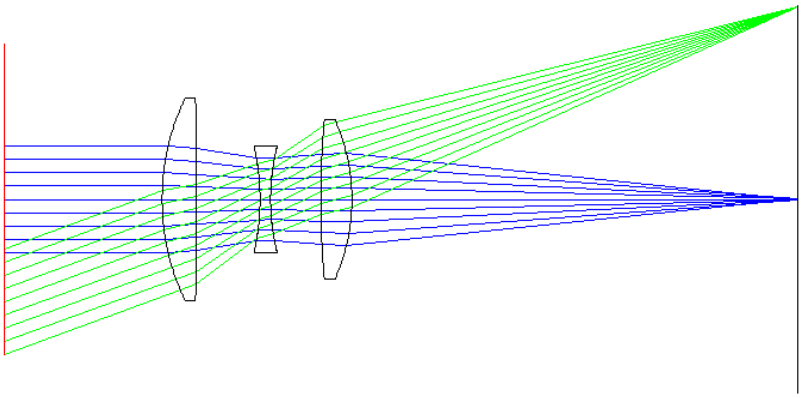
OPTI 415/515 Homework 1

Undergraduates do the first three problems. Graduates Students do all four questions.

1. Below is a raytrace of a Cooke triplet. Which surface is the aperture stop? Which surface is likely to cause vignetting if the field angle is increased?



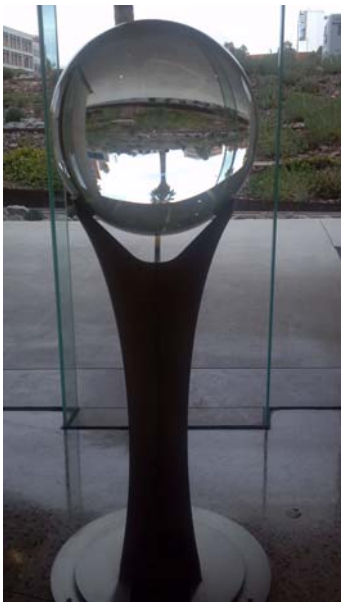
The chief ray is the center ray of the green bundle. It crosses the optical axis at the third surface. If the field angle is increased, the upper rim ray of the green bundle will get clipped by the sixth surface.

2. You need to build a machine vision system to inspect a part. You have a 100 mm focal length lens, a 1/3" CCD camera and the working distance needs to be 1 meter. If the part is 39.6 mm in diameter, how for is the CCD sensor from the lens (you can assume a thin lens here).

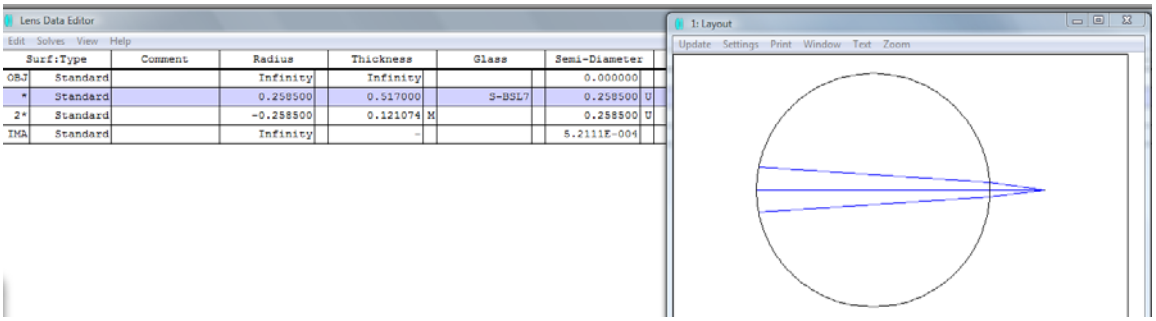
The object distance L = -1000 mm and the focal length of the lens is 100 mm, so from the Gaussian Imaging equation,

$$\frac{1}{L'}+\frac{1}{1000}=\frac{1}{100}\Rightarrow L'=111.111\,\text{mm}$$

3. In the lobby of Optical Sciences is a sculpture of a glass sphere. The sphere has a circumference of 1.623 m and is made from S-BSL7 glass. Using raytracing code, find the locations of the cardinal points. Assume $\lambda = 0.5876$ μm.



*I used Zemax with a wavelength of 0.5876 μm and S-BSL7 (index n = 1.516) for the material. The circumference is equal to p * diameter, so the diameter of the sphere is 0.517 m and the radius of curvature is 0.2585 m. The layout of the system and the locations of the cardinal points are below.*

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Object space positions are measured with respect to surface 1.
Image space positions are measured with respect to surface 3.
The index in both the object space and image space is considered.

                              Object Space          Image Space
Focal Length            :        -0.379574             0.379574
Focal Planes            :        -0.121074             0.000000
Principal Planes        :         0.258500            -0.379574
Anti-Principal Planes   :        -0.500649             0.379574
Nodal Planes            :         0.258500            -0.379574
Anti-Nodal Planes       :        -0.500649             0.379574
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4. **********Grads Only**********

Create a spreadsheet like the one illustrated in class to do a paraxial raytrace of the system listed in question 3. Calculate the cardinal points from the spreadsheet and verify they match the results of the raytracing code.

1	Sphere							
2		Object		Surf1		Surf2		Image
3	R	Infinity		0.2585		-0.2585		Infinity
4	C	0		3.868472		-3.86847		0
5	t		infinity		0.517			
6	n		1		1.516		1	
7								
8	$\bar{-}\phi$	0		-1.99613		-1.99613		0
9	t/n		infinity		0.341029		0.121234	
10								
11	y			1		0.319261		0
12	nu		0		-1.99613		-2.63342	
13								
14	ybar			0		0.034103		0.037973
15	nubar		0.1		0.1		0.031926	
16								
17								
18		The rear focal point is located 0.121234 m after the back surface						
19		The rear focal length is 1 / 2.63342 = 0.3797 m						
20		The rear principal plane is located 0.3797 m to left of rear focal point or 0.2585 to left of back surface.						
21		By symmetry, the front focal point is 0.121234 m to left of front surface						
22		and the front principal plane is 0.2585 m to the right of the first surface.						
23		The system is in air, so the nodal points are at the principal planes.						