OPTI 435/535 Homework #3 Due: October 28, 2021

Undergrads do problems 1 through 3
Grads do all four problems

1. Suppose an eye has a wavefront error

$$W(\rho,\theta) = 0.001 Z_4^0(\rho,\theta)$$

where $\rho = r/r_{max}$ and $r_{max} = 3mm$. If the pupil shrinks to $r_{max} = 1.5mm$, what is the new wavefront error in terms of Zernike polynomials? Hint: The two wavefronts should be identical over the smaller pupil diameter.

2. Use astigmatic decomposition to combine two lenses with prescriptions:

$$-3.00D/+1.00D \times 30°$$
$$-2.25D/+2.00D \times 50°$$

3. Design a well-corrected Φ = +4.00 diopter spectacle lens to correct hyperopia using Tscherning's ellipse. Assume a vertex distance of 14 mm (distance from spectacle to cornea) and a distance of 13 mm between the cornea and the center of rotation of the eye. The lens material is PMMA.
   (a) What two values of the anterior surface power ϕ_1 eliminate astigmatism for this lens?
   (b) What are the posterior surface powers ϕ_2 corresponding to powers found in part (a)?

*********************************Grads Only*************************************

4. Now design the same well-corrected +4.00 diopter spectacle lens as a thick lens in raytrace code. The vertex distance and the distanc between the cornea and the center of rotation of the eye are unchanged. To implement this layout, follow these steps

   (a) Start with an equiconvex 3 mm thick PMMA lens with radii of ±261.114386 mm.

   (b) Add an additional surface 27 mm behind the lens and set this surface to be the aperture stop. This effective puts the stop at the center of rotation of the eye (i.e 14 mm vertex distance plus 13 mm to the center of rotation). In doing so, the field angle corresponds to the rotation of the eye in object space.

   (c) Set the distance from the stop to the image plane as 237 mm. This corresponds to the distance from the center of rotation to the Far Point of the eye (i.e. 1 / 4 diopters = 250 mm minus 13 mm to the center of rotation.

   (d) Set the object at infinity. Note the actual lens power is slightly different than +4.00 D because of the separation between the lens and the cornea.

   (e) Set field heights of 0 an 15 degrees, the wavelength to 0.55 μm and the pupil size to 3 mm.

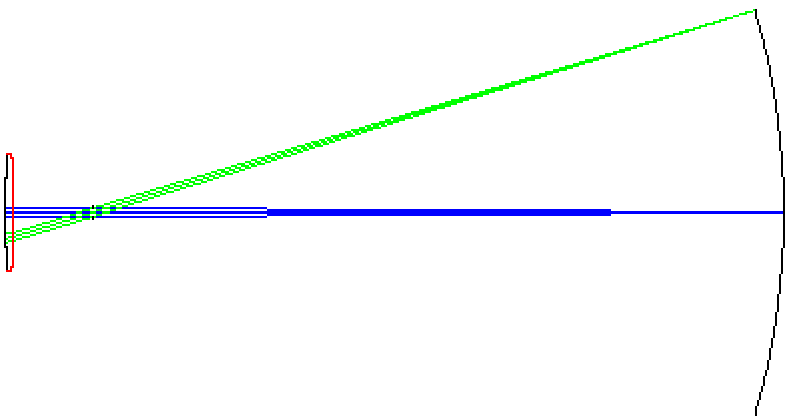
   (f) Set the radius of curvature of the image plane to -250. This corresponds to the Far Point sphere.

Your layout should look like the following:

Lens Data Editor

Edit Solves View Help

Surf:Type		Comment	Radius	Thickness	Glass
OBJ	Standard		Infinity	Infinity	
1*	Standard	anterior lens	261.114386	3.000000	PMMA
2*	Standard	posterior lens	-261.114386	27.000000	
STO	Standard	ctr of rotation	Infinity	237.000000	
IMA	Standard		Infinity	-	



We now wish to see what the astigmatism looks like as a function of lens bending. Plot the level of astigmatism (in the 15 degree field) as a function of the anterior lens radius. Reduce the radius of the anterior spectacle lens and then readjust the radius of the posterior surface of the spectacle to maintain focus for the zero degree field. As you change the front surface radius, there will be two shapes that minimize the astigmatism. Make sure you find both of them.

Convert the radii from the two solutions to surface powers and compare them to the values found in the previous problem.