

## Advanced Tutorial – Design an Extruded Lens

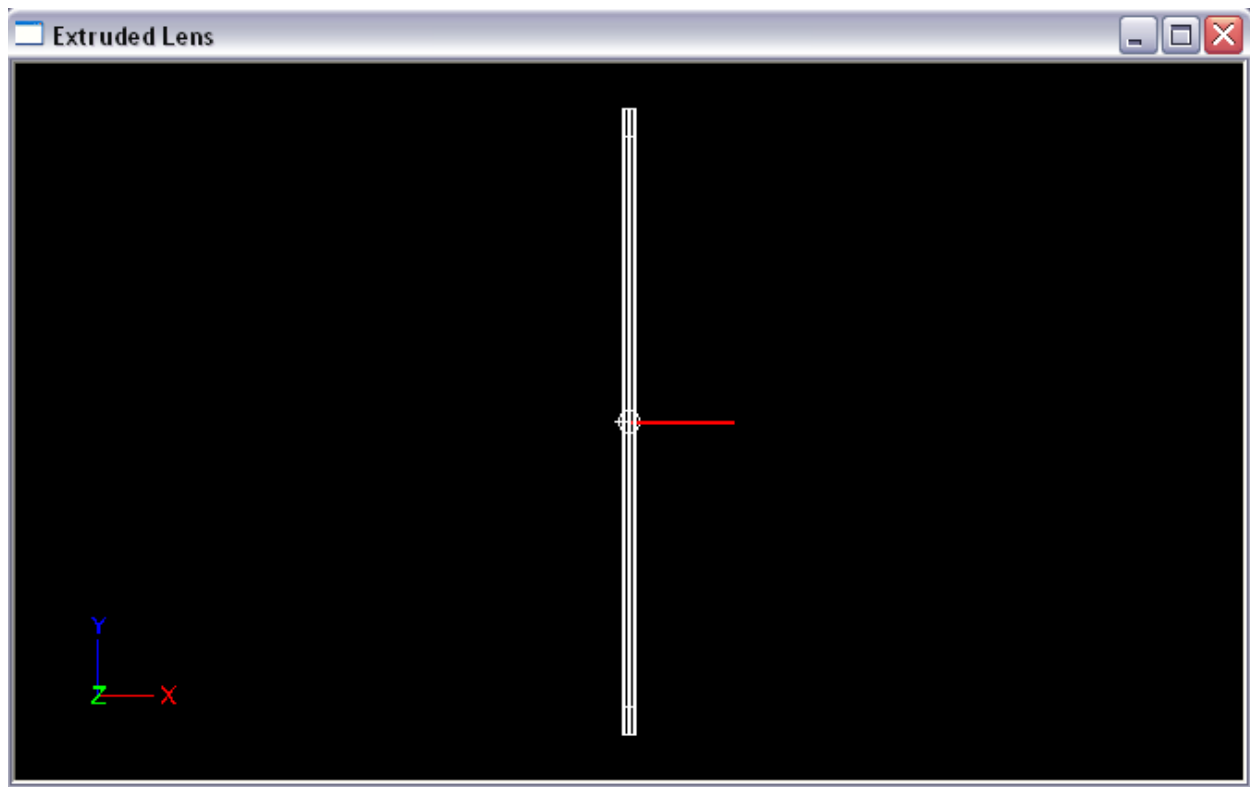
This tutorial demonstrates designing an extruded lens around a fluorescent source by utilizing Photopia's Parametric Lens Design Tool. It is a good idea to complete the beginner tutorials before attempting this advanced tutorial, since many of the more basic functions and concepts are not explained in this tutorial.

The lens design parameters for this tutorial will be the following: a 55° peak intensity (+/- 5°), an 8 inch maximum width, and a 3.5 inch maximum depth. We will use a 32W 4' T8 fluorescent as the source and acrylic as the lens material.

Note that this tutorial is in inches. To change the units of your project, choose **Settings > Project Settings**.

### Import the Lamp

1. Start a new project and choose **File > Save As** and give it the name *Extruded Lens.ray*.
2. Choose **File > Import Lamp** and then browse for the lamp file named *FO3231.LAMP*, which is the 32W 4' T8. Insert the lamp at 0,0.

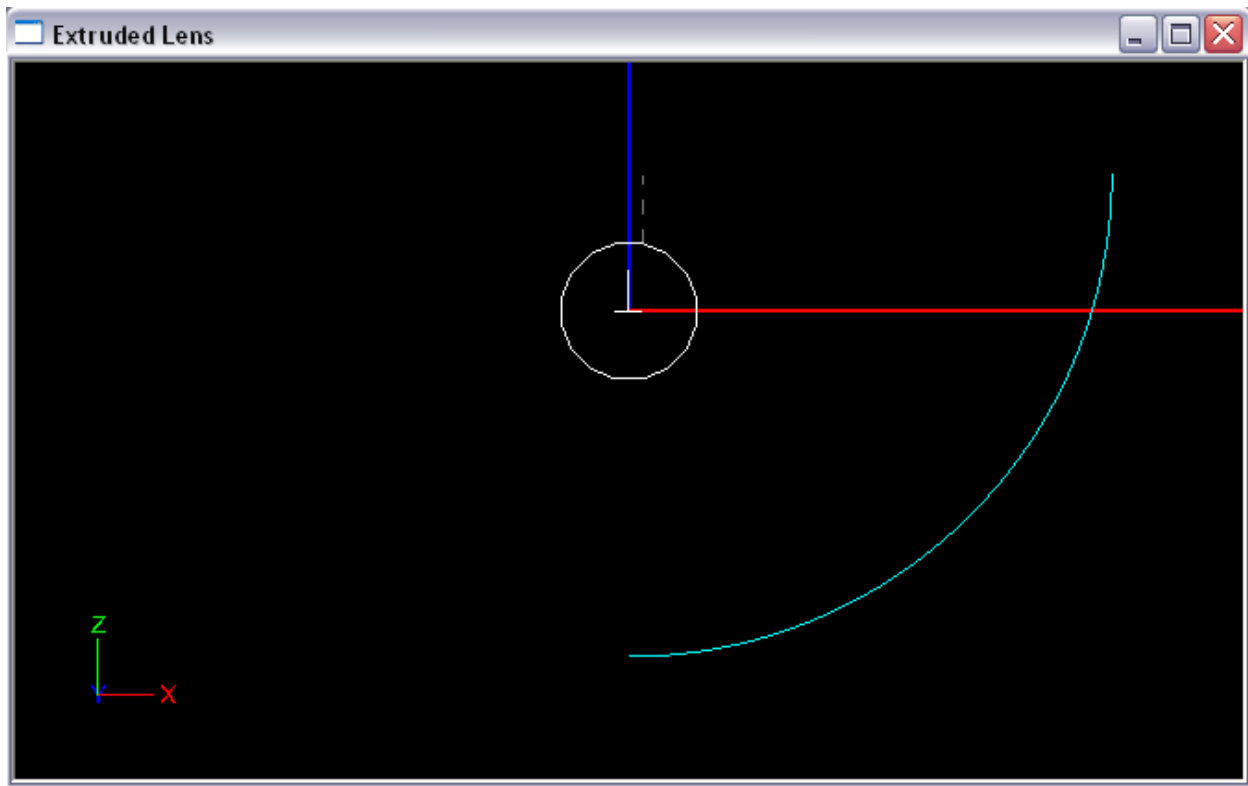


### Construct the Extruded Lens

We will start by drawing an arc that will serve as the lens base profile, to which the prisms will be mapped.

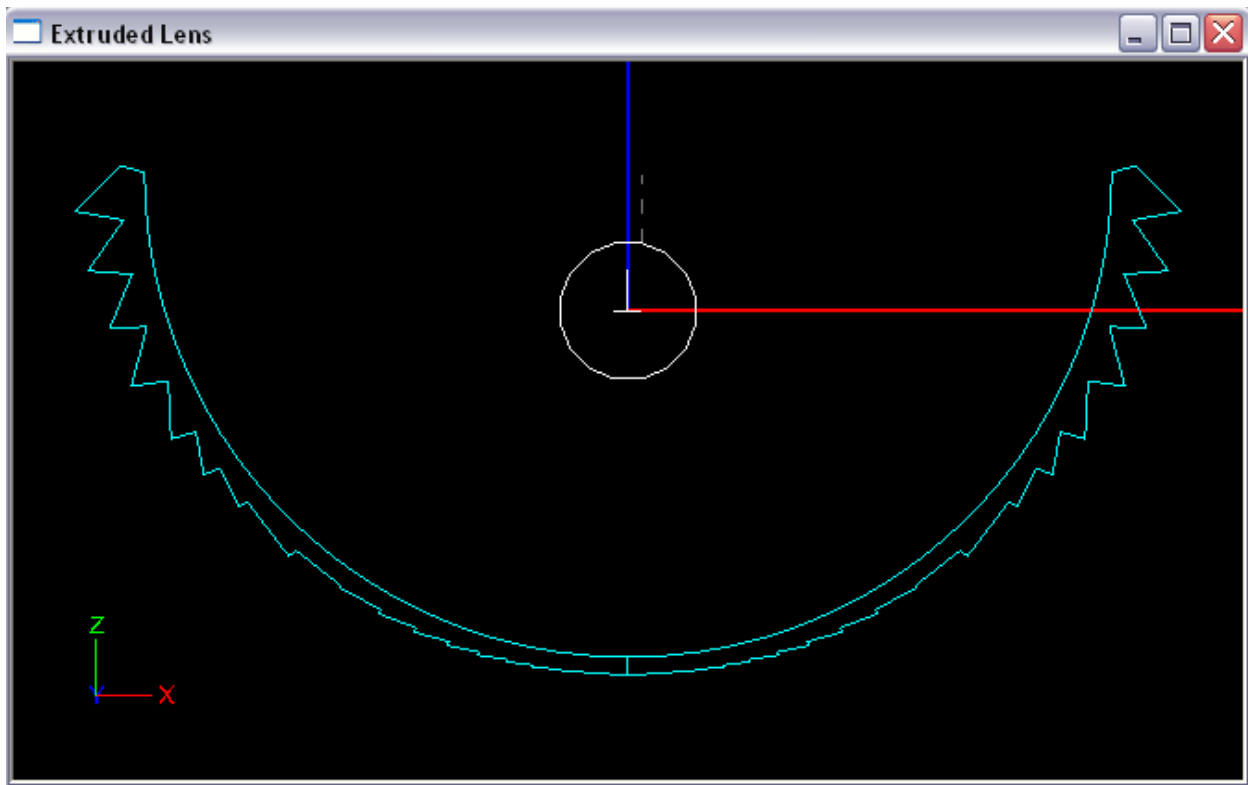
3. Under **Settings > Layers**, create a new layer named *REFR-Lens* and change the color to cyan. Set this new lens layer to be the current layer and click OK.
4. From a front view, choose **Draw > Arc**
  - a. Enter a start point of 0,-2.5 in order to start the lens below the fluorescent source.
  - b. Enter E for End Point.

- c. Enter 3.5,1 for the arc's end point so that the lens extends above the lamp.
- d. Choose 90 for the angular extent of arc, in degrees.



To turn the curve into an extruded lens:

5. Select the base profile by clicking on it, and then choose **Design > Lens > Extruded Symmetric**.
  - a. Press Enter to use the default lamp center of 0,0.
  - b. Press Enter again to use the default number of Refractor Prisms of 10.
  - c. Press Enter again to use the default index of refraction of 1.491, which is for acrylic.
  - d. Enter 0 for the aiming angle at the start of the profile to aim straight down.
  - e. Enter 70 for the aiming angle at the end of the profile to design towards our requirement.
  - f. Press Enter to use the default aiming angle increment of 5, in degrees.
  - g. Press Enter again to use the default minimum thickness of 0.125, in inches.
  - h. Enter 48 (in inches) for the extrusion length, so the lens fully covers the fluorescent source.

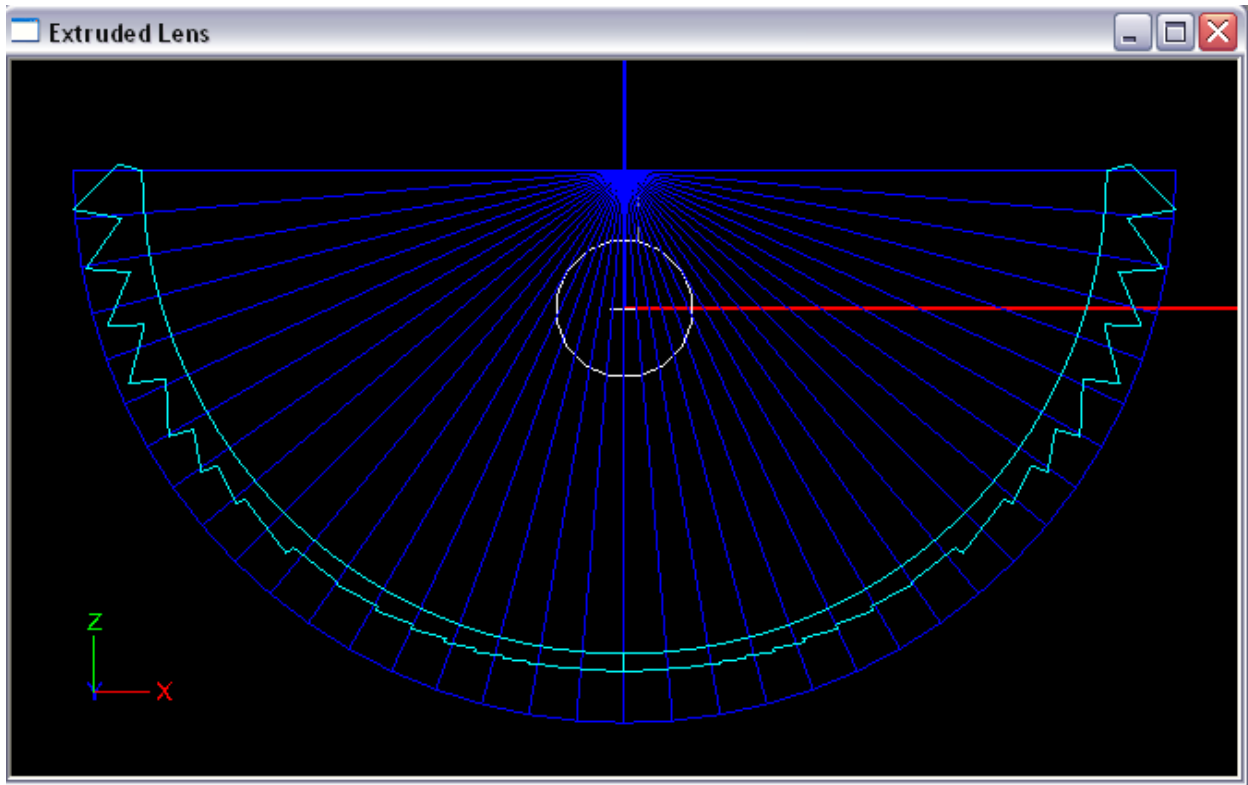


## Construct the Housing

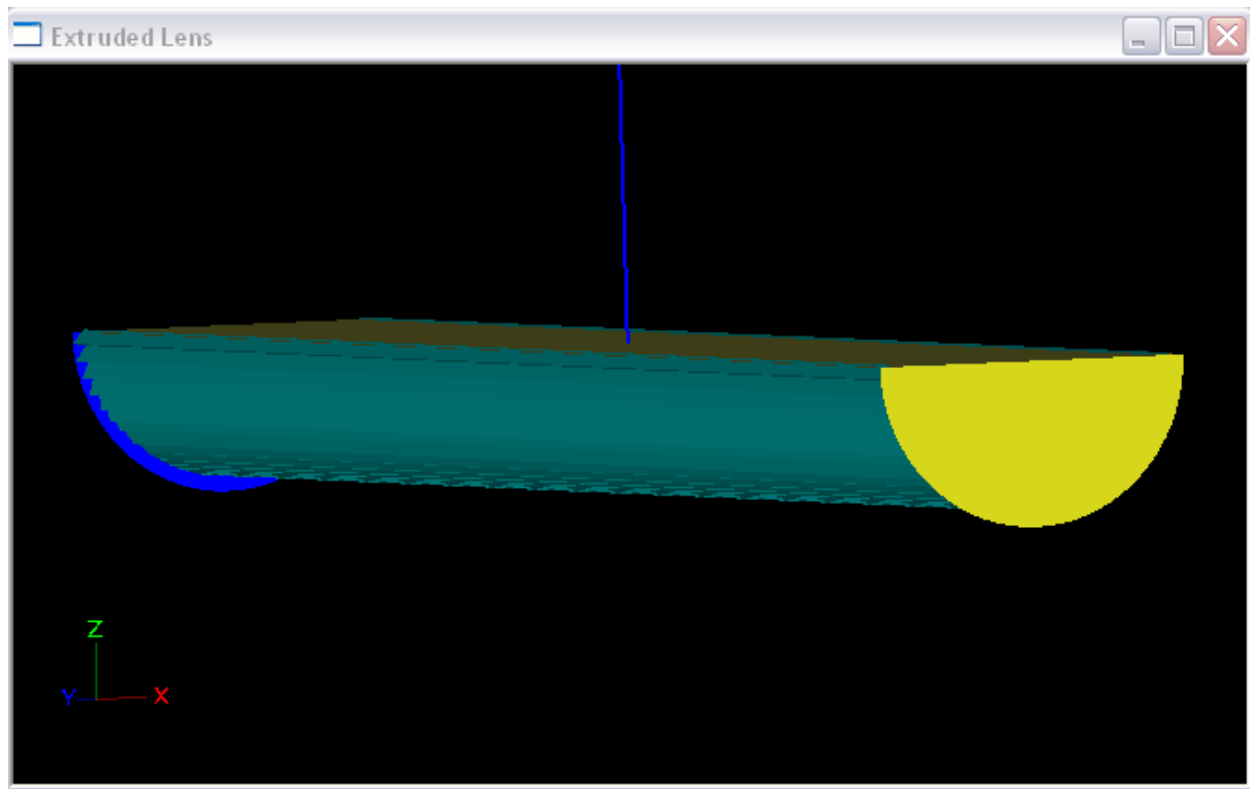
Next we will build a housing to enclose the optic we have created. We can start with the 8 inch maximum width, and a 3.5 inch maximum depth.

6. Under **Settings > Layers**, create a new layer named *REFL-Housing* and change its color to blue. Set this new reflective layer to be the current layer and click OK.
  - a. From a top view, choose **Design > Reflector: Polyline Based > Revolved**.
  - b. Press Enter to choose the default lamp center of 0,0.
  - c. Enter a start point of -4,-24 so that the end cap begins at the end of the lens.
  - d. Enter 4,-24 for the next point to make an 8" total width.
  - e. Press Enter to end reflector profile.
  - f. Press Enter to choose the default number of revolved sections of 36.
7. From front view, select the new revolved reflector end cap, and use the **Modify > Move** command to move it up 1" so it aligns with the lens.
8. With the end cap selected, change the Number of Mirrors under **Mirroring** in the property control from 0 to 1. The default mirror is appropriate in this case, so this will add an end cap at the other end of the lens as well.
9. With the end caps selected, change the Rev Extent under **Extrude/Revolve** in the property control from 360 to 180, which will change the end caps to half circles.
10. From front view, choose **Design > Reflector: Polyline Based > Asymmetric Extruded**.
  - a. Press Enter to choose the default lamp center of 0,0,0.
  - b. Enter a start point of -4,1 to begin the top of the housing.

- c. Enter 4,1 for the next point to complete the top of the housing.
- d. Press Enter to end reflector profile.
- e. Enter 48 for the extrusion length, in inches.



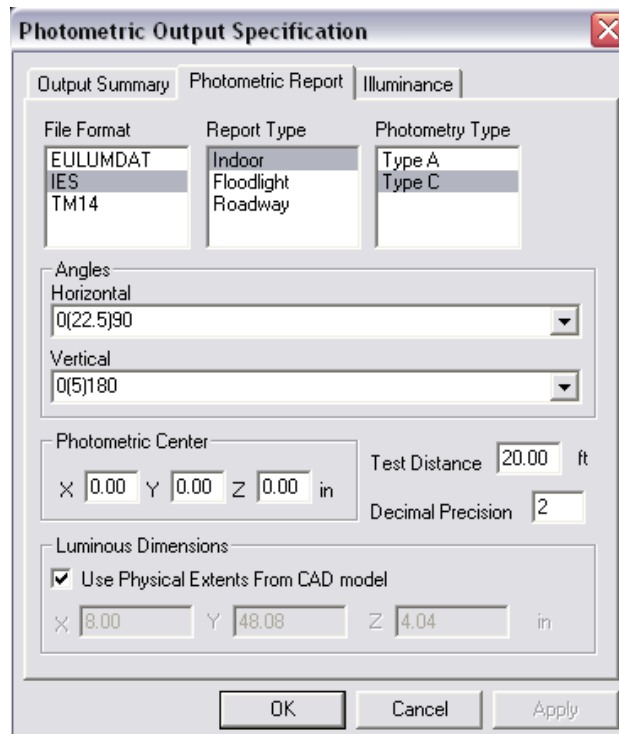
11. You can ensure that the surface is oriented correctly, as shown below, by right clicking in CAD view and choosing **View Style > Show Surface Orientation**, and then using Orbit. You can then return to the original view style by selecting **Wireframe** under the same menu.



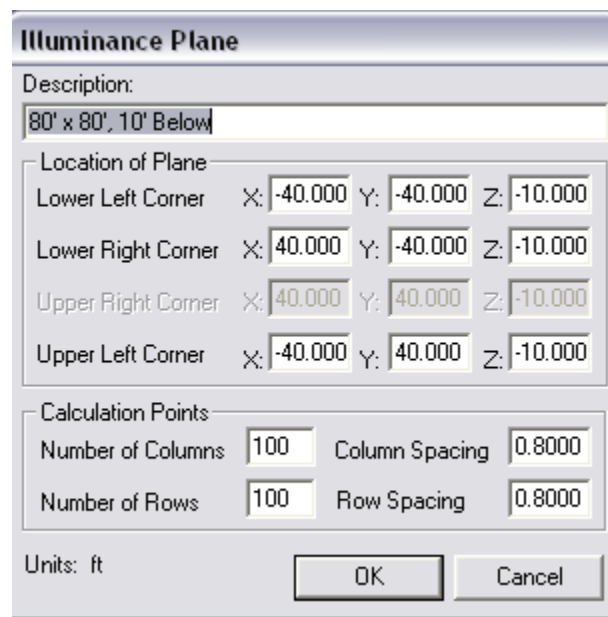
### Setup the Output and Materials

We should add an illuminance plane to the project, and need to specify materials for the optical components of our project.

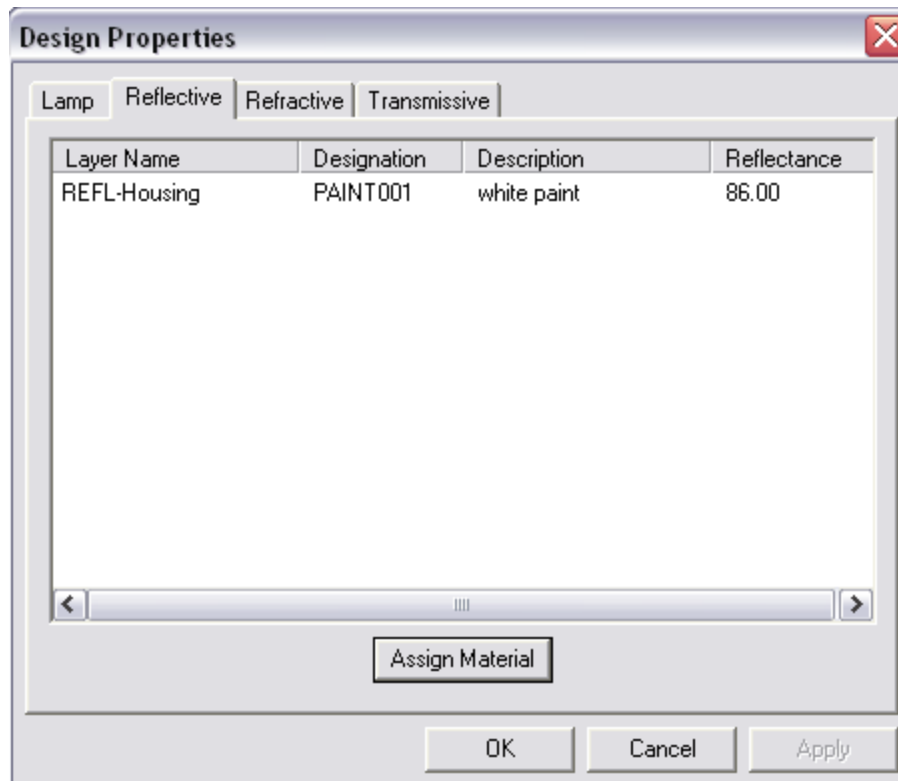
12. Under **Analysis > Specify Photometric Output > Photometric Report**, ensure that your photometric output is set up for a linear downlight with quadrilateral symmetry.



13. Under **Analysis > Specify Photometric Output > Illuminance**, create an illuminance plane 80'x80' 10' below the fixture. Click OK in both the Illuminance Plane window and the Photometric Output Specification window.



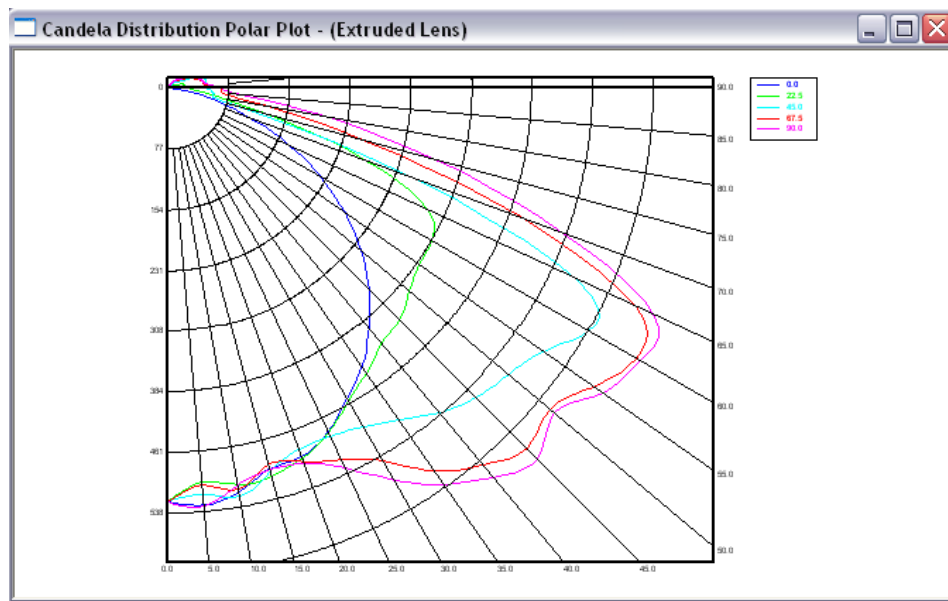
14. Under **Edit > Design Properties > Reflective**, select *Generic PAINT001* for the housing.
15. Under the **Refractive** tab, select *Generic ACRYLIC1* for the lens. Click OK.



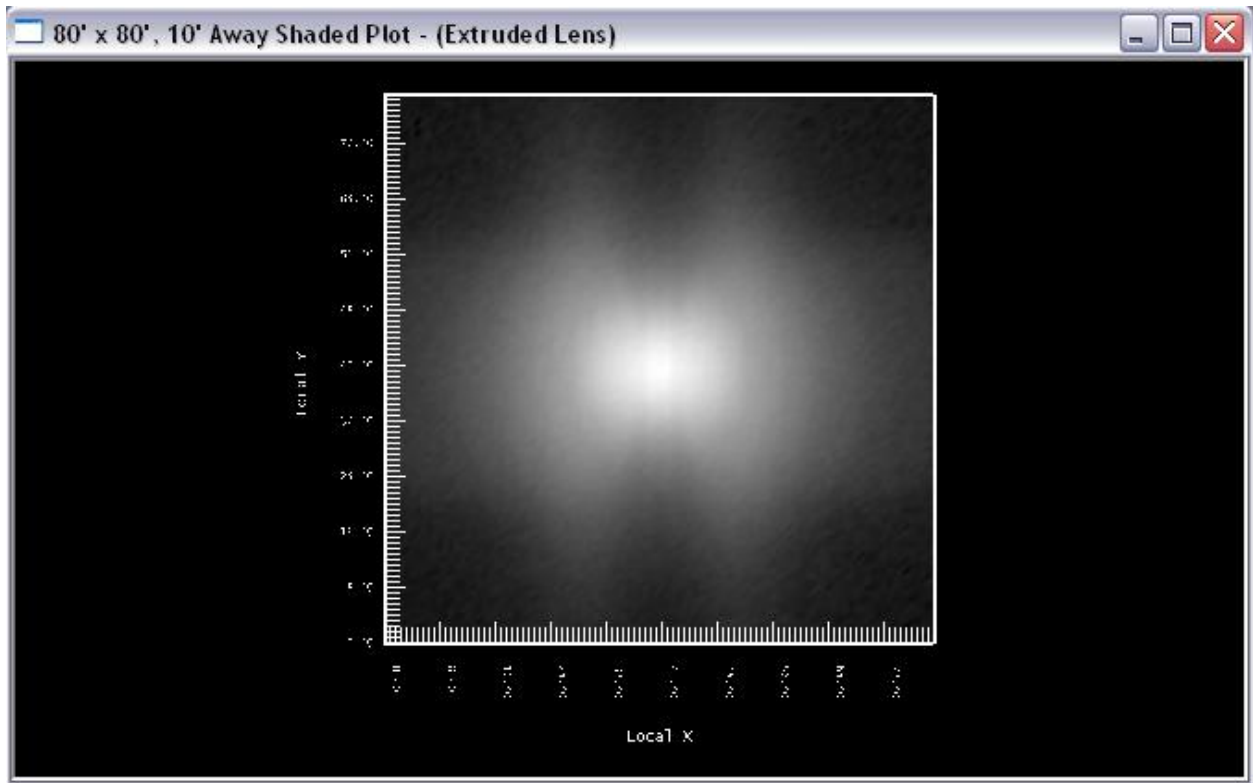
### Simulate the Design Performance

Now we can run a raytrace and test the performance of our extruded lens design.

16. Save the project and choose **Analysis > Begin Analysis** to begin the raytrace.
17. To view the candela distribution, choose **View > Candela Distribution > Polar Plot**.

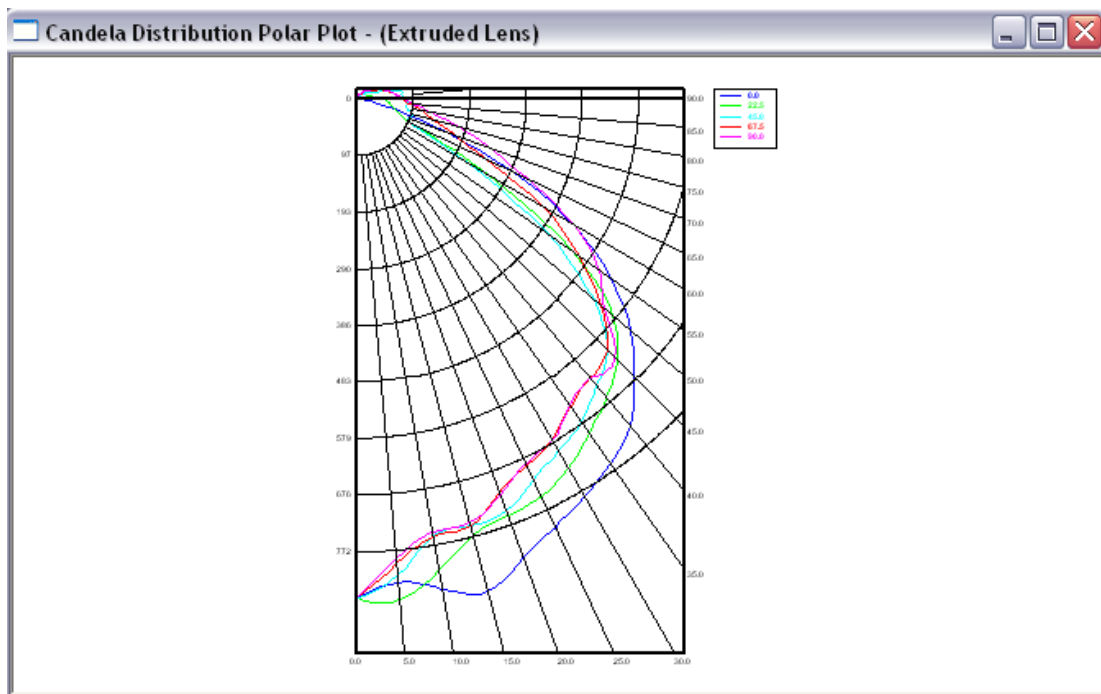


18. To view the shaded illuminance plane, choose **View > Illuminance > Shaded Plot**.



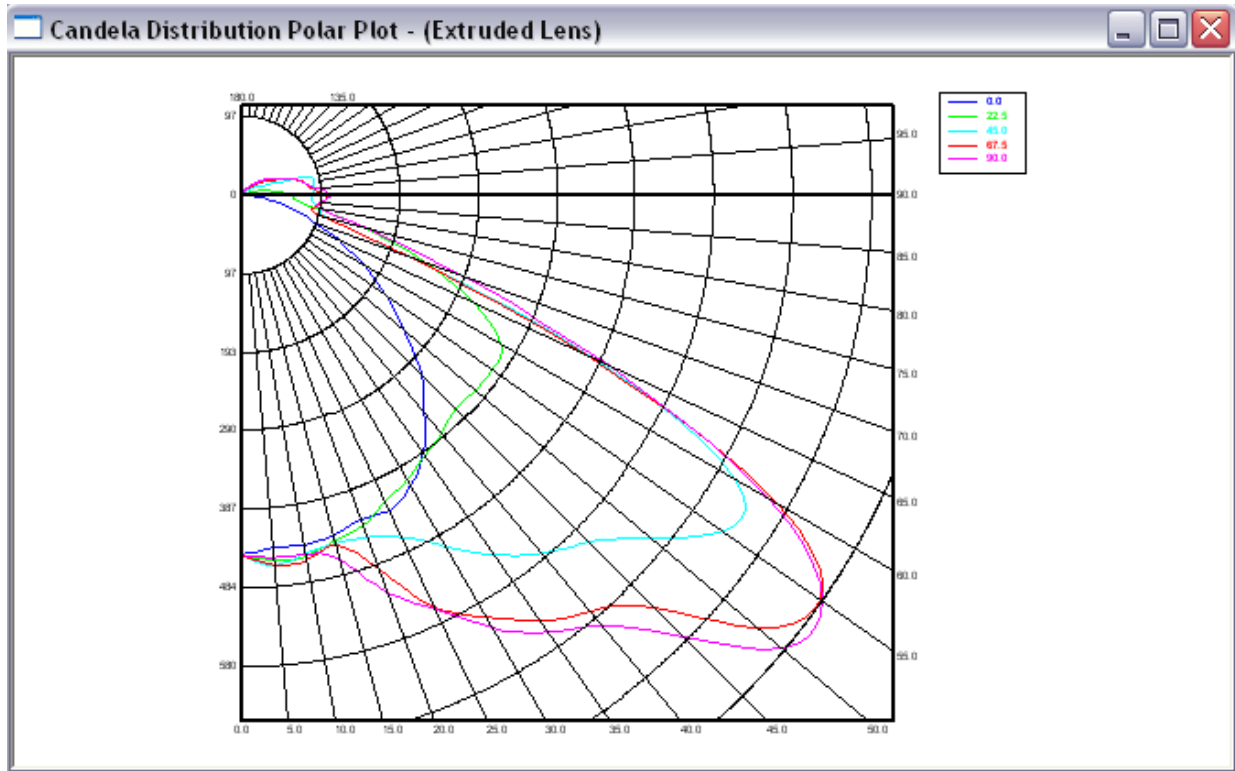
Both the candela plot and illuminance on the floor plane look decent, but we can make refinements for improved results.

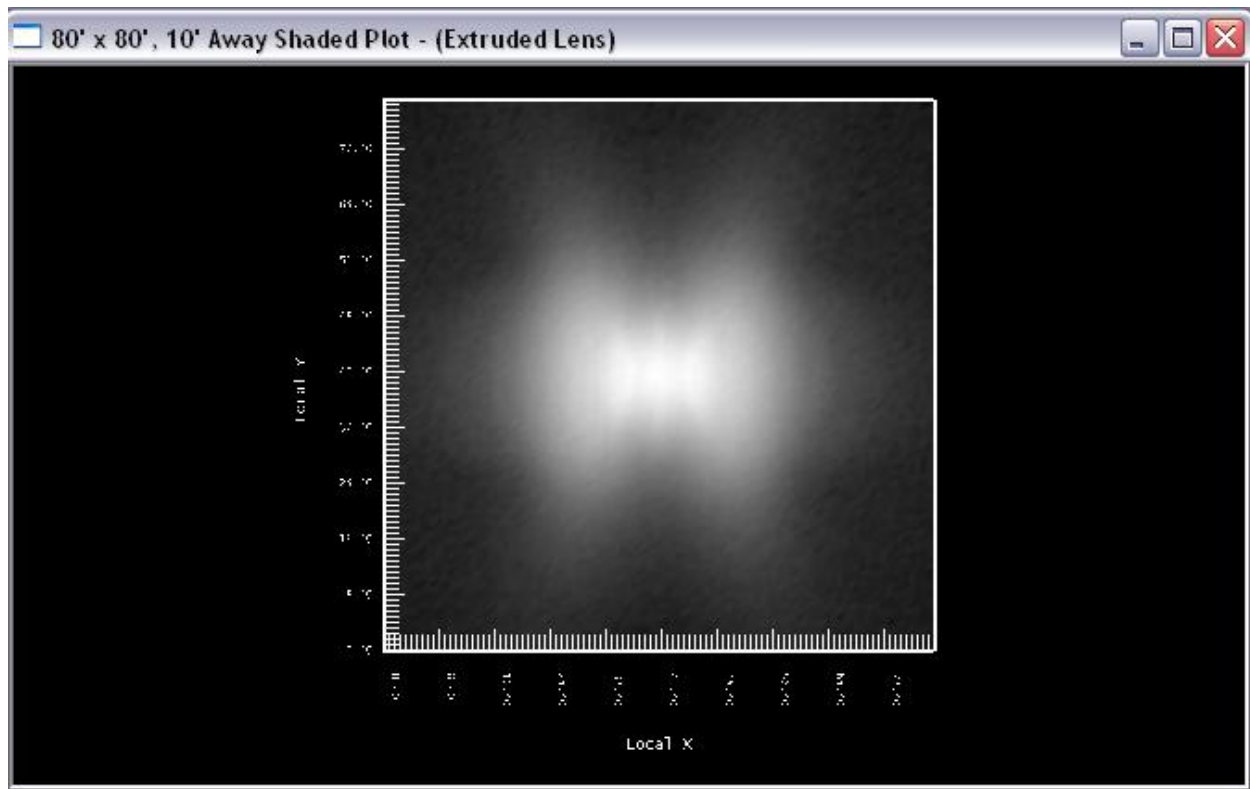
19. With the lens selected, choose **View > Parametric Optical Design**, change the aiming from 0(5)70 to 0(5)60 and click Update Aiming. This should bring the beam's peak closer to 55°.
20. Run the analysis again.





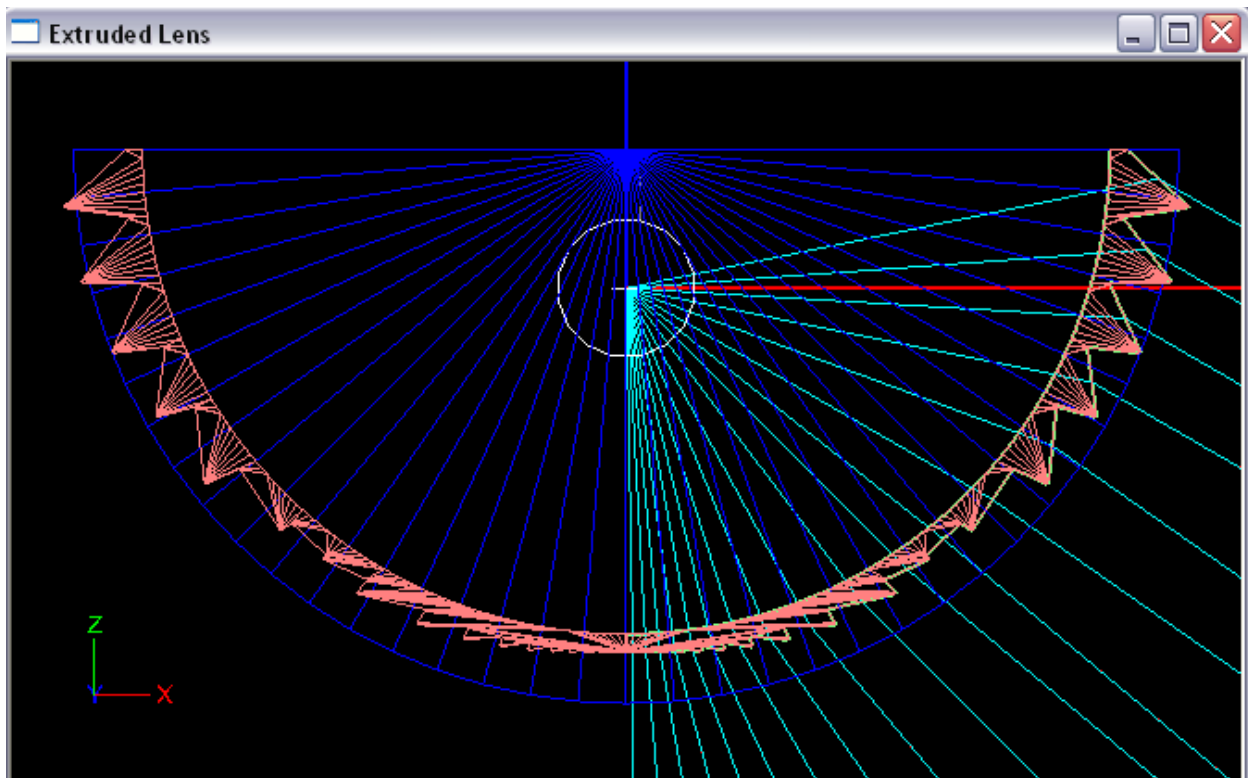
21. This time, we lost the punch of light at the higher angle. To weight the aiming to favor the higher angles and create a peak in the distribution, select the lens and change the Weight Exponent under **Weighting** in the property control from 1 to 3.
22. With the lens selected, change Number of Prism Steps under **Tooling Constraints** in the property control from 10 to 20 so the change in prism aiming along the lens becomes smoother.
23. Run the analysis again.





Both the candela plot and shaded illuminance on the floor plane have improved. We can now add some adjustments to make the design more realistic, and then run a final raytrace to confirm that none of these adjustments had undesired effects on our lens design.

24. With the lens selected, change both the Peak Fillet Radius and the Valley Fillet Radius under **Tooling Constraints** in the property control to 0.01" to account for the limitation of manufacturing.
25. Change the Arc Resolution under **Base Profile** from 4 to 1 so the lens profile is approximated at 1° increments rather than 4° increments, a closer approximation to a smooth inner surface.
26. Change Offset Style under **Offset Profile** from *Radial from Lamp Center* to *Simple Offset* so that the ends of the lens profile are perpendicular.
27. Change Close Start under **Optional Geometry** from *Yes* to *No* so that the center of the extrusion doesn't have a vertical wall between the two halves (recall that this is the start of the profile).
28. Change Cap Ends under **Optional Geometry** from *No* to *Yes* so that the ends of the lens model are closed with lens surface.



29. Run the analysis again.

Looking at the results, it appears that the adjustments we made had no undesired effects on our lens design, and we met all our design requirements so we will stop our design here.