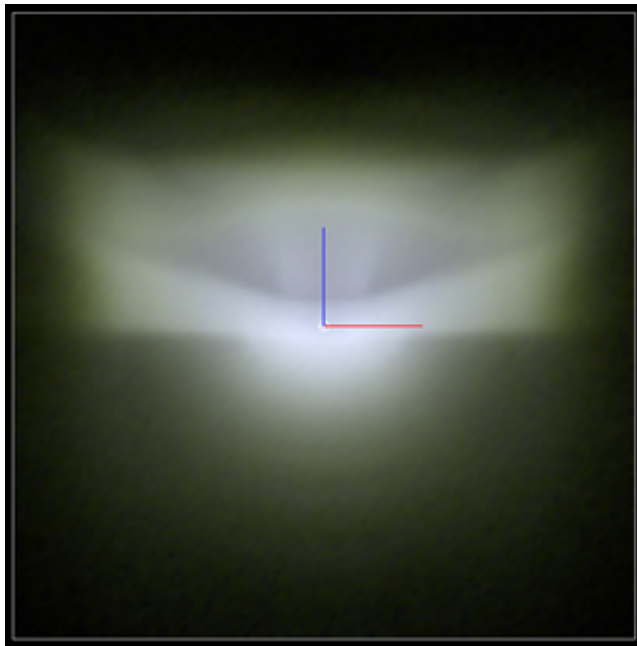
121. Adjust the loft resolution to be more smooth and uniform. In Properties under the Loft section, change the Vertical Resolution to be "80" and the Horizontal Resolution to be "100".



122. The lens is now bilaterally symmetric rather than quadrilaterally symmetric. Go to Analysis > Specify Photometric Output, on the Photometric Report tab change the Horizontal Angles to be "0(10)180" to capture both the forward and back light. Close the Photometric Output Specification window.

123. Save the project.

124. Begin the analysis and review your results:



Complete

Congratulations! You have completed the Type III Roadway Lens Design tutorial.

For more information and tutorials please visit our website at www.ltioptics.com. If you have any questions don't hesitate to reach out to our support team at photopia@ltioptics.com.